OPTICAL PHYTOPLANKTON DISCRIMINATOR (OPD) USER GUIDE

HIGH PRESSURE MODEL

VERSION 1.4 FEBRUARY 11, 2011

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Section 1: General Information

1.1 General Description

The Optical Phytoplankton Discriminator (OPD) is an electronic instrument that measures for the presence of algal organisms from their optical absorbance characteristics. This is accomplished by pumping a water sample through a Liquid Waveguide Capillary Cell (LWCC), illuminating it with a light source, and measuring the resulting light absorption spectra. A single measurement cycle takes typically 5 minutes but may require as long as eight minutes. The interval between cycles is programmable from continuous [zero interval] to several hours.

There are currently two models of the OPD instrument. A low-pressure model that is designed for shallow deployments and a high-pressure model designed for AUV, vertical profiler or towed deployments (100 meters maximum depth). Typically also integrated into the AUV deployed model is a Sea-Bird Electronics, Inc. CTD instrument which operates entirely independently of the OPD instrument.

After each cycle an OPD data report is logged internally and is sent to a host computer or any telemetry system that supports serial data communications. In the typical case of AUV deployment in a Webb Research Corp. electric glider, the host computer is the science bay Persistor computer.

The OPD is designed, once started, to operate autonomously [NOHOST mode] or under the step-by-step control of a host [HOSTED mode]. There are a number of user settable parameters that are used by the program to set the operating mode, sample the water, acquire spectral data, analyze the data, calculate a phytoplankton similarity index, and to log and report the results. This manual will guide the user for basic functions of the instrument.

1.2 Specifications

Mechanical:

Weight (in air)	13 kg
Diameter	21 cm [excluding CTD probe]
Length	30 cm
Depth Limit	70 meters maximum

Electrical:

Voltage	12v DC
Current	600 mA average while sampling
Current	50 mA while in sleep mode between cycles

1.3 Contents of Shipping Case

- OPD instrument
- Spare parts kit
- Power supply, wall plug
- Power switch box with cable
- Sample port flush fittings [2]
- OPD HP User Manual

Section 2: Operations and Maintenance

PREPARATION FOR DEPLOYMENT

Prior to deploying the OPD, two preparatory tasks are required.

- The Optical Phytoplankton Detector is shipped with 2 internal fluid reservoirs, the CDOM Reference water supply bag and CDOM Reference waste fluid bag. The supply reservoir needs to be filled and the waste reservoir emptied prior to deployment.
- Water samples are collected in a series of syringes driven by a syringe pump. Air that has entered the sample lines during shipping or storage needs to be removed before operation.

To accomplish these tasks the hull must be removed for access.

2.1 OPD Internal Access

1. Place the instrument vertically on a surface with the CTD ring facing down. Rest it on supports or blocks to avoid damage to cables.
2. A 9/64” Allen wrench is needed to remove the sample ports. ***[Note: See appendix J if your OPD is configured for a TRW-Webb Research G2 model glider, and do not remove the sample ports]

3. Remove both screws from each sample port. Remove the transparent cover, copper mask, and screen mesh filter element, leaving the black plastic filter base on the instrument. The filter base is attached to tubing. Separate the filter base from the instrument by carefully prying it away from the ring while drawing a short length of orange tubing thru the ring opening.

4. Using pliers grip the end of the tubing-to-port nut above the o-ring and turn the sample port base counterclockwise to unscrew it from the fitting. Remove base.

5. The yellow tubing ferrule and orange Peek ™ tube are now exposed. Using a flat head screwdriver, lightly separate the stainless steel compression ring from the ferrule.

Note: When removing the metal compression ring, note its orientation. The flattened end of the ring must face towards the nut; the narrow sharp-edged end of the ring must face towards the yellow rubber ferrule. This is very important since they play a key role in maintaining a proper water-tight seal of the instrument and the AUV.

6. Pull off the yellow ferrule then the stainless steel compression ring then the tubing-to-port nut and set aside. Pull the free end of the orange Peek ™ sample tube back through the hole in the ring being careful not to kink the tubing.

7. Repeat these steps to remove the other sample port and tube.
8. Use a ½ inch box wrench to unscrew the hex nuts that secure the aft ring.
9. Locate the semi-circular recesses on upper ring and use the hull separator tools, supplied with your AUV, by twisting back and forth to release the removable ring from the hull.

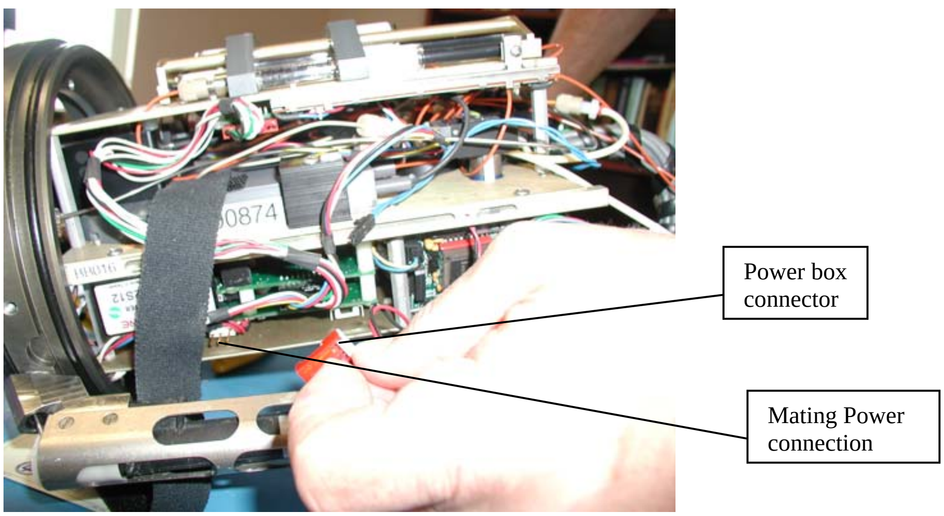
Recess,
1 of 2

10. Remove the hull from the CTD ring.

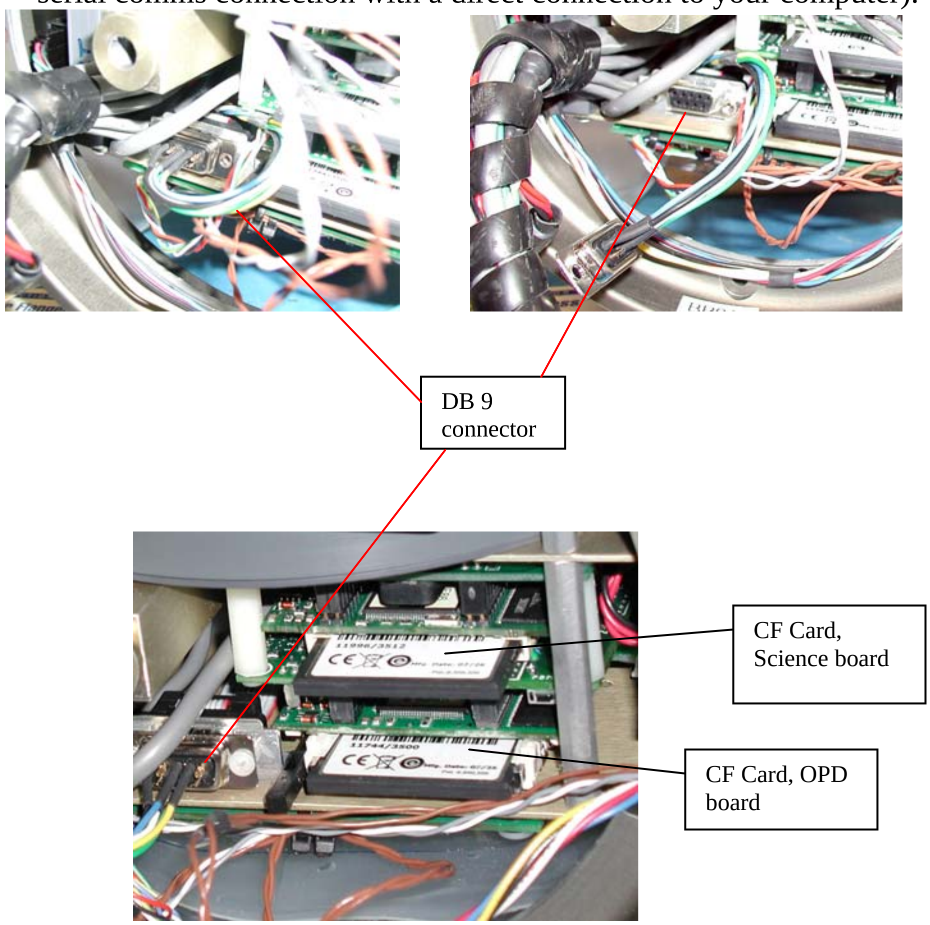
Velcro strap

2.2 Connections and Establishing Communications

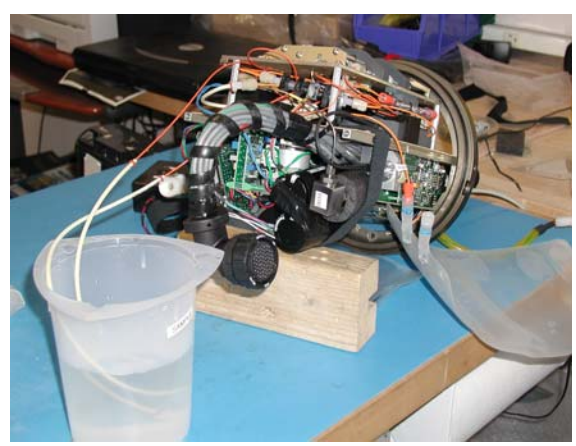
1. Remove Velcro strap holding the CDOM reservoir bags.
2. Place the OPD on its side with the syringe side up and leave the bags connected to the tubing.
3. Locate the OPD power connector shown below, and unplug the power cable from it. Leaving the power switch turned OFF, connect the power box and power supply to the OPD power connector.

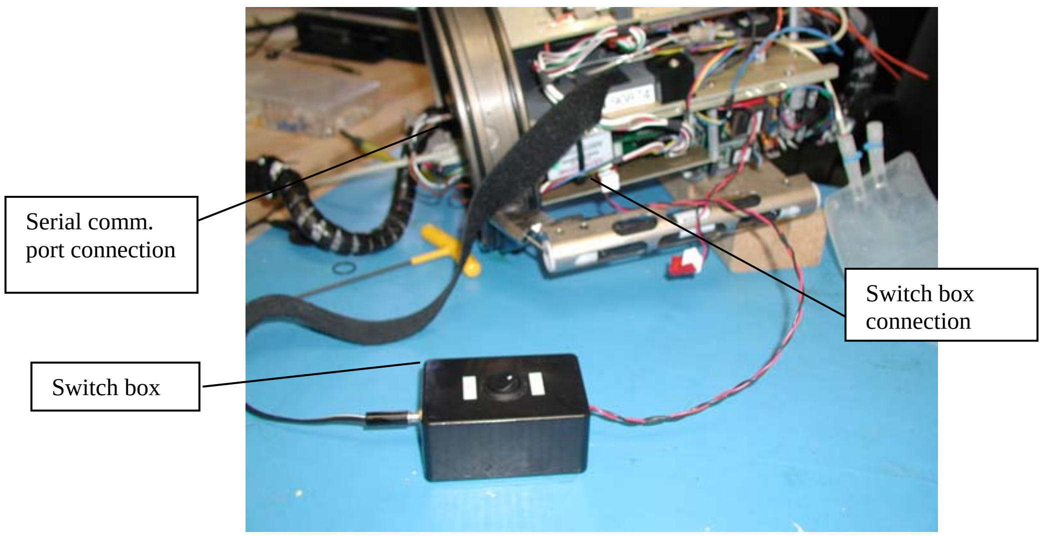


4. Find the RS-232 serial comm. port, near the compact flash cards on the end of the instrument. Disconnect, and connect a DB-9 serial comms cable from your computer to the port attached to the plate. (This step replaces the Science board serial comms connection with a direct connection to your computer).



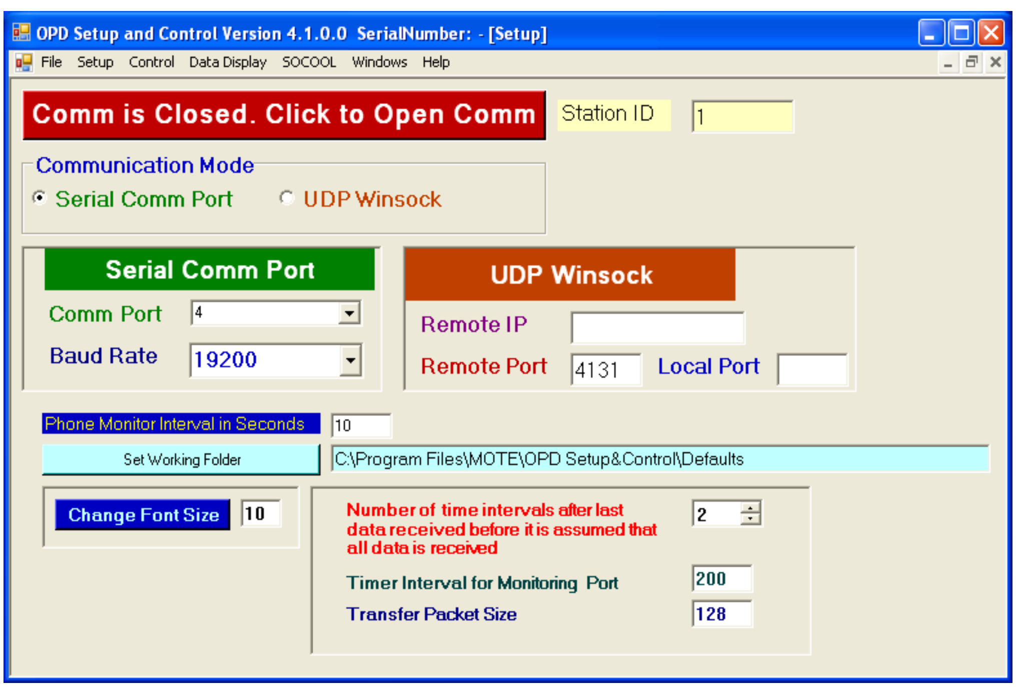
5. Connect extension tubing to the OPD sample port tubes. Submerge the extenders in a water sample container.





Note: If you have not already done so, refer to Appendix E and install the *<u>OPD Setup and Control</u>* *program on your computer.*

6. Open the OPD Setup and Control Program. The setup page appears on screen.



7. Choose the appropriate **Serial Comm Port** corresponding to the computer port that you earlier connected to the OPD.

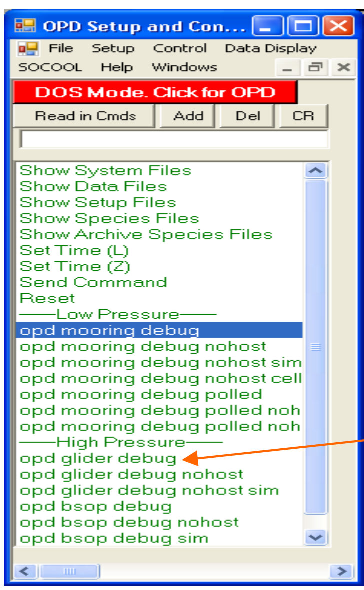
8. Set the Baud Rate to 19200.
9. Click on **Comm is Closed. Click to Open Comm**. The box will turn blue. **Comm is Open. Click to Close Comm**

10. In the tool bar, click Control. If the serial port opened successfully, the cursor on the main part of the screen will be blinking.
11. *** Before applying power to the instrument, note that if it has been powered down for over 10 hours you may experience a delay of as long as 30 seconds after first applying power until you see a serial comms response**:** the C:\ prompt. Please wait patiently with power applied while the power fail buffer capacitors are charged.Turn power on to the instrument through the switchbox. . ***Warning: once the instrument is powered on it should never have power removed unless the OPD program has logged off and you are returned to the C:\ prompt.
12. Below is the main header and C: prompt in PicoDOS mode that appears in the text dialog center portion of the Control screen when the Persistor processor starts up:

Persistor CF2I5 SN 01944 PicoDOS V4.02r1 PBM V4.00
(C) 1998-2005 Persistor Instruments Inc. - www.persistor.com

C:\>

…… indicating that the OPD instrument is now up in PicoDOS, i.e. “DOS Mode”, and ready to run a program. The program that you will run is named OPD.PXE or OPD.RUN, PicoDOS executable programs.



In Dos Mode, choose the appropriate program for the type of unit involved. When working with a High Pressure unit, under the High Pressure submenu, select **opd glider debug**. This selection opens the OPD program in Glider Mode.

Once the OPD program runs, a message will appear on screen:

C:\>opd glider debug
Voltage after Init() is:
12.990506 volts.
10/14/09 13:13:29
Ready

The OPD instrument is now ready to run a cycle

10. Click on **DOS Mode.Click for OPD**. When selected the box turns blue. **OPD Mode. Click for DOS**

Now, the OPD mode command list is populated on the left side of the screen. If a cycle is running, under the section **---Sampling ---** , select the **STOP** command.

2.3 OPD Commands

Note: the OPD menu commands are executed immediately once single-clicked on. To avoid problems, do not click on a command unless certain of its function.

In OPD mode, the following basic commands appear in the left menu:

Command	Definition
Sampling	
Start	Starts a run based on setup parameters.
Stop	Stops the currently running cycle. After some delay the screen will read "Stop Requested". STOP will also bring the unit out of sleep mode.
Exit	Closes Log files and shuts down OPD. Returns to PicoDOS. The screen will say "Log file closed". EXIT will also bring the unit out of sleep mode.
Status	Reports the status message after a cycle in polled mode.
Setup	
cycles to do	This sets the number of sample cycles per run. . A value of "0" means an infinite number of cycles. The value of "1" means one cycle will run, the value of "2" means two cycles will run etc…
cycle time	Number of minutes between cycle starts.
Set time to local	Sets time to local time
Set time to GMT	Sets time to Greenwich Mean Time
Disc repeat rate	Number of times the discriminate measurement is repeated in a cycle. If 1 is entered then it will do a total of 2 discriminate measurements per cycle
Messages on	Turns on Debug text reporting output to the console
Messages off	Turns off Debug text reporting output to the console
CDOM ref interval	Designates the cycles at which a CDOM reference measurement is taken. e.g. CDOM Ref Interval=9 would apply to cycle #'s 1, 9, 18, 27, etc…
CDOM ref flush time	Number of seconds that the CDOM reference pump and Sample pump will run in a cycle.
CDOM ref supply	Amount of CDOM ref fluid, ml, left in the CDOM ref supply bag.
CDOM reference on	Turns CDOM ref part of measuring cycle on
CDOM reference off	Turns CDOM ref part of measuring cycle off
SetDiscFlowTime	The number of seconds of sample pump operation in the Discriminate portion of the cycle, range 0-60 sec
Reports	
Sampling Setup	Reports the current sampling configuration settings. By selecting Sampling Setup the user can view the current parameters set in the unit.
Sensors Report	Reports serial number of unit, firmware version, bypass pressure value, battery voltage, sample syringe pump position, depth, leak status, end of travel status, port select valve position, CDOM reference mL remaining, and time.

Basic HP OPD Commands

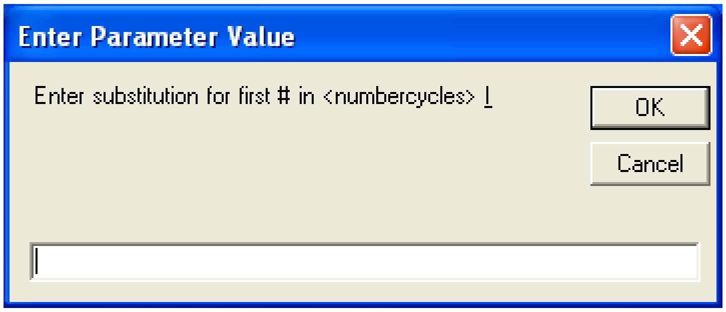
Command	**Definition**
Shutter Open	Opens the D2 light source shutter
Shutter Closed	Closes the D2 light source shutter
Lights on	Turns the D2 light on (tungsten and deuterium sources)
Deuterium on	Turns only the Deuterium light source on
Tungsten on	Turns only the Tungsten light source on
Lights off	Turns all lights off
Select Filter	Selects Filter channel for water sample
Select Bypass	Selects Bypass channel for water sample
Reference Pump On	Turns CDOM reference pump on
Reference Pump Off	Turns CDOM reference pump off
Sample Pump On	Turns sample pump on
Sample Pump Off	Turns sample pump off
Override On	Sample pump will only run from syringe end stop if override is on
Override Off	After clearing the end of travel optodetector at syringe end stop, turn override off
Reverse Sample Pump	Once syringe pump reaches an end of stroke and parks, this command reverses it and sends it to the opposite end stop.
Set Valve A	Changes sample port selector valve to A port
Set Valve B	Changes sample port selector valve to B port
Valve Toggle	Instructs valve to switch to other port
Status Report	Reports the current OPD status message
LWCC Flush	Makes reference pump run forward and then reverse multiple times. This is used mainly to run cleaning solutions through the system.

Other commands may also appear in your left-hand menu. Additional <opcode> and other advanced commands are listed in Appendix F. These commands should be under the direction of a factory service technician.

11. Once the cycle has stopped, under **---Reports---** click on the Sampling Setup and Status Reports. The settings reported should be validated before initiating actual bench or field measuring cycles. To change the parameters seen in the Sampling Setup or Sensors Reports, under the **-----Setup-----** heading in the left side of the screen, select the parameters to be changed:

A pop-up box for the parameter selected will appear on the screen for entry of the desired value.

Example: cycles to do



Enter a value and click ok.

2.4 Replenishing the CDOM Reference supply

1. Disconnect the luer lock fitting from the fluid bag labeled CDOM Reference supply.

2. To refill, use a luer syringe or tubing fitting that will fit one of the two luer fittings on the bag. The CDOM Reference fluid should be filled from a pre-mixed solution comprised of 3 *parts* of 0.22um filtered water (preferably from the body of water the instrument will be sampling in), and *2 parts* 1N HCl (1 Normal Hydrochloric acid). The maximum volume of fluid the bag can hold once placed in the instrument is 350 mL. Please do not exceed this amount.

3. Remember to manually reset the value of "CDOM Ref Supply mL." to 350 in the OPD parameters.
4. Once fluid has been added, purge the bag of all air, and re-connect to its tube

2.5 Purging Air from the System

1. In the parameter menu in Setup, turn Reference pump on. This will pump CDOM reference fluid from its supply bag to the waste bag by way of some of the instrument's fluid circuits. Operate the pump while watching for bubbles released into the waste reservoir. Operate until the bubbling ends.
2. Select Reference pump off.
3. Select Reverse Sample Pump. The syringe pump will begin to move the syringe plungers pushing fluid and trapped air from two of the four smaller, 2.5 mL, syringes and out of the sample ports. Check for any leaks around the syringes. The pump will move to an end travel point and stop.

   The purpose of doing this is to expel as many air bubbles from the sample syringes as possible. If a bubble is later pumped into the optical waveguide it will reflect nearly all of the light and disrupt the measurement. It is sometimes helpful to incline the instrument just before pumping to encourage air bubbles to rise to the tubing fitting end of the syringes.

Repeat select Reverse Sample Pump. The port selector valve will toggle and the syringe pump will move the syringe plungers in the opposite direction, pushing fluid and trapped air from the other two sample syringes.

Repeat as many times necessary to remove the air.

2.6 Testing and Operating the Instrument

1. To test the instrument run several measurement cycles. Select the command AUV if this is in your command menu. Otherwise, type in the command "AUV" in the command box above the left menu selections, then press enter. This will test for the presence of the AUV.BAT file in the OPD flash card root directory and, if found, will execute the command string "OPD GLIDER NOHOST DEBUG". If this does not occur, replace the AUV.BAT file.

2. Set cycle time to zero, numbers of cycles to 5 and set CDOMreference to On as described in section 2.3.11.

   Once the configuration is set the instrument is ready to run a cycle. Ensure the sample fluid supply is ready, the sample port tubes still immersed, and the Cdomref bags are still connected

3. Click on Start to begin the measurement cycle.
4. As the cycle(s) are in progress, the data displayed on the screen describes the progress of the run. Verify that the sample [syringe] pump operates and moves the syringes through several strokes, interrupted by optical measurements.

Below is an annotated example of a typical cycle session:

```
SN 19 cycle #1 of #0 cycles with cycletime 0
12/20/07 10:57:32
Voltage before starting cycle 1 is: 12.546347 volts.
```

First part of message informs of instrument Serial number, cycle number that will run and total number of cycles, cycle time, date and battery voltage instrument currently has.

```
Adjust integration time.
93 ms:
```

Integration time is the Length of time in msec the spectrometer collects pixels to make the peak value 54000-59000.

```
Pixel 1095 = 59103 , Pixel 703 [440nm] = 37196
84 ms:
```

```
Pixel 1095 = 54417 , Pixel 703 [440nm] = 34266


Valid integration time = 84 ms

Dark:
Pixel 399 = 2455 , Pixel 703 [440nm] = 2400
```

Dark is a Spectrometer measurement run without light. Pixel values will be low compared to other parts of the cycle.

```
CDOM:
Pixel 1095 = 54265 , Pixel 703 [440nm] = 34337
```

In the CDOM measurement part of the cycle the sample is filtered so that CDOM will remain in the water but particles, such as phytoplankton, will have been removed by the filter.
When running a CDOM Ref part of a cycle, a similar message will appear while a sample of the reference fluid from the reservoir is measured for comparison to the water sample values.

```
Discriminate:
Pixel 1094 = 48687 , Pixel 703 [440nm] = 30097
Pixel 1095 = 51542 , Pixel 703 [440nm] = 32185
```

In the Discriminate part of the cycle the raw, unfiltered water sample is measured. In the case above, with Disc repeat=1, two discriminate measurements of the same sample water are made.

*Below is the final report message from the instrument at the end of the cycle. [The parameter descriptions of parts of the Status Message given (*in parenthesis*) are not part of the actual final report].*

```
SerialNumber 27
BatteryVoltage 12.085
BypassPressure 2.343      (Internal filter transmembrane pressure, psi)
Status 200                (Error Status code, see Appendix H)
IntegrationTime 62        (integration Time, msec)
CDOMRefLeft 291.5         (CDOM Ref remaining,ml.)
CycleStartTime 1297376558 (Timestamps)
CycleStopTime 1297376624
AbsorbanceA 0.000         (Absorbance slope),
AbsorbanceB 0.000         (Absorbance intercept)
corr0 -0.15               (Species model used & Similarity Index)
```

Please refer to the Glossary, Appendix A, for more details on Similarity Index and other aspects of the OPD operation.

5. The instrument should run 5 complete measuring cycles with no sleep between, logging a report message at the end of each. Verify no leaks, no sample syringe bubbles, and a low Similarity Index value of 0.2 or less for each cycle.

6. When ready to stop or run another operation, select stop from the sampling listbox. (The stop command will not stop a cycle immediately if you are running a cycle. A stop requested message will appear).

7. Select exit from the toolbar and wait for a message "Log file closed" followed by the command prompt C:\. Power can then be turned off from the switch box.

8. To exit the program, select Close from the File menu.

9. Remove the OPD flash card and inspect the log files in the Results folder as described in section 2.6. Ensure the debug.txt file is not corrupt and that the 5 cycles just run were properly logged.

2.7 Downloading Data Files

In the high pressure model OPD it is much easier to access the Compact Flash memory card than in other OPD models as the card is accessible with the instrument fully assembled. As download of data files requires removing the hull to supply power to OPD and then runs very slowly it's preferred that the user simply use a computer and CF card reader to open the Results folder and read, copy, and erase files by that means.

2.8 Results Folder Files

Saved in the Results folder of the OPD Compact Flash memory card are a variety of files:

1. xxxxxxxx.STT file: Named automatically as SNyymmdd.STT where SN is the units serial number, yy is the year,mm is the month and dd is the day. This file contains all of the status messages of a sampling event. Status messages are described in section 2.4

2. xxxxxxxx.LOG : Named as yymmddss.LOG where yy is the year, mm is the month, dd is the day and ss is the second. The log files contain a mixture of character strings and spectrometer readings. The program OPD Analysis is available from Mote for viewing and interpreting log files.

4. DEBUG.TXT is a text file record of every step of the measurement cycles, commands received, error messages, status messages, etc. logged and timestamped as the instrument operates. The file is best viewed with the Windows WORDPAD program.

Example of data displayed in a DEBUG.TXT file:

```
SN 17 cycle #1 of #0 cycles with cycletime 0
```

```
11/28/07 20:52:52
Voltage before starting cycle 1 is: 12.546347 volts.

Adjust integration time.
93 ms:
Pixel 1095 = 59103 , Pixel 703 [440nm] = 37196
84 ms:
Pixel 1095 = 54417 , Pixel 703 [440nm] = 34266
Valid integration time = 84 ms
Dark:
Pixel 399 = 2455 , Pixel 703 [440nm] = 2400
CDOM:
Pixel 1095 = 54265 , Pixel 703 [440nm] = 34337
Discriminate:
Pixel 1094 = 48687 , Pixel 703 [440nm] = 30097
Pixel 1095 = 51542 , Pixel 703 [440nm] = 32185
SerialNumber 27
BatteryVoltage 12.085
BypassPressure 2.343
Status 200
IntegrationTime 62
CDOMRefLeft 291.5
CycleStartTime 1297376558
CycleStopTime 1297376624
AbsorbanceA 0.000
AbsorbanceB 0.000
corr0 -0.15
```

4. current.log & tmp.log : These are active back up copies of the primary log files.

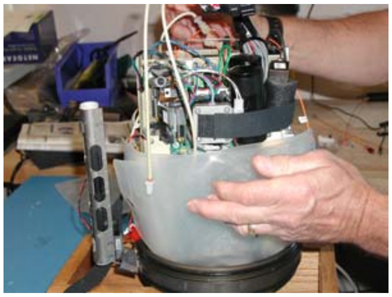
2.9 Filter Replacement

The hollow-fiber filter used in OPD has a maximum rated trans-membrane pressure of 15 psi. The parameter `ByPass Pressure` reports that pressure across the filter in the Status Message for every cycle. After many cycles, bypass flushing and CdomRef cleaning will still leave the filter membrane permeability too low. It must be replaced at or before the pressure exceeds rating during operations. A spare filter has been included in your spare parts kit. See Appendix B for replacement parts information.

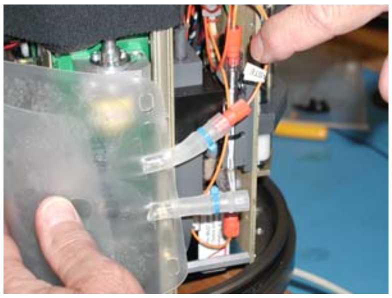
2.10 Reassembling OPD

1. Reconnect the DB-9 connector from OPD to Science and reconnect the OPD power cable to its connector as depicted in section 2.2.

2. Place CDOM reference bags inside the CTD ring.



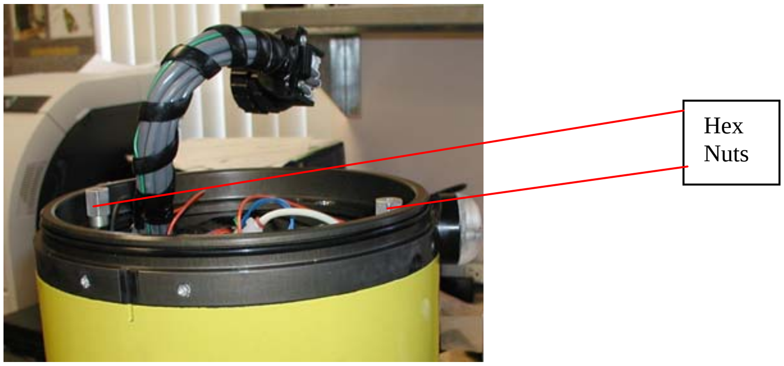
3. Make sure the tubing will not be crimped or pinched when replacing the hull.



4. Fasten the Velcro strap to hold the fluid bags in place.

5. Replace the hull. Aligning the engraved index marks on the upper and lower part of the hull with the ring index marks will assure bolt hole alignment for the aft ring.

Index
marks

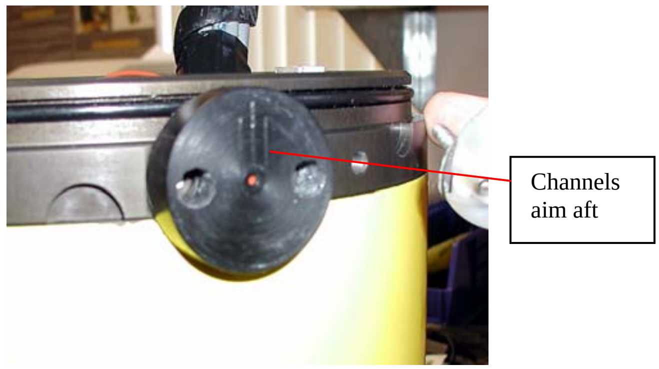


6. Replace the aft ring. Secure it to the chassis frame with the hex nuts removed earlier. Apply only a light torque.

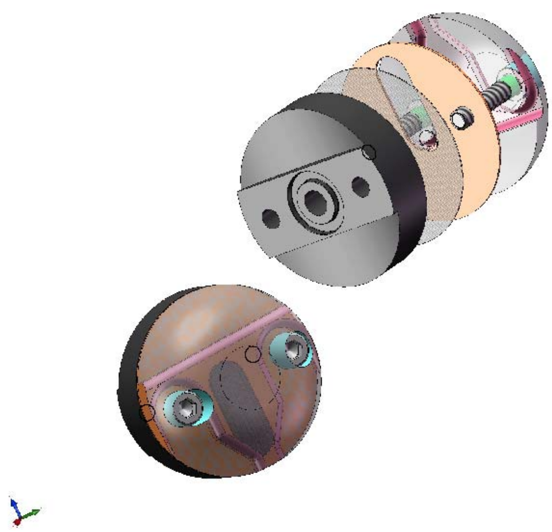
7. [For G2 glider configured OPDs , see appendix J]. Thread the Peek ™ sample port tubes through the ring openings and carefully slide the plastic tubing-to-port nut, metal compression ring and rubber ferrule, in that order, onto the tubing. The flattened end of the compression ring must face towards the nut with the narrow end of the rubber ferrule towards the sharp edge of the ring.

8. Ensure that the sample port base has the size -012 o-ring still captive in the groove on the bottom. Ensure all o-rings are undamaged, lightly lubricated and that all o-ring seating surfaces are clean.
9. Insert the ferrule/tubing assembly into the sample port base. Hold the tubing flush with the end of the rubber ferrule while finger tightening the sample port base to the nut. Finish with a light torque of the base while gripping the nut with pliers.

10. Rotate the sample port base so that its channels are facing aft, as shown below, and then insert the tubing –to-port nut into the opening in the ring, seating its o-ring.



11. Assemble the copper mask to the transparent port cover with the oval opening positioned above the water channel in the cover, as shown in the figure.



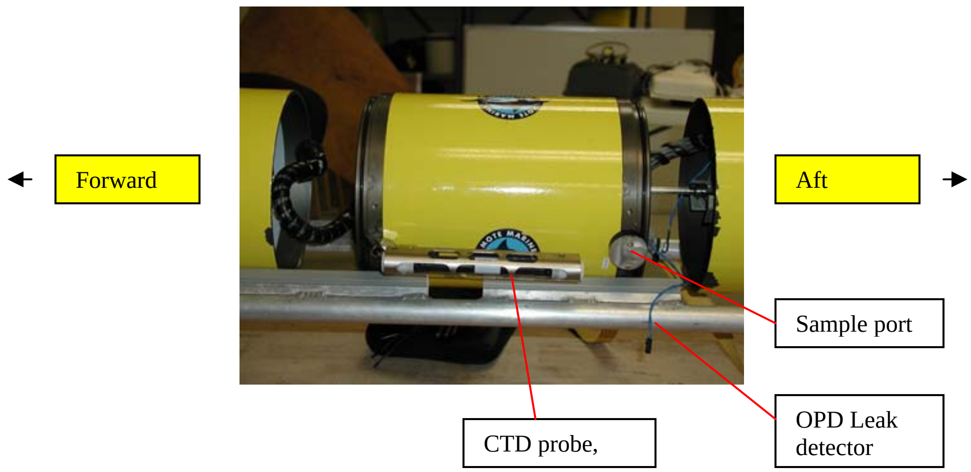
12. Clean and reassemble the filter screen to the transparent port cover on top of the copper mask.

13. Assemble this cover assembly to the port base aligned so that the oval opening in the copper mask rests above the channels in the base, clamping the screen mesh between them.   Secure with the 8-32 socket head cap screws.

Section 3: Glider Operations

3.1 Glider Ops

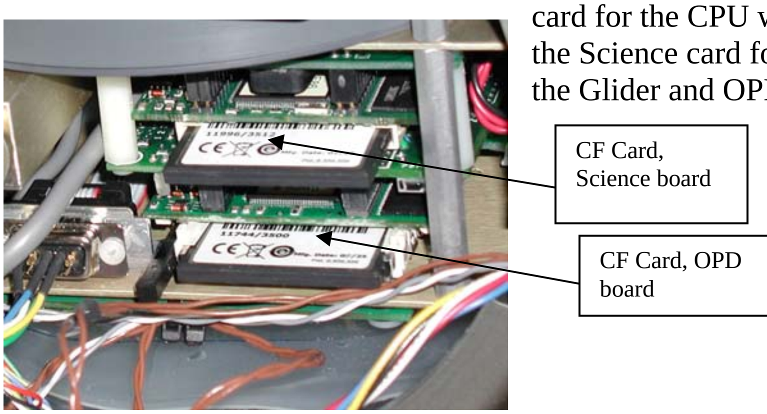
1. When the OPD is ready to be used in the Glider, position it gently on the glider cart being careful with the sample ports. Position the instrument with the CTD probe on the port side facing aft



.

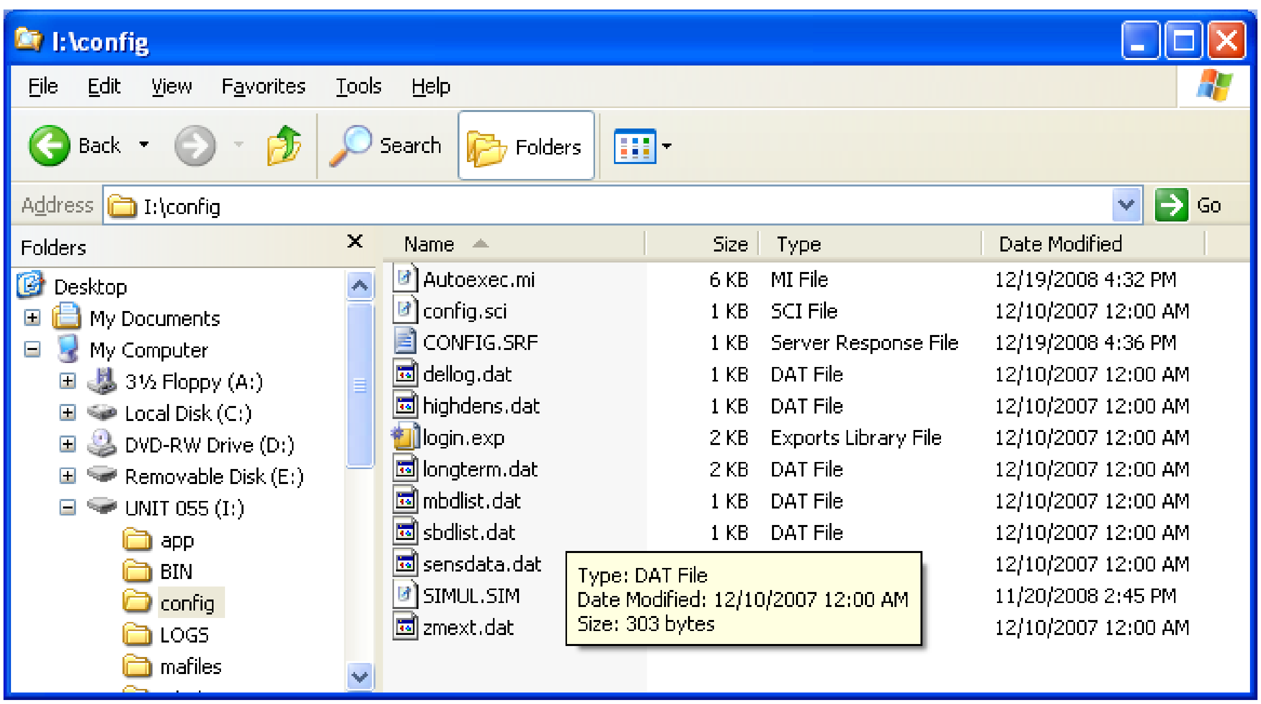
2. Connect ONLY the aft umbilical cable to the glider control board . *DO NOT CONNECT THE FORWARD UMBILICAL CABLE WHEN WORKING WITH THE GLIDER OPEN ON THE BENCH. This will protect the ballast pump from being moved and damaged while not under vacuum.*

The entire system (Glider, Science and OPD) has three main boards and flash cards associated with them. The Glider has one in its aft end, which has the function of running the glider operations. Inside the OPD, there are 2 flash cards, both labeled. The OPD card for the CPU which runs the instrument and the Science card for the CPU which integrates the Glider and OPD functions.



3. Locate the Glider flash card and remove from board. Insert into PC flash card reader on the computer.

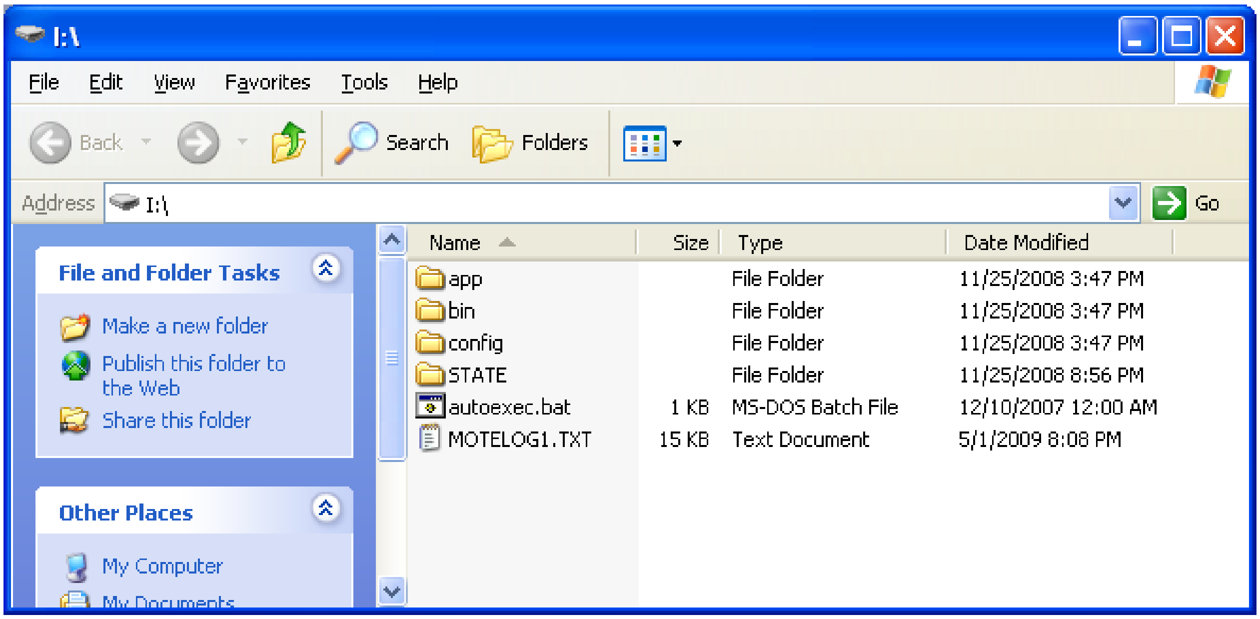
4. Below is an example of the root directory of the glider flash card:
Note the file SIMUL.XXX, where .XXX is either .SIM or .SAV. Rename it to SIMUL.SIM.



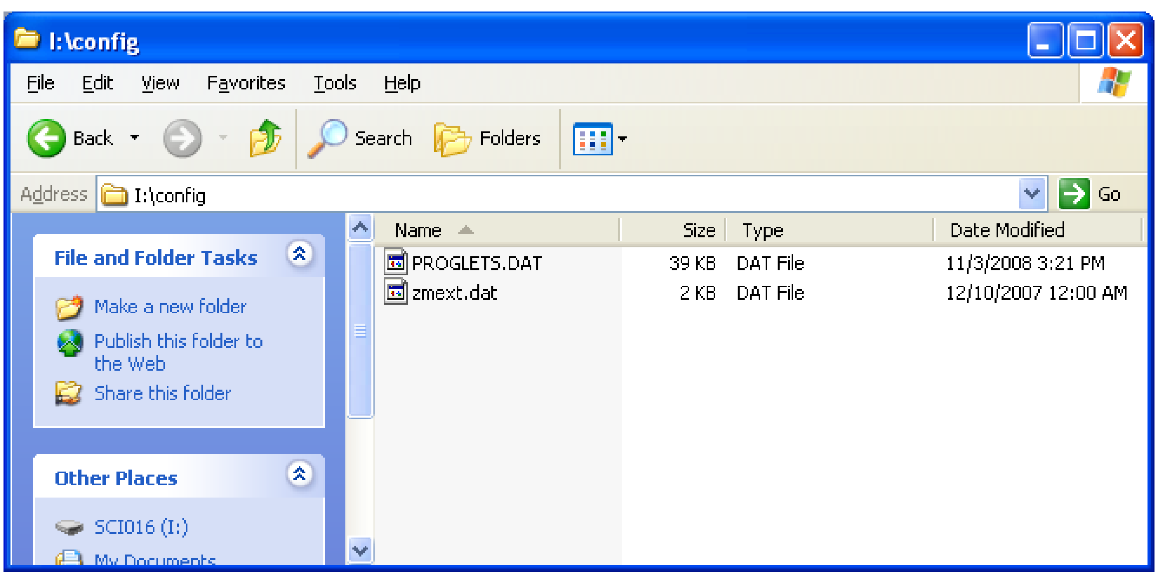
Edit the SIMUL.SIM file as required to read:

```
#simul sim
#on_bench
just_electronics
```

5. Replace the glider flash card and remove and read the Science flash card. Here is an example of the root directory of Science:



6. Here is the content of the Science config folder:



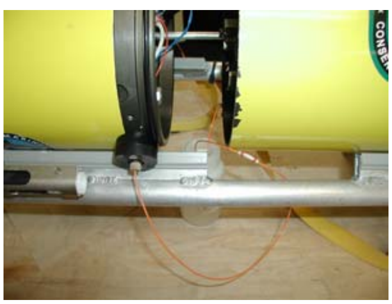
7. Open PROGLETS.DAT with WordPad. Some of the lines in this file need to be made active, i.e. “un-remarked”, by deleting the “#” leading remarks character from the line. This makes these lines active instructions and configures Science to operate these OPD and CTD sensors via their proglet programs. Modify the lines as shown in example below:

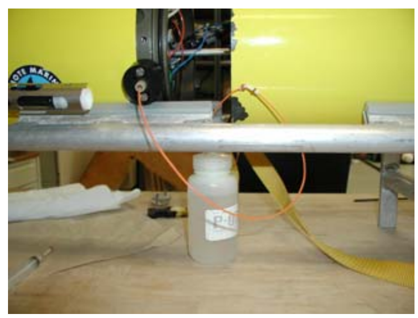
```
# proglets.dat
#
# This file specifies the configuration of a
# science computer in a Webb Research Glider.
#
……..
#
#-----------------------------------------------------------------------
# CTD41CP Sea-bird  CTD(SBE-41)
# Continuous Profile Unit
#          Seabird CTD             OES                      Persistor
#Hardware: Pin 1(Power CTRL)                               Pin 27
(CTD5)
#          Pin 2(TX OUT)        J7pin25(UART4 RXC)
#          Pin 3(MODE)                                     Pin 26
(CTD6)
#
proglet = ctd41cp
     uart =     2     # UART4-RXC
     bit  =     27    # Power Ctrl
     bit  =     26    # MODE
     start_snsr=c_profile_on(sec)
     simulator = ctd41cp_sim
#
#-----------------------------------------------------------------------
# Mote Brev Buster
#
 proglet = MoteBB
     uart        =     0    # UART4-RXA/TXA
     start_snsr =     c_MoteBB_on(sec)
     bit = 30               # power control
```

8. Save Proglets.dat.
9. Save and delete the Motelog1.txt file. Return the flash card to the Science card socket.

10. [For G2 glider configured OPDs , see appendix J]. Remove the 2 sample port covers and replace with the test port covers with extension tubes. Before inserting the ports into the water sample bottle, with a water- filled syringe, fill the extenders with water to remove any air in the tubes.

11. Insert both tubes in a water sample bottle.





12. Prepare Freewave serial comms, then apply power to the Glider. Glider battery power is preferred over a power supply for first operations after OPD has been idle.
13. As the glider operation begins, Cntrl-C to terminate the start sequence.
14. Turn off the bladder air pump
15. Stop iridium calls
16. Enter a local lat/long near the first waypoint of your gotoL10.ma file.
17. Select “zero_ocean_pressure”
18. Run a glider mission of your choice. Consider a mission timeout setting of 15 minutes or so to get the glider to “surface” and report frequently.
19. Once Glider simulates “flying” and passes a depth of 2 meters on its first dive, the proglet will command the OPD instrument to turn on and begin a cycle. Subsequently OPD will continue to run measurement cycles at its configured Cycle Time whether ascending, diving, hovering, or on the surface as long as its power supply is not interrupted. If interrupted by Glider/Science for .SBD data file transfer

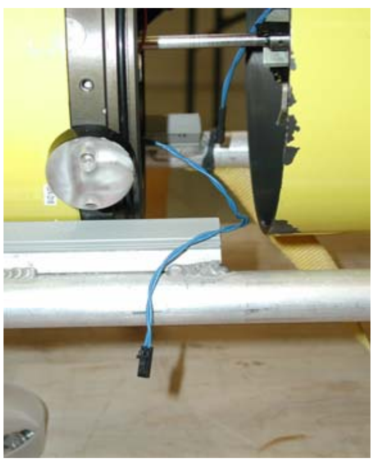
via iridium, for example, measurements will not resume until glider again dives below 2 meters.

20. Allow the simulation to run until the Glider "surfaces". Verify in the glider surface report that OPD parameters less than 600 or so seconds old are reported.
21. Stop operation, exit gliderdos.
22. *** Always wait 3 minutes before removing power or unplugging the aft umbilical cable to the glider.
23. Remove the OPD and Science flash cards. Verify OPD data has been logged successfully. Verify that a new Motelog1.txt file was created and properly logged the comms between OPD and Science and between Science and Glider.

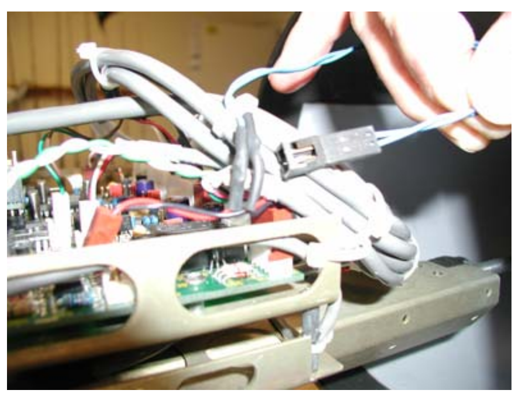
3.2 Downloading Data Files from OPD

1. Downloading the key data files from OPD, such as the Similarity Index values, is typically done throughout the glider mission in the surface reports and then in more detail in the .SBD data reports. See a later section of this manual for configuration details of your glider files to enable this.
2. OPD also logs all data in its Results folder on the flash card. Uploading the data to your pc via flash card reader is the preferred data transfer method for the HP OPD unit. Once uploaded and saved, delete the contents of the OPD flash card Results folder before the next mission or test.

3.3 Installing the OPD Leak Detection Cable



1. Delivered with the instrument is a new 2-conductor cable for connecting the OPD leak probe to the Glider's leak detection circuit. Splicing this connection into your glider should be done before glider/OPD deployment.



2. Unplug connector J10 from leak on the glider control board.
3. Cut the red and black leak sensor cable and splice the OPD blue cable wires into it. Once done the two glider leak sensors as well as the

OPD leak sensor should all be connected to J10 and the glider's detection circuit. Reconnect J10.

4. Each time that you connect the aft umbilical cable from OPD to glider board, you should next connect the OPD leak connector to its mate on the glider board.

Section 4 : Appendices

Appendix A: Glossary

1. **Adjust int**(egration) time is an instrument program sequence that appears near the beginning of each cycle. It is best when integration time is low (60 msec or less), indicating a clean, well-coupled optical path from the light source through the LWCC to the spectrometer. Steadily rising values over time indicates progressive fouling of the LWCC. Erratic values indicate entrained air bubbles or debris.

2. **BSOP** is an acronym for Bottom Stationed Ocean profiler, a vehicle designed and developed by the University of South Florida's (USF) Center for Ocean Technology. BSOP is an autonomous, freely drifting, vertically profiling vehicle designed for applications on the continental shelf. By parking on the bottom between vertical water column profile depth excursions BSOP maintains its geographic station under typical continental shelf conditions. BSOP carries sensors, collects, stores, and transmits data via a bi-directional satellite link. Mote has supplied and USF has deployed a high pressure OPD instrument configured as one of the sensors of BSOP.

3. **CDOM** refers to Colored Dissolved Organic Matter. In the context of this OPD manual we refer to the CDOM measurement part of the cycle, where the water sample is filtered so that CDOM will remain, but particles, such as phytoplankton, are removed by a filter. The optical measurements of CDOM are then used to mathematically remove its optical absorption effects from the measurements of the unfiltered water during the analysis of the optical data.
4. **CDOM Reference** is a mixture of 3 parts filtered sample water with 2 parts 1N HCl solution. A supply of this fluid is used to periodically clean the LWCC lumen and to adjust the settings of the instrument.
5. **Cell** is an OPD configuration for using a cell phone modem for communications.
6. **Dark** refers to a Spectrometer measurement run without light. Dark Pixel readings are subtracted from illuminated readings as an instrument compensation step on every cycle.
7. **Discriminate** refers to the part of the measurement cycle where the raw, unfiltered water sample is optically measured.
8. **Debug** is an optional OPD program feature that sends detailed progress information for each cycle to the computer console and the DEBUG.TXT log file.
9. **Nohost** is an optional OPD program feature that automatically starts measurement cycles. In this mode of operation, once started, OPD runs autonomously for as long as electrical power is provided.
10. **Polled** is an optional OPD program feature that keeps OPD awake for as long as 5 minutes after completing a cycle while awaiting a host to poll it for its status message. Once it reports status it goes to sleep or proceeds with the next cycle.
11. **Similarity Index (SI):** Research has shown that the phytoplankton species K.brevis can be discriminated from other bloom forming species based on

analyses of its optical properties. In the similarity index (SI) analysis for K.brevis identification, the fourth derivative of the particulate absorption of an unknown sample is compared with the fourth derivative of the particulate absorption spectrum of a monospecific K. brevis culture. Results show that the SI correctly discerns K.brevis from other members of natural, mixed phytoplankton communities. The reason for the success of this approach lies in the fact that K.brevis displays unique absorption peaks at 444 and 469 nm owing to the presence of a particular photosynthetic pigment. Fourth-derivative analysis amplifies minor inflections in the absorption spectrum and so permits resolution and discrimination of this pigment. In addition, research has found that there is a linear relationship between K.brevis biomass and SI magnitude, permitting rapid determination of bloom magnitudes from the measurement. In general, SI readings above 0.6 on a scale from 0.0 to 1.0 indicate detection of a significant biomass of K.brevis.

Research has now extended this measurement to numerous other plankton species. The OPD instrument is provided with a library of Species Files capturing the absorption spectral "fingerprints" of K.brevis and numerous other species. For development of additional species parameter files please contact Mote Marine Laboratory's Phytoplankton Ecology Department.

12. **Sim** refers to an OPD program simulation mode. It uses the parameters set up in the configuration files to simulate measurement cycles and issue status messages but does not employ the pumps, valves, or sensors of the instrument. This mode may be useful in testing the user's configuration of the instrument to be sure that it will perform on the schedule and in the modes desired once in a real operational mode.
13. **.PXE** is a program file extension for PicoDOS eXEcutable files. OPD.PXE or OPD.RUN is the executable program file (firmware) required for operation of the OPD instrument and must reside in the main root directory of its Compact Flash memory card.

Appendix B: Replacement Parts

1. The hollow fiber membrane filter mounted on the edge of the OPD main chassis plate is specified as:
   FILTER, HOLLOW FIBER, SPECTRUM LABS #X12E-100-20N, PKG OF 20, VWR PN#28170-590.
   As we buy these from VWR in qty you are welcome to buy these from Mote or to purchase directly from VWR or other supplier. One spare filter is included in your spare parts kit.

   2. If you need to replace the screen mesh sample port filter elements that mount in the holders on the outside of the aft Science bay ring, that is a custom part that you may purchase directly from Mote. Two spare screen mesh filters are included in your spare parts kit.

Part numbers and prices are listed below:

MOTE PART NUMBER	DESCRIPTION	UNITS	PRICE
2038	FILTER, SAMPLE PORT , HIGH PRESSURE	EA	$48.00
144	FILTER, HOLLOW FIBER, SPECTRUM LABS	EA	$27.63

To order parts, just send your purchase order to Mote Marine Laboratory, marked to attention of Phytoplankton Ecology.

Appendix C: Configuring Glider files for operations with OPD

Pre-deployment of OPD:
To prepare for a real glider flight with OPD after all bench tests of OPD and Glider are done:

1. be sure to change the file name of SIMUL.SIM to SIMUL.SAVE
2. Configure your SBD.DAT and CONFIG.SRF files as described below.
3. Save a copy, then delete the MOTELOG1.TXT file from the science flash card. A new log will be created in the real mission.
4. Be sure that the file AUV.BAT is in the root directory of the OPD flash card.
5. Remember the 3-minute rule: when exiting the glider program, after the program tells you it's okay to remove power from the glider, wait an additional 3 minutes before removing power to prevent corruption of the OPD files and program.

Appendix D: Configuring glider for OPD parameter reports

Below is a Sensor parameter listing for OPD:

```
        # Mote Marine Lab Optical Phytoplankton Detector (BreveBuster)
        # last modified: ahails@mote.org 14 MAR 08
sensor: c_motebb_on(sec)                0 #
sensor: sci_motebb_is_installed(bool)   0 #  installed on science
sensor: sci_motebb_sn(nodim)            0 #
sensor: sci_motebb_status(nodim)        0 #
sensor: sci_motebb_volt(nodim)          0 #
sensor: sci_motebb_press(nodim)         0 #
sensor: sci_motebb_cdomref(nodim)       0 #
sensor: sci_motebb_int_time(nodim)      0 #
```

```
sensor: sci_motebb_start_time(timestamp) 0 #
sensor: sci_motebb_stop_time(timestamp)  0 #
sensor: sci_motebb_absorb_a(nodim)       0 #
sensor: sci_motebb_absorb_b(nodim)       0 #
sensor: sci_motebb_corr0(nodim)          0 #
sensor: sci_motebb_corr1(nodim)          0 #
sensor: sci_motebb_corr2(nodim)          0 #
sensor: sci_motebb_corr3(nodim)          0 #
sensor: sci_motebb_corr4(nodim)          0 #
sensor: sci_motebb_corr5(nodim)          0 #
sensor: sci_motebb_corr6(nodim)          0 #
sensor: sci_motebb_corr7(nodim)          0 #
sensor: sci_motebb_corr8(nodim)          0 #
sensor: sci_motebb_corr9(nodim)          0 #
sensor: sci_motebb_corr10(nodim)         0 #
sensor: sci_motebb_corr11(nodim)         0 #
sensor: sci_motebb_logout(nodim)         0 #
```

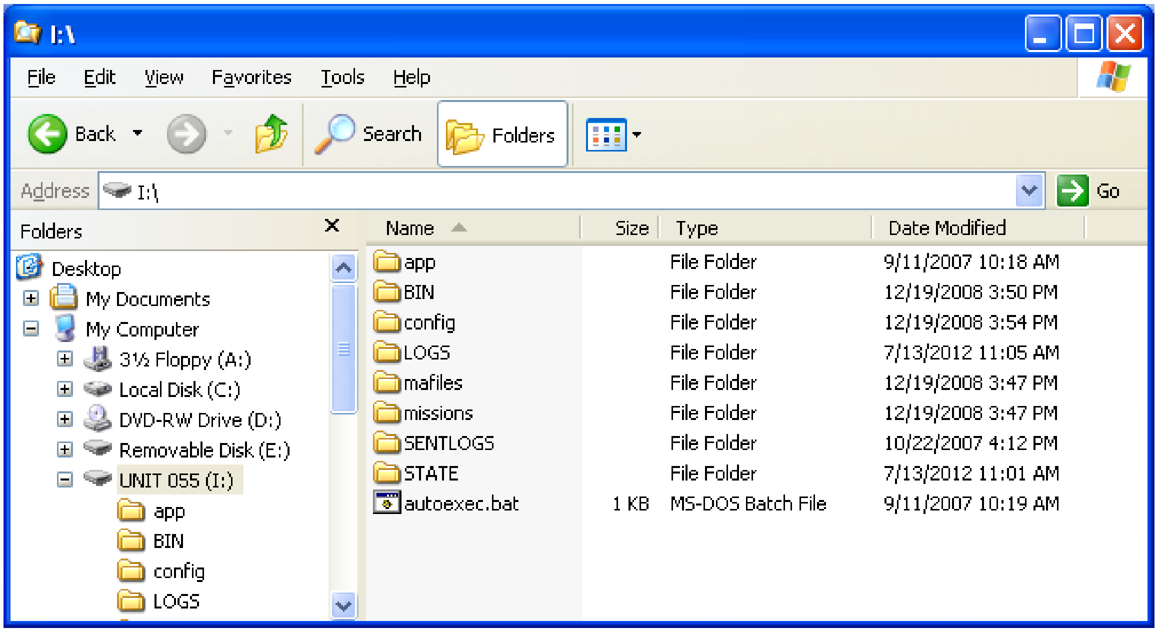
The above parameters will be reported by OPD to Science, then by Science to Glider at the end of each OPD measuring cycle. At your discretion some of them may also then be reported to the user's Dockserver computer ashore by the glider via iridium or freewave radio by including them in your .SBD reports [change your SBDLIST.DAT file] and in surface reports [change your CONFIG.SRF file]

Be sure to run glider code version 6.34 or higher to ensure OPD compatibility.

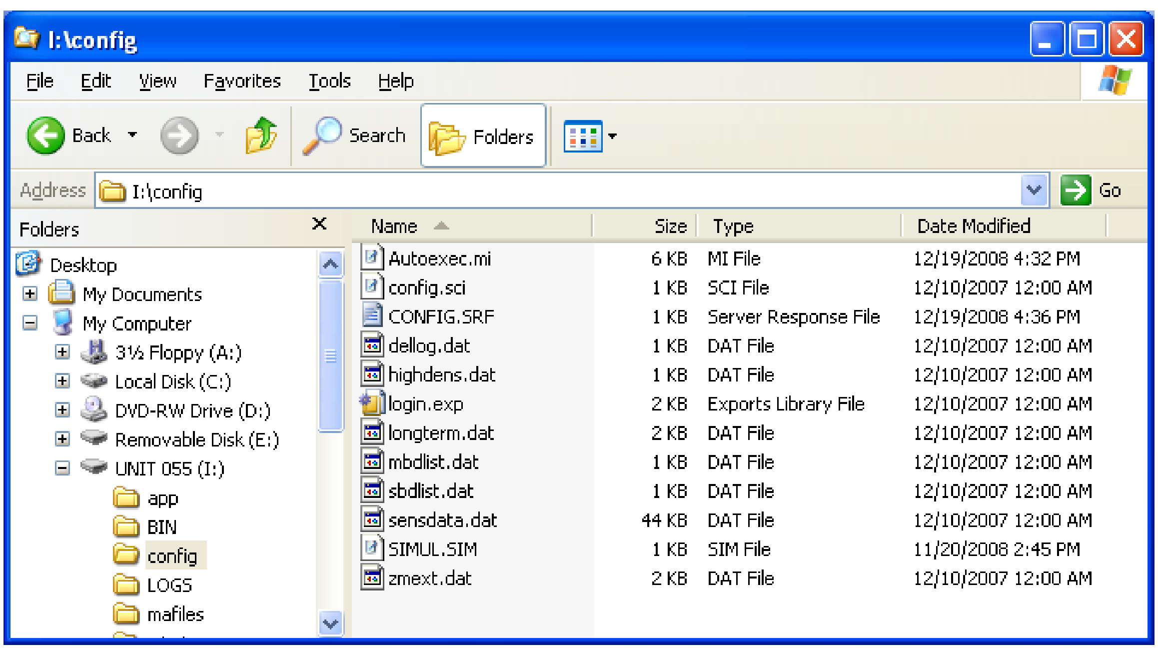
In our proglet, Mote has increased time delay to 90 sec in the routine MoteBB_end to delay allowing Science to shut OPD down. Now Science waits to get "Log file closed" from OPD. If Science gets this message it sends "sci_motebb_logout" to glider, then removes power from OPD. If it does not get this message it removes power after 90 seconds has elapsed. By adding this "sci_motebb_logout" parameter to your glider surface reports you can monitor whether OPD is having its power removed prematurely.

Below are examples of both of those files, located on the glider in its flash card at Gliderflash\config :

Root directory of Glider flash card:



Directory of I:\config folder:

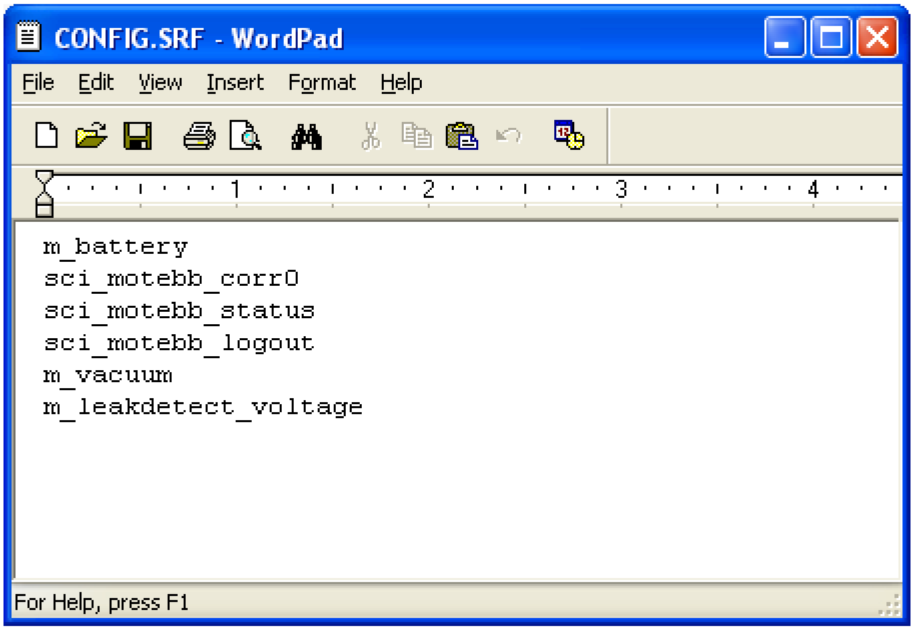


SBDLIST.DAT sample file

```
# 28-Jun-01 tc@DinkumSoftware.com reduced sensors for New Jersey
# 05-Sep-01 tc@DinkumSoftware.com Added c_wpt_lat/lon m_gps_lat/lon
# 14-Jul-03  fnj@DinkumSoftware.com  Added optional record interval (secs)
#                                    If 0 or not present, do it the old way
# 6 Sept 07 ahails@mote.org removed water vx and vy, added c_pitch, m_pitch,
#  c_battpos, m_battpos
#  17APR08 AHAILS REMOVED TILDE AT END OF FILE
#  21OCT08 AHAILS@MOTE.ORG ADDED sci_motebb_logout

M_PRESENT_TIME
M_PRESENT_SECS_INTO_MISSION
M_WATER_VX
M_WATER_VY
M_WATER_DEPTH 15
M_DEPTH       15
M_LAT         60
M_LON         60
C_WPT_LON
C_WPT_LAT
M_GPS_LON
M_GPS_LAT
M_WATER_COND
M_WATER_TEMP
M_WATER_PRESSURE
C_PITCH
M_PITCH
C_BATTPOS
M_BATTPOS
sci_motebb_sn   0 15
sci_motebb_status       0 15
sci_motebb_volt 0 15
sci_motebb_press        0 15
sci_motebb_cdomref      0 15
sci_motebb_int_time     0 15
sci_motebb_start_time   0 15
sci_motebb_stop_time    0 15
sci_motebb_absorb_a     0 15
sci_motebb_absorb_b     0 15
sci_motebb_corr0        0 15
sci_motebb_logout
```

Sample CONFIG.SRF file




```
m_battery
sci_motebb_corr0
sci_motebb_status
sci_motebb_logout
m_vacuum
m_leakdetect_voltage
```

Appendix E: Installing OPD Setup & control on your computer

On the web, go to http://coolgate.mote.org/socool/downloads/

Click on OPD Setup & Control.
OPD Installer.txt will have instructions on how to download to your computer:

```
1. Unzip OPD Setup&Control to a local folder.

2. Run setup.exe

3. Run regscom.bat

Default location
c:\Program Files\Phytoplankton Ecology\OPD SetupControl

4 Launch OPDSetupControl.exe
```

Appendix F: Opcodes

Parameter	Opcode
Sampling	
Start	<cycle>
Stop	<stop>
Exit	<closedown>
Status	<status>
Setup	
cycles to do	<numbercycles> &I
cycle time	<cycletime> &I
Set time to Local	<timesync> &L
Set time to GMT	<timesync> &Z
Disc repeat rate	<discrepeat> &I
Messages on	<debugon>
Messages Off	<debugoff>
Cdom ref interval	<cdomrefrepeatrate> &I
Cdom ref flush time	<cdomrefflushtime> &I
CDOM ref Supply mL	<cdomrefmliterleft> &I
CDOM reference on	<cdomrefon>
CDOM reference off DiscFlowTime	<cdomrefoff> <opcode> 99
Reports	
Sampling Setup	<opcode> 21
Sensors report	<opcode> 14
HP OPD Commands	
Adjust Int Time	<opcode> 17
Shutter Open	<opcode> 2
Shutter Closed	<opcode> -2
Lights On	<opcode> 3
deuterium on	<opcode> 35
Tungsten on	<opcode> 36
lights Off	<opcode> -3
Select Filter	<opcode> 4
Select Bypass	<opcode> 5
Select Closed	<opcode> 6
Reference Pump On	<opcode> 8
Reference Pump Off	<opcode> -8
sample Pump On	<opcode> 7
sample Pump Off	<opcode> -7
set Valve A	<opcode> 10
Set Valve B	<opcode> -10
Valve Toggle	<opcode> 15
Status Report	<opcode> 52
LWCC Flush	<opcode> 43

Command	**Definition**
adjust int time	Checks and adjusts the optical sampling integration time
Shutter Open	Opens light shutter
Shutter Closed	Shuts light shutter
Lights on	Turns D2 light on [both tungsten + deuterium]
Deuterium on	Turns Deuterium light only on
Tungsten on	Turns Tungsten light only on
Lights off	Turns all lights off
Select Filter	Selects Filter channel for water sample
Select Bypass	Selects Bypass channel for water sample
Select Closed	Closes off water flow
Reference Pump On	Turns CDOM reference pump on
Reference Pump Off	Turns CDOM reference pump off
Sample Pump On	Turns sample pump on
Sample Pump Off	Turns sample pump off
Set Valve A	Changes Valve to A port
Set Valve B	Changes Valve to B port
Valve Toggle	Instructs valve to switch to other port
Status Report	Reports current message even if you have done a cycle
override on	
override off	
reverse sample pump	runs sample pump in reverse mode
Valco cal	calibration for Valco port selector valve
pos cal	

Appendix G: Setup Default Values

cycles to do	1
cycle time	0
set time to local	No
set time to GMT	Yes
disc repeat rate	1
Debug messages on	Yes
Debug messages off	No
CDOM ref. Interval	9
CDOM ref.flush time	60
CDOM ref. Supply ml	0
CDOM ref. on	No
CDOM ref.off	Yes
Disc Flow time	8
Sample Pump speed	127
CDOM Ref. Pump speed	200
CDOM Stroke Position	70
CdomRefPumpCal	10

Appendix H: OPD error codes and the Status code

The parameter 'Status' is a 16-bit integer whose hexadecimal value is reported in the OPD status message. Bit manipulation is used to encode the status of operational errors into the value of the integer Status. The error types are pre-assigned the following Hex and binary values:

Error Condition	**Hex Value**	**Binary Equiv.**
No error	0x00	0000000000
Leak	0x01	0000000001
PumpTimeOut	0x02	0000000010
FullSpeedToEndOverrun	0x04	0000000100
GotoXOverrun	0x08	0000001000
SameSpeedToEndOverrun	0x10	0000010000
Valve failure	0x20	0000100000
Spectrometer error	0x40	0001000000
Deuterium light failure	0x80	0010000000
Tungsten light failure	0x100	0100000000
Corrupt Data	0x200	1000000000
Filter Transmembrane OverPressure	0x400	10000000000
CF Card Low File Space	0x800	100000000000

Each time that the OPD program tests for and finds one of the error conditions to be true it performs a bitwise 'OR into' of the value of the error into the value of Status:

```
Example:    Status= Status | statPumpTimeOut
```

This results in the bits of the binary value of Status each being encoded as either 0 or 1 in correlation with each of the error types as can be seen in the binary column of the error table above. If no error or only one error condition exists the Status code is 0 or is the Hex value of the single error and interpretation is direct and simple.

For combined errors, decoding the reported Status code requires converting the Hex value of Status to Binary, then determining which bits of that binary value have the value of 1 and correlating those bits with the above listed error types. An online converter such as http://www.easycalculation.com/hex-converter.php may be helpful.

It's also possible to deduce which combinations of errors are encoded in the Status code by adding various combinations of Hex values assigned to the errors. For example, a deuterium light failure, 0x80, combined with a leak, 0x01 results in a reported Status code of 81. Even without the step of the binary conversion to 0010000001 it's clear that code 81 could only result from the combination of these two codes 0x80 and 0x01.

Appendix I: OPD CONFIG.TXT descriptions

- CorrWaveMin 400 – The lower end of the wavelength range, in nm, over which the Similarity Index is evaluated
- CorrWaveMax 700 – The upper end of the wavelength range over which the Similarity Index is evaluated.
- AbWaveMin 390 - The lower end of the wavelength range over which CDOM absorption is evaluated.
- AbWaveMid 440 – The wavelength value where CDOM absorption is reported.
- AbWaveMax 490 - The upper end of the wavelength range over which CDOM absorption is evaluated.
- NumberCycles 0 - The number of measurement cycles to perform. A value of "0" means an infinite number of cycles.
- CycleTimeMinutes 10 – The number of minutes from one cycle start until the next cycle start.
- WaveSaveMin 350 - The lower end of the wavelength range of saved raw spectra.
- WaveSaveMax 750 - The upper end of the wavelength range of saved raw spectra.
- CdomRefFlushTime 30- The number of seconds the CdomRef pump runs during its portion of cycles designated by CdomRefRepeatInterval. Also the number of seconds that the sample pump runs during the CDOM portion of the cycle while sample water is being filtered by the 0.22 micron filter.
- CdomRefRepeatInterval 9 – The number of cycles between CdomRef reference measurements
- DiscRepeat 1- Number of repeat discriminate samples. A value of 1 results in a total of two pumped water samples of the discriminate [unfiltered] fluid, where the second sample is less likely to be contaminated by either a precedent cdomref or water sample.
- FilterSize 47 – The size of the Gaussian smoothing filter applied to the raw data.
- RunDepth 1.000000e+00 Not currently used
- ShutDownDepth 5.000000e-01 Not currently used

- FilterSigma 1.200000e+01 – The width of the Gaussian smoothing filter applied to the raw data.

- WriteTraces 1 – Boolean value specifying whether or not to save raw spectra. 1=Save, 0= No Save.

- DoCDOMRef 1 A value of 1 turns on the CdomRef part of the cycle, a value of 0 turns it off. It should always be 1 unless troubleshooting.

- DoCDOM 1- A value of 1 turns on the CDOM part of the cycle, a value of 0 turns it off. It should always be 1 unless troubleshooting.

- DoDisc 1- A value of 1 turns on the Discriminate part of the cycle, a value of 0 turns it off. It should always be 1 unless troubleshooting.

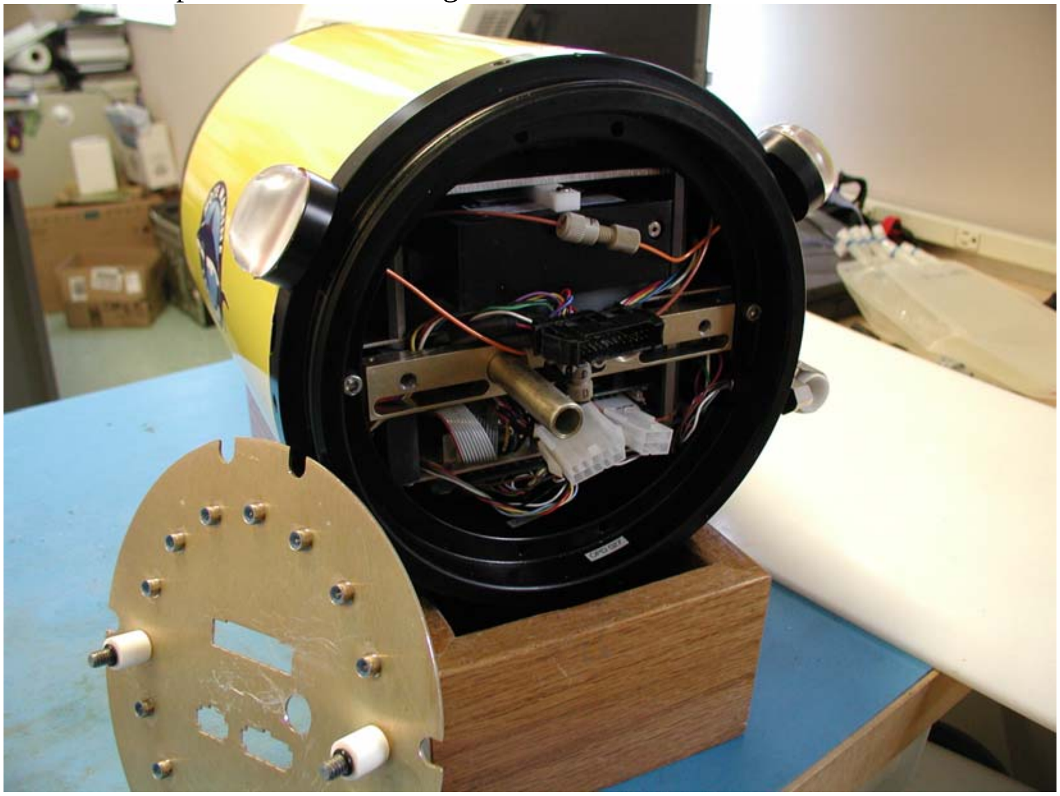
- GPSget 0 Reserved for future use where a GPS sensor is available. Should always be 0.

- DiscFlowTime- The number of seconds of sample pump operation in the Discriminate portion of the cycle, range 0-60 sec. Contact tech support before changing.

Appendix J: G2 Glider OPD internal access

For the G2 glider the OPD sample ports have been moved to the forward hull ring and should not be removed.

Instead, remove forward science bay guard plate. Take care to release the forward glider connectors from the plate before removing it.



This allows access to the tubing and fittings, including those connecting to the sample ports. Fittings should only be tightened to firmly finger tight, never using tools. Unscrew the fitting marked 'V' from its connection to the tee, and the fitting marked 'P' from its mating inline fitting. Connect the adapter tubes provided to the 'P' and 'V' tubes that lead into the instrument. These adapter tubes will be used to supply sample water to the instrument during bench and glider setup. The other instructions of this manual apply to both the G1 and G2 configured OPD instruments.