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1. Specifications

<table>
<thead>
<tr>
<th>Model</th>
<th>DFL (^1)</th>
<th>DFLS (^2)</th>
<th>DFLB (^3)</th>
<th>DFLSB (^4)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mechanical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diameter</td>
<td>2.5 in (6.3 cm)</td>
<td>2.5 in (6.3 cm)</td>
<td>2.5 in (6.3 cm)</td>
<td>2.5 in (6.3 cm)</td>
</tr>
<tr>
<td>Length</td>
<td>9.0 in (22.8 cm)</td>
<td>9.3 in (23.6 cm)</td>
<td>12.4 in (31.6 cm)</td>
<td>12.6 in (32.4 cm)</td>
</tr>
<tr>
<td>Weight, in air</td>
<td>1.5 lbs (0.7 kg)</td>
<td>1.8 lbs (0.8 kg)</td>
<td>1.9 lbs (0.9 kg)</td>
<td>1.9 lbs (0.9 kg)</td>
</tr>
<tr>
<td>Material</td>
<td>Acetron/ABS</td>
<td>Acetron/ABS</td>
<td>Acetron/ABS</td>
<td>Acetron/ABS</td>
</tr>
<tr>
<td><strong>Environmental</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature range</td>
<td>0–30 deg C</td>
<td>0–30 deg C</td>
<td>0–30 deg C</td>
<td>0–30 deg C</td>
</tr>
<tr>
<td>Depth Rating</td>
<td>600 m</td>
<td>150 m</td>
<td>600 m</td>
<td>150 m</td>
</tr>
<tr>
<td><strong>Electrical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analog Output</td>
<td>0–5 VDC</td>
<td>0–5 VDC</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>RS-232 Output</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>ADC Resolution</td>
<td>12 bits</td>
<td>12 bits</td>
<td>12 bits</td>
<td>12 bits</td>
</tr>
<tr>
<td>Internal Data Logging</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Anti-Fouling Shutter</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Internal Batteries</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Connector</td>
<td>Subconn MCBH6M</td>
<td>Subconn MCBH6M</td>
<td>Subconn MCBH6M</td>
<td>Subconn MCBH6M</td>
</tr>
<tr>
<td>Input Voltage</td>
<td>7.5–15 VDC</td>
<td>7.5–15 VDC</td>
<td>7.5–15 VDC</td>
<td>7.5–15 VDC</td>
</tr>
<tr>
<td>Current, Typical</td>
<td>80 mA</td>
<td>80 mA</td>
<td>80 mA</td>
<td>80 mA</td>
</tr>
<tr>
<td>Current, Sleep</td>
<td>150 µA</td>
<td>150 µA</td>
<td>150 µA</td>
<td>150 µA</td>
</tr>
<tr>
<td>Shutter Cycle</td>
<td>-</td>
<td>100 mA</td>
<td>100 mA</td>
<td>100 mA</td>
</tr>
<tr>
<td>Data Memory</td>
<td>10,910 samples (64 kB)</td>
<td>10,910 samples (64 kB)</td>
<td>10,910 samples (64 kB)</td>
<td>10,910 samples (64 kB)</td>
</tr>
<tr>
<td>Sample Rate, digital</td>
<td>0.5–10 Hz</td>
<td>0.5–10 Hz</td>
<td>0.5–10 Hz</td>
<td>0.5–10 Hz</td>
</tr>
<tr>
<td>Time Constant, analog</td>
<td>0.25 sec</td>
<td>0.25 sec</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Optical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wavelength excitation</td>
<td>455 x 120 nm</td>
<td>455 x 120 nm</td>
<td>455 x 120 nm</td>
<td>455 x 120 nm</td>
</tr>
<tr>
<td>Wavelength emission</td>
<td>685 x 70 nm</td>
<td>685 x 70 nm</td>
<td>685 x 70 nm</td>
<td>685 x 70 nm</td>
</tr>
<tr>
<td>Sensitivity per volt*</td>
<td>20 µg/l</td>
<td>20 µg/l</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sensitivity per count*</td>
<td>0.025 µg/l</td>
<td>0.025 µg/l</td>
<td>0.025 µg/l</td>
<td>0.025 µg/l</td>
</tr>
<tr>
<td>Resolution (volts)</td>
<td>0.0015</td>
<td>0.0015</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Resolution (counts)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Range, typical*</td>
<td>100 µg/l</td>
<td>100 µg/l</td>
<td>100 µg/l</td>
<td>100 µg/l</td>
</tr>
<tr>
<td>Linearity</td>
<td>99% R(^2)</td>
<td>99% R(^2)</td>
<td>99% R(^2)</td>
<td>99% R(^2)</td>
</tr>
</tbody>
</table>

1 Digital fluorometer  
2 Digital fluorometer with shutter  
3 Digital fluorometer with internal batteries  
4 Digital fluorometer with internal batteries and shutter

*Other ranges available upon request.

Specifications subject to change without notice.
1.1 Configuration

DFL  RS-232 output*; 0–5 V; logging-capable
DFLS  Shuttered version of DFL
DFLB  Equipped with self-contained batteries
DFLSB  Equipped with self-contained batteries and a shutter

*Optionally configured for TTL serial and not available on units with self-contained batteries.

1.2 Connectors

ECO-Series digital fluorometers use a six-pin bulkhead connector. The pin functions for this connector are shown in Figure 1. Table 1 summarizes pin functions for the bulkhead connectors.

![ECO-DFLxx Connector Schematic](image)

**Figure 1. ECO-DFLxx Connector Schematic**

<table>
<thead>
<tr>
<th>Pin (or Socket)</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ground</td>
</tr>
<tr>
<td>2</td>
<td>RS-232 (RX)</td>
</tr>
<tr>
<td>3</td>
<td>Reset</td>
</tr>
<tr>
<td>4</td>
<td>V in</td>
</tr>
<tr>
<td>5</td>
<td>RS-232 (TX)</td>
</tr>
<tr>
<td>6</td>
<td>DFL, DFLS: analog output</td>
</tr>
<tr>
<td></td>
<td>DFLB, DFLSB: battery output</td>
</tr>
</tbody>
</table>

Input power of 7.5–15 Volts DC is applied to pin 4. The power supply current returns through the common ground pin. The input power signal has a bi-directional filter. This prevents external power supply noise from entering into ECO-DFLxx, and also prevents internally generated noise from coupling out on to the external power supply wire. Data is sent out the Serial Output pin, as described in the Data Format Section.
On the DFL and DFLS, 0–5-volt analog output is measured between pin 6 (analog output), and pin 1 (ground).

1.3 Test Cable
A test cable is supplied with each unit. This cable includes three legs:

1. A power interface module with switched battery power and a switched reset line.
   - The interface module will yield different auxiliary outputs depending on which type of instrument is connected:

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>DFL, DFLS</td>
<td>Analog output</td>
</tr>
<tr>
<td>DFLB, DFLSB</td>
<td>Internal battery voltage</td>
</tr>
</tbody>
</table>

   **WARNING**
   Pin 6 is always “hot.” Be sure to keep the dummy plug on the DFLB and DFLSB when not in use.

2. A DB-9 serial interface connector for plugging into your PC or data logger;
3. A six-socket in-line connector plugs into the sensor to provide power and obtain signal.

DFLB and DFLSB (internal battery units) are supplied with a jumper plug that provides power from the internal batteries for autonomous operation. (Power is supplied from pin 6 to pin 4.)

1.4 Shutter
The DFLS and DFLSB include an integrated non-contact anti-fouling shutter for use in extended deployments. This shutter can be manually controlled by a host controller package, or can perform autonomously as part of a pre-programmed sampling sequence, upon instrument power-up. The rate of closure and opening is dependent upon both temperature and depth.

1.5 Batteries
The DFLB and DFLSB incorporate two 9-volt batteries as their internal power source. They can either use standard alkaline cells for a total capacity of approximately 1000 mA-hrs, or for longer deployments can use LiMnO₂ cells to achieve more than 2000 mA-hrs of operational capacity. Actual total usage time of the internal batteries is a function of several parameters. These include nominal water temperature, sequence timing, sample periods, and total deployment duration.
WARNING!
Do not ship assembled battery packs via commercial airline.

When two or more 9-volt lithium batteries are assembled in the instrument's pressure can, they are classified as Dangerous Goods and do not meet DOT and IATA regulations. They must be disconnected and packaged to prevent accidental shorting.

WARNING!
Pin 6 is always “hot.” Be sure to keep the dummy plug on the DFLB and DFLSB when not in use.

For even greater deployment capability contact WET Labs for information on external battery packs.
2. Theory of Operation

The *Environmental Characterization Optics*, or *ECO* miniature fluorometer allows the user to monitor chlorophyll concentration by directly measuring the amount of chlorophyll-a fluorescence emission from a given sample volume of water. Chlorophyll, when excited by the presence of an external light source, absorbs light in certain regions of the visible spectrum and re-emits a small portion of this light as fluorescence at longer wavelengths. The *ECO* uses two bright blue LEDs (centered at 455 nm and modulated at 1 kHz) to provide the excitation source. A blue interference filter is used to reject the small amount of red light emitted by the LEDs. The blue light from the sources enters the water volume at an angle of approximately 55–60 degrees with respect to the end face of the unit. Fluoresced light is received by a detector positioned where the acceptance angle forms a 140-degree intersection with the source beam. A red interference filter is used to discriminate against the scattered blue excitation light. The red fluorescence emitted is synchronously detected by a silicon photodiode.

**For DFL/DFLS:** Digital and analog formats. The 0–5 VDC output can interface with a digital voltmeter CTD, A/D converter, or other data-logging device.

**For DFLB/DFLSB:** The digital output comes in the form of an RS-232 send data stream.

![Figure 2. Optical configuration of *ECO* fluorometer](image-url)
3. **Instrument Operation**

Please note that certain aspects of instrument operation are configuration-dependent. These are noted where applicable within the manual.

3.1 **Instrument Description**

The standard ECO delivery consists of the following:

- the instrument itself (a small cylinder with a miniature six-pin connector)
- a test cable, configured for quick on-delivery testing of the instrument. It has a well-marked DB-9 connector (pluggable into a PC) and internal 9V battery.
- this user’s guide
- a flash stick for testing the fluorometer
- software for host computer (one CD)
- device file (on floppy disk)
- instrument-specific calibration sheet
- protective cover for optics
- spare parts kit:
  - two end flange o-rings
  - two vent plug o-rings (DFLB and DFLSB only)
  - two jacking screws for connector flange removal (DFLB and DFLSB only)
- DFLB and DFLSB (internal battery models)—Jumper plug for autonomous operation
- DFLB and DFLSB—Three pre-cut segments (7 inches) of 0.036-inch diameter monofilament for end flange
- DFLB and DFLSB—Three pre-cut segments (0.250-inches) of 0.094-inch diameter white nylon bar stock for replacing the white plastic dowel pin
- DFLS and DFLSB (shuttered models)—Allen wrench for shutter removal

The **ECO-DFL** is designed to provide an RS-232 serial interface to a host computer or data logger. It can also provide a 0–5 V analog signal output for integration with a CTD or other data logger.

The **ECO-DLFS** is similar to the DFL, but is shuttered. It can operate by direct control of a host computer or can be programmed for semi- or fully autonomous operation. It can also provide a 0–5 V analog signal output for integration with a CTD or other data logger.

The **ECO-DFLB** is similar to the DFLS except it is powered by internal batteries. It can operate by direct control of a host computer or can be programmed for semi- or fully autonomous operation. Note: 0–5 V output is not available in this configuration.
The **ECO-DFLSB** is similar to the DFLB except it is shuttered. It can operate by direct control of a host computer or can be programmed for semi- or fully autonomous operation. Note: 0–5 V output is not available in this configuration.

### 3.1.1 ECO Host Hardware Requirements

- 90MHz or higher microprocessor
- 640 x 480 VGA or higher resolution screen supported by MS Windows
- MS Windows 95 or later
- 24 MB RAM

### 3.2 Instrument Configuration

To perform a basic operation check, configure the instrument, or run it in a simple bench top configuration, one needs the instrument, a test cable, and a host computer. Insert a test (or patch) cable onto the bulkhead. Be sure to align the pins and then push straight in without wiggling the cable from side to side. To remove the cable, grasp the body of the connector (not the wire) and pull straight out. Many connectors are damaged by rocking the connector from side to side as they are pulled out.

**WARNING!**

Always use a regulated power supply to provide power to ECO sensors if not using the 9V battery provided with the test cable: power spikes may damage the meter.

The **ECO-DFL** is programmable, and as such, is flexible in start up and sampling capabilities. Supplied from the factory, DFL and DFLB models are configured to begin continuously sampling upon power-on. The shuttered models are programmed to perform a single complete measurement cycle. Upon applying power the sensor’s shutter will open, a discreet measurement will occur, and upon completion, the shutter will close and the instrument will return to sleep mode until power is cycled again or it is reconfigured using the ECO Host software.

The **ECO** sensors can be used in a moored or profiling mode, with or without a host computer/data logger. The **ECOs** are versatile instruments, capable of operating under a variety of user-selected settings. Using a host computer and factory-supplied **ECO** Host software will enable the user to take advantage of **ECO** capabilities.

### 3.3 Instrument Setup

1. Install the ECO Host software on the host computer: insert the CD and double-click on the “Setup” file. Once installed, it will reside as “EcoHost” in the programs under Windows “Start” menu.

2. Set the test cable power module switches to “off” and to “WET Labs Host” prior to connecting the test cable to the instrument.
3. Plug the test cable DB-9 connector into the host computer’s serial port and connect the ECO to the test cable.

4. Switch the test cable to the “On Batt” position to supply power to the meter. (If connected to a separate power supply, use “On Aux.” setting.)

5. Start ECO Host. The screen below will appear.

![Figure 3. ECO Host introductory screen](image)

6. Choose ECO Digital Fluorometer, then the computer Comm port the instrument is connected to. Click Apply Quick Setup.

7. The window in Figure 3 will appear. The settings are on the right; on the left is a summary explanation of chosen settings.

**Shuttered Unit Factory Configuration:** Shuttered *ECO* instruments are factory-configured to perform one complete measurement cycle and return to low-power sleep mode until power is cycled again. To communicate or reconfigure a shuttered *ECO* instrument, you must select the Interrupt Autostart button in the ECO Host setup window (Figure 4). Once you have selected this setting the unit will remain active and receptive to commands from ECO Host until powered down. Interrupt Autostart must be selected each time you wish to change the configuration or set up the shuttered *ECO* instrument.
8. **Verify Time and Date Settings**

The first time ECO Host is run on a given computer, the date format will need to be set: go to the Options pulldown menu at the top of the ECO Host window, then Date Format and select your preferred format.

If the meter has been without power for more than 6 hours, the time and date will need to be reset.
9. Verify Sampling and Intervals settings

- **Delay Before Data Blocks (hours):** Number of hours before data acquisition begins.

- **Measurement Smoothing:** Choose from between 1 and 255 data points on the selection slide bar. This will equal a measurement. A popup below will display how many seconds the measurement will take. A higher number yields better resolution, but a slower response time. Optimum setting is 200.

- **Delay Between Measurements (Seconds):** The number of seconds between data point acquisition, not counting shutter open and close times.

- **Number of Measurements per Data Block:** The number of points to acquire in this set.

- **Logger Capacity (% full):** Percentage of total instrument memory capacity used.

  **Note**
  The internal logger can store a maximum of 10,910 entries.

10. Verify Control Bits settings

<table>
<thead>
<tr>
<th>Auto Start</th>
<th>CHECKED</th>
<th>UNCHECKED</th>
</tr>
</thead>
<tbody>
<tr>
<td>**Instrument starts collecting data when power is applied. Note that you will be unable to communicate with the instrument until you select <strong>Interrupt Autostart.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o Instrument will power up and wait for commands.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Log Enabled</th>
<th>CHECKED</th>
<th>UNCHECKED</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data is automatically saved internally in the instrument.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o Data is not saved internally.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wake Up</th>
<th>CHECKED</th>
<th>UNCHECKED</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Instrument will wait for further commands when execution of the current settings is completed.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o Instrument will go to low power sleep mode when current settings are completed.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Append</th>
<th>CHECKED</th>
<th>UNCHECKED</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data will be added to that which the meter has saved internally.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o New data will overwrite previously acquired data.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Interrupt Autostart:** Clicking on this will take you through the steps to stop data collection if the Auto Start box was checked.

When you have input all the desired settings, read the **Expanded Settings Summary** on the left portion of the ECO Host window to verify the settings that will be sent to the instrument when **Apply Settings** is clicked.

**Apply Settings:** Clicking this button in the lower right corner of the screen applies the selected settings. These settings are saved and can be retrieved in the future by selecting **Retrieve Settings.**
11. With desired settings applied, select the third tab on the main window, **Data and Packet Processing** (Figure 5). This window allows you to view raw data as it’s being collected and monitor collection status.

- **DFL Calibration**: Input the instrument-specific values provided on the characterization sheet that shipped with the sensor.
- **Packets Received** is the total packets received by the host since the instrument was turned on.
- **Packets Recorded** represents saved raw data.
- **Append File** allows you to add to, or append, to a previously saved raw data file.
- **Start Logging Raw Data** provides the ability to save raw data files for future use.
- **Run** begins data collection.

![DFLxx Data and Packet Processing window](image)

**Figure 5.** DFLxx Data and Packet Processing window

The flowchart on the following page provides a summary for setting up the DFLxx instrument.
Wait 500 ms.
Check for a
command

Yes

Auto
Start
checked

Yes

Current
instrument
setting

No

Power
On

Ready to accept
commands

No

(Won)

Delay before
data blocks
(hours)

No

One measurement
is comprised of x data
points.

No

Shuttered
Unit

Yes

Open shutter

No

Shuttered
Unit

Yes

Close shutter

No

Wait for the delay
between data points
(seconds)

Yes

Write data
point to
memory

Log
Enabled

Yes

Open shutter

No

Sleep for the delay
between data points
(seconds)

No

Shuttered
Unit

Yes

Close shutter

No

Data points
taken equal
1 data block

Yes

Log
Enabled

No

Place data
terminator in
memory

Yes

Log
Enabled

Wake Up
checked

Yes

Sleep. Do not accept commands
until power is cycled again.
3.4 Testing Output

**Note**

ECO fluorometers are sensitive to AC light. Before making measurement, turn AC lighting off.

Test the instrument’s signal using the flash stick. For best results, perform test in ambient light only (turn off AC lighting).

1. Connect the ECO to a test cable and host computer. Start ECO Host. Select the COM port from the Connection pulldown menu. It is good practice to select Interrupt Autostart to cycle the power to the sensor and ensure no data is lost. Then apply desired settings for continuous operation.

2. Remove the protective cover. In the Data and Packet Processing window, select run.

3. Hold the fluorescence stick 1–4 cm above the optical paths in an orientation that maximizes exposure of the stick. (Parallel with the beams, not intersecting them).

4. Digital output will range from approximately 150–175 (air offset) to 4095 counts.

**Note**

On the DFL and DFLS models you can plug a multimeter into Aux. Out on the test cable box to monitor analog voltage.

5. Analog-capable instruments (DFL and DFLS) connected to a voltmeter will output between approximately 200 mV and 5 volts (5 volts represents saturation).

3.5 Collecting, Viewing, and Saving Data

ECO Host allows you to collect, view, and save both raw and processed data simultaneously. It is recommended you save the raw data file since you will be unable to perform future data analysis without that file.

With the meter connected to a power supply and host computer, supply power to the meter and set up ECO Host as desired.

**3.5.1 Collect, View and Save Both Raw and Processed Data**

**Caution!**

Unless you first select **Start Logging Raw Data**, no data collected will be saved to the computer.
1. Go to the **Data and Packet Processing** window and select **Start Logging Raw Data**; input a filename to save collected raw data to.

2. Go to the **Graphs** pulldown menu and select **Chl Vs. Time**. The output in the **Graphical Output** window will be the processed data (µg/l chlorophyll). If you want to append an existing data file, check the append box.

3. Go to the **Graphical Output** window and select **Start Recording**. Input a filename for saving processed data to.

4. Select Run. Both the raw and processed data will begin being collected and saved. The raw data can be viewed in the **Data and Packet Processing** window and the processed data can be viewed in the **Graphical Output** window. Note that the values appear in the **Output** window but not in the graph area.

5. When you are finished collecting data, select **Stop Logging Raw Data** (**Data and Packet Processing** window) and **Stop Recording** (**Graphical Output** window).

![Graphical Output window](image)
6. Under the Connection pulldown menu, select Close Port. Turn off power to the DFLxx.

7. Both raw and processed data files are saved as tab-delimited ASCII text and can be viewed and graphed in any spreadsheet software such as MS Excel.

3.5.2 Collect, View and Save Raw Data Only

1. Go to the Data and Packet Processing window and select Start Logging Raw Data; input a filename to save collected raw data to.

2. Select Run. The raw data will begin being collected and saved. It can be viewed in the Data and Packet Processing window or graphically in the Graphical Output window: click Start Graphing. Data points appear on the grid. To change the scale of view:
   - Autoscale seeks to provide the best fit to show all data, though the y-axis scale can be changed either by clicking In or Out (similar to a zoom function) or by clicking Min/Max and supplying a range.
   - The scroll bar under the graph area allows you to select the viewing resolution for up to 24 hours.

3. When you are finished collecting data, select Stop Logging Raw Data.

4. Under the Connection pulldown menu, select Close Port. Turn off power to the DFLxx.

5. Both raw and processed data files are saved as tab-delimited ASCII text and can be viewed and graphed in any spreadsheet software such as MS Excel.

3.5.3 Processing Raw Data

ECO Host will convert raw data (counts) obtained during a deployment (or as above during meter checkout) to processed data (µ/l chlorophyll). With the meter connected to a power supply and host computer, supply power to the meter and set up ECO Host as desired.

Caution!

It is strongly recommended you save both raw and processed data. Failure to save raw data files will preclude the ability to perform future data analysis.

1. Be sure the DFLxx meter’s calibration values are entered in the Data and Packet Processing window.

2. Under the Graphs pulldown menu, select Chl Vs. Time. If this is not selected, the data will not be converted from counts to u/l chlorophyll.
3. In the **Graphical Output** window, select **Start Recording** and input a filename for the processed data to be saved to.

4. Select **Download Data from Eco sensor** from under the **Eco Memory** pulldown menu.

5. Select **Open Raw File** and select the file containing the saved raw data. Select the green **Play** button. ECO Host will begin processing the raw data and saving it to the filename you specified in step 3. Processing time is dependent on file size. When processing is complete, the filename at the top of the graph area will display :EOF (end of file) after the filename. **Stop Playing** will change to **Start Playing**, and the **Close Raw File** button will become **Open Raw File**.

6. The processed data is now available for viewing in spreadsheet software. Close the port connection and turn off power supply to DFLxx.

### 3.5.4 Viewing Processed Data in Spreadsheet Software

Viewing either raw or processed data in a spreadsheet such as Excel is straightforward but there are several conversions that need to be made to the date and time.

The data will have a column for time that needs to be converted from Julian to read in standard formats. Divide the value in the time column by 64800 for this conversion. It may be helpful to create an additional column in Excel for the date and time so that upon conversion, the original column data stays intact.

### 3.6 Deployment

Depending upon your specific deployment requirements you may need to configure the instrument settings before deployment. The host software operations are reviewed in the previous section. How the instrument is configured depends upon your system and objectives, however as a general guide for different deployment options we provide the following information for assuring that your instrument is configured properly.

**Periodic operation with storage**—You must have a host computer to configure this mode. If using ECO Host Software, select the following settings to reset the memory:

1. In the **Main** window, **Control Bits** area:
   - **Log Enabled**: On
   - **Append**: either Off or On
2. Press **Apply Settings**. This will reset the Data Points to 1.

To configure data acquisition settings:

1. In the **ECO Setup** window, **Control Bits** area:
2. In the ECO Setup window, Sampling and Intervals area:
   - Delay Before Data Blocks: user defined
   - Samples per second: 1 (recommended)
   - Delay between Data Points: user defined
   - Number of Data Points per Data Block: user defined, between 1–65535.

*Internal battery operation with periodic sampling and storage*—See above. If you expect more than an 8-hour delay before deployment, set delayed start parameter to appropriate time interval.

**Note**
The clock can only hold its setting for approximately eight hours without power being applied to the instrument.

### 3.6.1 Mounting the Instrument

The *ECO* fluorometer requires no pumps to assure successful operation. Once power is supplied, the unit is ready for submersion and subsequent measurements (Depending upon software setup configuration.) Some consideration should be given to the package orientation. Do not point the sensor face directly into the sun or other bright lights.

Other than these basic considerations, one only needs to make sure that the unit is securely mounted to whatever lowering frame is used and that the mounting brackets are not damaging the unit casing.

**Note**
*ECO*-DFLB and -DFLSB units only:
Always check vent seal plug for full insertion immediately prior to deployment.

### 3.7 Shutter Operation

The *ECO*-DFLS and -DFLSB are provided with a non-contacting anti-fouling shutter. The shutter extends the possible deployment duration by retarding biological growth on the instrument’s optical surface. The shutter covers the optical surface while the instrument is in “sleep” mode. When the meter wakes up, the optical surface is exposed by the shutter’s clockwise rotation.

If power is shut off in mid cycle, the shutter will reinitialize when power is applied again.
- If the instrument was preparing to take a sample, that process will continue—a sample will be taken and the shutter will rotate to a stop over the optics.
• If the instrument had just completed taking a sample, the shutter will continue rotating to the closed position, take another sample, then rotate around to stop over the optics.

3.7.1 Shutter Cleaning and Maintenance
When not in active sample mode, the shutter can be removed by loosening the set screw that attaches the shutter to the instrument. Take care to ensure no unnecessary torque is placed on the axle.

To clean, wash in soapy water, rinse and dry thoroughly. Note the condition of the copper plate on the instrument side of the shutter. When it shows signs of corrosion and pitting, it needs to be replaced. (Please call the factory for a replacement.)

When replacing the shutter back on the instrument, slide the shutter onto the axle shaft until it rests on the axle shoulder protruding approximately 0.5 mm from the sensor face.

**WARNING!**

Do not try to make the shutter contact the instrument face.

The shoulder is designed to maintain the proper distance between the shutter and the optics—the shutter should not touch the instrument. It should be aligned to cover the optics to the maximum extent possible. Again, take care to ensure no unnecessary torque is placed on the axle.

3.8 DFLB and DFLSB: Using Internal Batteries

**WARNING!**

Do not ship assembled battery packs via commercial airline.

When two or more 9-volt lithium batteries are assembled in the instrument’s pressure can, they are classified as Dangerous Goods and do not meet DOT and IATA regulations. They must be disconnected and packaged to prevent accidental shorting.

ECO sensors powered with internal batteries can either run directly from the internal batteries or can operate from power supplied by an external DC power supply (7–15 Volts). Internal-to-external source conversion is facilitated by a jumper plug that plugs into the unit’s bulkhead connector. When inserted, the plug forms a connection from the battery to the electronics power supply. By removing the plug, the instrument can be powered and communicate via a test or deployment cable. Setup conditions, instrument check-out, real-time operation, and data downloading are thus
all achieved identically to the methods prescribed for the DFL and DFLS units. Once programmed, you must plug in the jumper plug within eight hours to preserve clock settings.

3.8.1 Procedure to Replace Batteries

**WARNING!**

Changing the batteries will require opening the pressure housing of the ECO sensor. Only people qualified to service underwater oceanographic instrumentation should perform this procedure. If this procedure is performed improperly, it could result in catastrophic instrument failure due to flooding or in personal injury or death due to abnormal internal pressure as a result of flooding.

WET Labs Inc. disclaims all product liability from the use or servicing of this equipment. WET Labs Inc. has no way of controlling the use of this equipment or of choosing qualified personnel to operate it, and therefore cannot take steps to comply with laws pertaining to product liability, including laws that impose a duty to warn the user of any dangers involved with the operation and maintenance of this equipment. Therefore, acceptance of this equipment by the customer shall be conclusively deemed to include a covenant by the customer to defend and hold WET Labs Inc. harmless from all product liability claims arising from the use and servicing of this equipment. Flooded instruments will be covered by WET Labs Inc. warranties at the discretion of WET Labs, Inc.

1. Removing connector end flange:
   a. Dry off instrument thoroughly.
   b. Unplug battery jumper connector.
   c. With connector end flange pointed downwards away from face, release seal vent plug.
   d. Remove moisture from vent plug area.
   e. Using filament extraction tool, remove filament.
   f. Using jacking screws provided with sensor, lift flange from pressure can until seal is broken.
   g. Remove excess moisture from flange–can seal area.
   h. Carefully remove flange until access to Molex connector is gained.
   i. Unplug Molex connector.

2. Removing and replacing old batteries:
   a. Remove three screws that hold fast the batteries.
   b. Replace batteries.
   c. Re-fasten screws.
   d. Plug in Molex connector. Sensor operation can now be tested if desired.

3. Checking vent plug, changing O-rings:
If there is fouling on the vent plug, it should be cleaned and the two 010 O-rings replaced. Otherwise, this mechanism should be maintenance-free.

**WARNING!**

The pressure can is made of plastic material that scratches easily. Do not let the screwdriver slip and scratch the can when removing or replacing the vent plug. Use a toothpick (something softer than the plastic) to remove the O-rings from the vent plug.

a. Pull vent plug out about half way; hold plug while unscrewing the truss screw. When screw is removed, pull vent plug from end flange.
b. “Pinch” bottom O-ring around vent plug to form a small gap you can work a toothpick into. Use the toothpick to help roll the bottom O-ring off the plug.
c. Perform the same procedure with the top O-ring.
d. Clean the vent plug using a dry lint-free tissue or cotton swab.
e. Clean the vent plug hole in the end flange as in step d. above.
f. Lightly coat two undamaged or new O-rings with silicon grease. Install the top O-ring (nearest to large end of plug) first, then the bottom one.
g. Insert vent plug into its hole in the end flange and hold it while inserting the truss screw. Rotate the vent plug to begin tightening the screw. Finish tightening using a screwdriver, being careful not to overtighten truss screw.

**Note**

A portion of the truss screw head has been removed to allow for venting in case of pressure buildup.

4. Replacing end flange:

**Note**

Make sure end flange and pressure can are dry before proceeding with end flange replacement.

a. With Molex connector unplugged, remove O-ring from end flange, inspect for nicks and tears, clean and apply a spare coating of O-ring grease.

**WARNING!**

Do not use O-ring if scratched or torn.

b. Clean O-ring groove and seating surface in the can.
c. Re-apply O-ring onto flange.
d. Re-plug Molex connector.
e. Purge can with dry nitrogen or argon.
f. Replace end flange and re-insert filament. Replace with spare monofilament if damaged or flattened. Take care not to pinch the O-ring.
g. Ensure the vent plug on the end flange is 180 degrees (opposite) from the white plastic dowel in the pressure housing. If the dowel is damaged, replace with spare (white nylon bar stock that shipped with instrument).
h. Pull the vent plug out to vent any residual pressure, then push it back in, ensuring it is firmly seated.

3.9 Upkeep and Maintenance
The ECO-DFLxx are compact devices and their maintenance can be easily overlooked. However, the DFL is a precision instrument and does require a minimum of routine upkeep. After each cast or exposure of the instrument to natural water, flush the instrument with clean fresh water, paying careful attention to the sensor face. Use soapy water to cut any grease or oil accumulation. Gently wipe clean with a soft cloth. The sensor face is composed of ABS plastic and optical epoxy and can easily be damaged or scratched.

WARNING!
Do not use acetone or other solvents to clean the sensor.

At the end of an experiment, the instrument should be rinsed thoroughly, air-dried and stored in a cool, dry place.
4. Data Analysis

Data from the ECO fluorometer, whether digital or analog, represents raw output from the sensor. Applying linear scaling constants, this data can be expressed in meaningful forms of chlorophyll fluorescence. Refer to Section 3.5.3, “Downloading Data or Retrieving Files” for details of data collection format and retrieval.

4.1 Analog Response

The ECO-DFLxx response is linear over the measurement range provided. The instruments have a measurement range of approximately 0.02 to 100.0 µg/l. Because of the varied environments in which each user will work, it is important to do calibrations using similar sea water as you expect to encounter in situ. Please refer to characterization section for further details. This will provide an accurate blank, equivalent phytoplankton types and similar physiological conditions for calculating the scale factor, thereby providing an accurate and meaningful calibration. Once a zero point has been determined and a scale factor established, the conversion of DC volts to chlorophyll concentration is straightforward using the equation:

\[
[\text{Chl}]_{\text{sample}} = (V_{\text{sample}} - V_{\text{blank}}) \times \text{Scale Factor}
\]

where  
- \([\text{Chl}]_{\text{sample}} = \text{Concentration of a chlorophyll sample of interest (µg/l)}\)
- \(V_{\text{sample}} = \text{voltage output when measuring a sample of interest (VDC)}\)
- \(V_{\text{blank}} = \text{measured signal for a sea water blank (VDC)}\)
- \(\text{Scale factor} = \text{multiplier in µg/l-volts}\)

A scale factor is then applied to the analog output signal to provide the direct conversion of the analog output voltage to chlorophyll concentration.

A scale factor is supplied from the factory. While this constant can be used to obtain approximate values, field calibration is highly recommended.

4.2 Digital Response

Digital data is processed in a similar fashion to analog data. Scaling is linear, and obtaining a “calibrated” output simply involves subtracting a digital offset value and multiplying the difference by the instrument scaling factor.

\[
[\text{Chl}]_{\text{sample}} = (C_{\text{sample}} - C_{\text{blank}}) \times \text{Scale Factor}
\]

where  
- \([\text{Chl}]_{\text{sample}} = \text{Concentration of a chlorophyll sample of interest (µg/l)}\)
- \(C_{\text{sample}} = \text{Raw counts output when measuring a sample of interest (VDC)}\)
- \(C_{\text{blank}} = \text{Measured signal in raw counts for a sea water blank (VDC)}\)
- \(\text{Scale factor} = \text{multiplier in µg/l-volts}\).
5. Characterization and Testing

Prior to shipment, each ECO is characterized to ensure that it meets the instrument’s specifications.

5.1 Testing

When the instrument is completely assembled, it goes through the tests below to ensure performance.

5.1.1 Pure Water Blank

Pure, de-ionized water is used to set the “zero” voltage of the meter. This zero voltage is set for 150 counts (+/-50) on all models.

5.1.2 Pressure

To ensure the integrity of the housing and seals, ECOs are subjected to a wet hyperbaric test before final testing. The testing chamber applies a water pressure of at least 50 PSI.

5.1.3 Mechanical Stability

Before final testing, the ECO-DFLxx meters are subjected to a mechanical stability test. This involves subjecting the unit to mild vibration and shock. Proper instrument functionality is verified afterwards.

5.1.4 Electronic Stability

This value is computed by collecting a sample once every 5 seconds for twelve hours or more. After the data is collected, the standard deviation of this set is calculated and divided by the number of hours the test ran. The stability value must be less than 2.0 mV/Hour.

5.1.5 Noise

The noise “figure” is computed from a standard deviation over 60 samples. These samples are collected at one-second intervals for one minute. A standard deviation is then performed on the 60 samples, and the result is the published noise on the calibration form. The calculated noise must be below 2 mV.

5.1.6 Voltage and Current Range Verification

To verify that the ECO operates over the entire specified voltage range (7–15 V), a voltage-sweep test is performed. ECO is operated over the entire voltage range, and the current and operation is observed. The total power consumption (voltage times current) must remain below 600 mW over the entire voltage range.
6. General Terminal Communications

While WET Labs supplies a host software package for instrument configuration and data retrieval, the unit sensors can be controlled from a terminal emulator or customer-supplied interface software. This section outlines hardware requirements and low-level interface commands for this type of operations.

6.1 Interface Specifications

6.1.1 Communications Settings
- baud rate: 9600
- data bits: 8
- parity: none
- stop bits: 1
- flow control: none

6.1.2 IO Pin Assignments
See Section 1.2 for connector pin IO assignments.

6.1.3 Using the Test Cable
Set the test cable switch to “Term” (unconnected) when using a terminal program. Most of these do not allow direct control of the “DTR” line, but hold it high instead. This will hold the instrument in a reset condition and no interaction will be possible. When this line is brought high, it forces the internal microprocessor to reboot from its firmware. This allows for the interruption of instrument execution without cycling power. Holding this line high leaves the microprocessor rebooting continuously. WET Labs-supplied test cables have a switch to make or break this connection. Break the connection (set switch to “Term”) when using a terminal program. Set switch to “WET Labs Host” when using the ECO-Host program.

6.2 ECO Command List and Data Format

If the auto-start bit is set (discussed in detail later), the instrument will automatically begin operation one-half second after power is applied. The output in this mode will depend upon the instrument’s internal settings.

If the auto-start bit is not set, the instrument is ready for interaction after power is applied. A properly connected and configured terminal program will show a display similar to the following:

```
F3.12sim
>
```

The “F” indicates that this is a fluorometer. “3.12sim” is the firmware version number. The greater-than symbol, “>” indicates the instrument is ready for a command.
The commands the instrument recognizes are:

!!!!!
Stops data collection; allows user to input setup parameters.

r run
Causes the execution of the current setup.

p print
Displays the current settings. More detail will be supplied in a separate section.

o output
Initiates data transfer from the instrument's internal memory to the host. Each set is terminated by “65535” on a line by itself. The format is tab delimited text, with the values being DATE, TIME, VALUE. This format is also the same sent out the serial port during instrument operation.

u update
Allows the input of the date and time. Date format is mmddyy, such as 081299 for August 8, 1999. Once “u” is entered the instrument responds with “d.” When the 6 characters of the date have been entered, the time prompt appears “t.” The entered time format is hhmm, in 24-hour (or military) time. The instrument has an internal back up, and will hold time and date for approximately 8 hours with no power applied.

c clock
Displays the instrument’s current date and time in its internal format, separated by a tab. The instrument uses a julian-type date and time. The date is an Excel date format, the displayed time number, when divided by 64800 will give an Excel time format (fraction of a day). For example, “36384 46125” translates to “8/12/99 17:05:00.” Timing resolution is approximately 1.3 seconds.

b bits
Sets the instrument’s 6 control bits. Entering “b” causes the instrument to respond with “SGALWM.” This is the order in which the bits (zero or 1 for each) must be entered.

S  Start bit
“1” in this location will cause the instrument to begin executing the current setup one-half second after power is applied.
“0” will cause the instrument to await commands when power is applied.

G  currently reserved; should be set to “0”
A  currently reserved; should be set to “0”
**L Logging**
“1” in this location will cause the instrument to log data to internal memory as well as send it out its serial port. The internal storage is non-volatile. It will remain intact when instrument power is turned off.
“0” will prevent the instrument from logging data internally.

**W Wake-up**
“1” in this location will cause the instrument to return to command receiving mode when it finishes executing the current settings.
“0” will cause the instrument to drop into a low-power sleep state when it has finished executing the current settings.

**M Append**
“1” in this location causes the instrument to append new data to old when logging internally.
“0” will cause each new data set to be written over the old. Each auto-execution or “run” command is considered a “set” for this purpose.

**t time constant**
Sets the number of samples to average for one data point. The valid range is 1 to 255. Higher numbers will cause slower instrument response. Two hundred is normal for a fluorometer.

**d delay**
Sets the time in hours for the instrument to wait before executing its settings. Usually set to 0.

**q quantity**
Sets the quantity of data points to be acquired for each single execution. Valid range is 0 to 65535. 0 (zero) is a special case; this will cause the instrument to continue acquiring data until power is removed or the “reset” line is asserted.

**i interval**
Sets the time interval (in seconds) between data points when multiple points are requested. Valid range is 0 to 65535.
6.2.1 Settings display
When “p” is pressed, the instrument’s current settings are displayed in the following format:

S 0
G 0
A 0
L 0
W 1
M 1
T 30
D 0
Q 200
I 0
MP 316
>

All values correspond to the initials used when entering the settings with the exception of “MP.” This is a “memory pointer,” showing the location where the next data set will be recorded. The last memory location used is 65525. Dividing the MP number by 65525 indicates the percentage of storage space currently used. Once all storage space is used, the instrument will cease to record data internally, but will continue to send it to the serial port. To overwrite existing data, set the “M” bit to zero (press “b” at the prompt and then put a 0 in the sixth location when entering the control bit settings.)

6.2.2 Normal operation
When instrument settings are satisfactory, press “r” to execute these settings. If the unit has a shutter, it will open and close as needed. If the quantity of data points is set to “1,” then the sequence for a shuttered unit would be: shutter opens (~8 sec.), measurement taken and sent to the serial port, shutter closes (~8 sec.).

6.3 Data Format
The RS-232 data output directly from the instrument is tab delimited ASCII text with the following format:

- The first column is an MS Excel-format julian date.
- The second is a numerical time value. Dividing this value by 64800 yields an MS Excel-format time (fraction of a day). A row is of data is terminated with a carriage return and line feed. A “>” character indicates the instrument is awaiting instructions. A “!” character indicates the instrument has entered its low power sleep state. In shuttered units, these are not sent out until the shutter has completed its closing motion, and can thus be used as a shutter closed confirmation.
The TTL data output is fixed length ASCII text with no delimiters, and has the following format:

- The first 5 characters are an Excel format julian date.
- The next 5 characters are a numerical time value. Dividing this value by 64800 yields an MS Excel-format time (fraction of a day).
- The next 4 characters are the signal measurement in raw counts. A “.” indicates the instrument has completed its instruction set and, if a shutter is present, that the shutter is now closed.

**Note**

The internal logger on a digital fluorometer can store a maximum of 10,910 entries.
## Revision History

<table>
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<th>Date</th>
<th>Revision Description</th>
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<td>A</td>
<td>12/07/99</td>
<td>New document</td>
<td>C. Moore, W. Strubhar, H. Van Zee</td>
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<td>B</td>
<td>12/08/99</td>
<td>Revise Operation Section per trial run</td>
<td>W. Strubhar</td>
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<td>C</td>
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<td>Correct pinouts (DCR 27)</td>
<td>D. Whiteman</td>
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<td>D</td>
<td>09/11/00</td>
<td>Add vent plug maintenance steps (DCR 55)</td>
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<td>Add lithium battery warning (DCR 65)</td>
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<td>H</td>
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<td>I</td>
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<td>Correct connector pin references (sections 1.2 and 1.3) (DCR 110)</td>
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<td>Add spare monofilament and plastic bar stock to shipping list (DCR 146)</td>
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