KONGSBERG

Seaglider Piloting Tools

Users Guide

Revisions

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Document history

Rev. A Initial Release

Rev. B Renamed to "Dive Data", updated with regression plots.

Rev. C Renamed "Piloting Tools". Updated install and usage directions.

Rev. D Removed regression plots.

Rev. E Changed references of DiveData to Piloting Tools (but left the Matlab section unchanged) and added DivePlot Details plot.

Rev. F Added info regarding file permissions when installing on Linux

Rev. G Updated for the 1.1.R4 release with Timeseries plots.

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1 OVERVIEW

The Seaglider Piloting Tools is a program used for basic piloting of a Seaglider. It requires the NetCDF output of the basestation code (pGGGDDDD.nc files where p = processed, GGG = glider ID number, and DDDD = dive number). The content of a netCDF file is described in the Seaglider_Quality_Control_Manual.html.

2 ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

Term	Definition
CT	Conductivity and Temperature sensor
GPCTD	Glider Payload Conductivity, Temperature, Depth sensor
GUI	Graphical User Interface
UI	User Interface
IDE	Integrated Development Environment
nc	File extension for NetCDF files. Used as abbreviation to denote a netCDF file.
kml	File extension for Google Earth files

Rev. G

3 REQUIRED TOOLS

3.1 Software

- Seaglider Piloting Tools installer or Seaglider Piloting Tools source
- Matlab 2011b or later (optional)
- Google Earth

3.2 Hardware

- A Windows 7 workstation. The Piloting Tools should also work on a Linux workstation, but this has not been tested.

4 INSTALLATION AND CONFIGURATION

4.1 Seaglider Piloting Tools

4.1.1 Standalone Installation (Windows Only)

The Seaglider Piloting Tools software comes packaged in an installer (PilotingTools_Win.exe). Follow these steps to install the software onto the computer. Note that the tools can be installed in any directory you want – the directories listed are just suggestions.

1. Create a folder in C:\ and name it PilotingTools.
2. Copy the installer to the new folder PilotingTools.
3. Double-click on the installer.
4. When the User Account Control dialog asks whether to allow the MCRInstaller.exe to run, click the "Yes" button.
5. When the MATLAB Compiler Runtime Installer dialog appears, click the 'Next' button.
6. On the next screen, click the "Yes" radio button and then the "Next" button.
7. If the Confirmation window indicates that the MATLAB Compiler Runtime is already installed, click the "Install" button. The Piloting Tools require this particular version of the Compiler Runtime.
8. When the Installation Complete window is displayed, click the "Finish" button.
9. Ignore the readme.txt file.

4.1.2 Installation for Matlab

4.1.2.1 MATLAB 2011b

Install MATLAB 2011b (or later) per the instructions that are provided with the software.

4.1.2.2 Seaglider GUI Piloting Tools

The Seaglider Piloting Tools software comes packaged in a compressed archive file (PilotingTools_MATLAB.tar.gz). Follow these steps to install the software onto the computer. Note that the tools can be installed in any directory you want – the directories listed are just suggestions.

Linux

1. Create a folder on your home directory (/home/<user>) and name it **DiveData.**
2. Extract the contents of the archive file **PilotingTools_MATLAB.tar.gz** to the new folder **DiveData**. (e.g. tar xvzf PilotingTools_MATLAB.tar.gz).
3. cd to the **DiveData** folder and set all of the file permissions to read/write for the user.
4. set all of the directory permissions to read/write/execute for the user.

Windows

1. Create a folder in **C:** and name it **DiveData**.
2. Extract the contents of the archive file **PilotingTools_MATLAB.tar.gz** to the new folder **DiveData**. A Windows archiving tool such as 7-Zip (www.7-zip.org) can be used for this step.

4.1.2.3 Configuring MATLAB 2011b

Run the MATLAB application

Per the instructions provided by MATLAB 2011b or newer, start the MATLAB software. When the MATLAB Integrated Development Environment (IDE) appears on your computer monitor, it will look very similar to Figure 1.
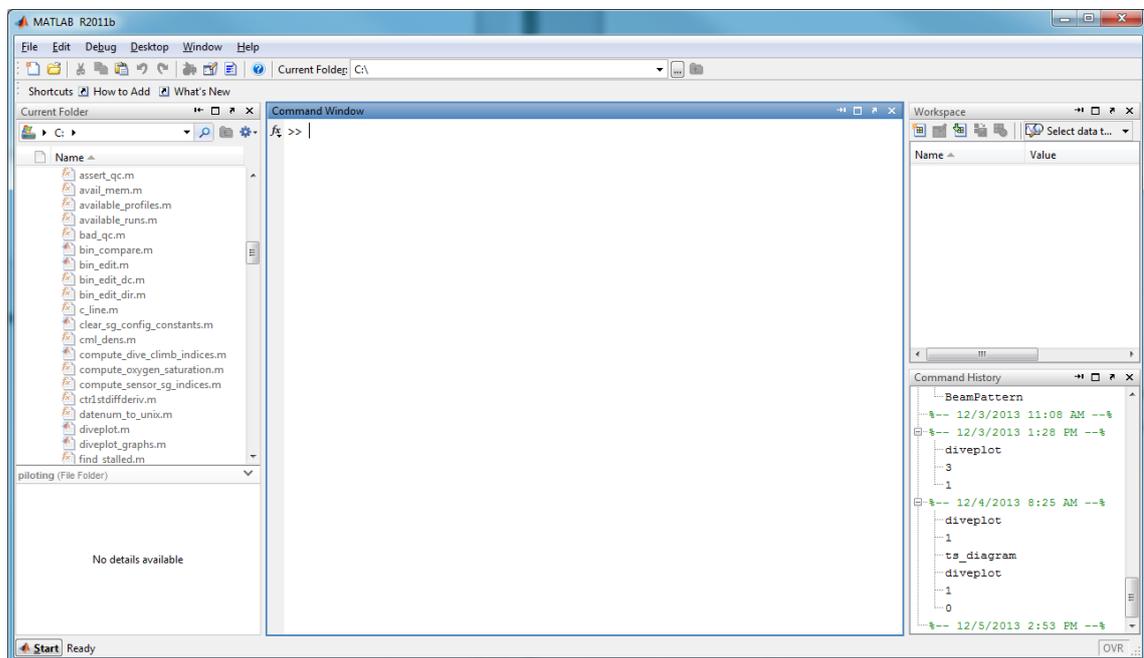
Figure 1 Example of MATLAB Integrated Development Environment

Set Path

Click on the menu item 'File->Set Path…' to invoke MATLAB's 'Set Path' feature (Figure 2). Click on the 'Add with Subfolders…' button, and use the file browser to browse to the directory where the piloting tools were installed. Click 'Ok' to close the file browser. Back in the 'Set Path' dialog, use the 'Move Up' and 'Move Down' buttons to make the 'piloting' directory and its subdirectories appear in the following order:

DiveData

DiveData\commonFiles

DiveData\Plot_PAR

DiveData\Plot_WL_Fluor

DiveData\Plot_WL_Scatter

DiveData\WETLabs

DiveData\UW.diveplot

Click 'Save' and then 'Close'. Changes to the MATLAB path take effect immediately.
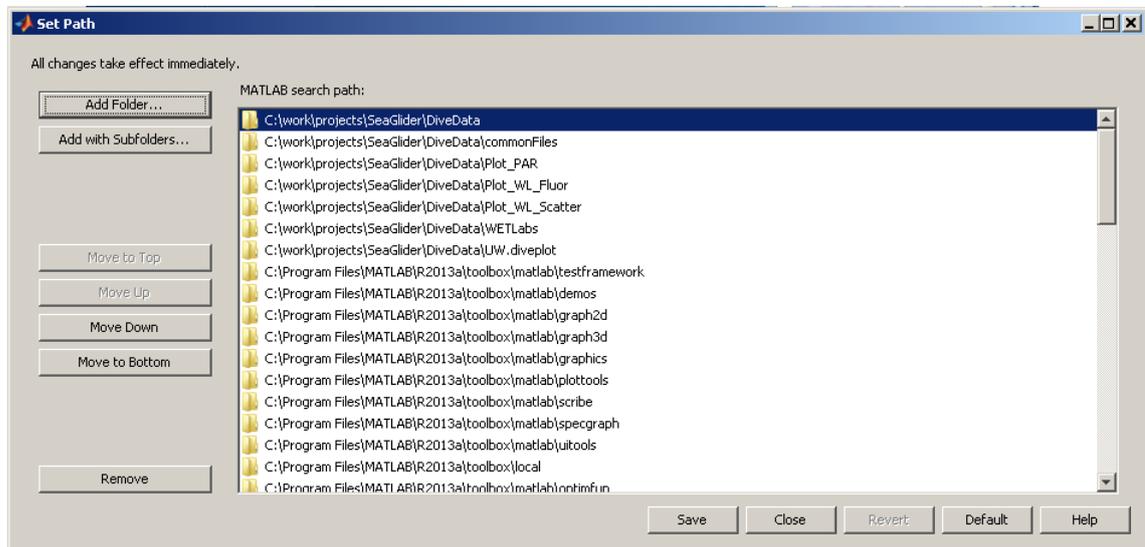
Figure 2 MATLAB Set Path dialog

4.2 Google Earth

Go to www.google.com/earth/index.html and download the installation package for your operating system. Execute the installation package and follow the installation instructions.

5 USING THE TOOL

5.1 Starting the program

5.1.1 Standalone

Double-click on the PilotingTools.exe file.

This will display the Piloting Tools window as shown in the figure below.
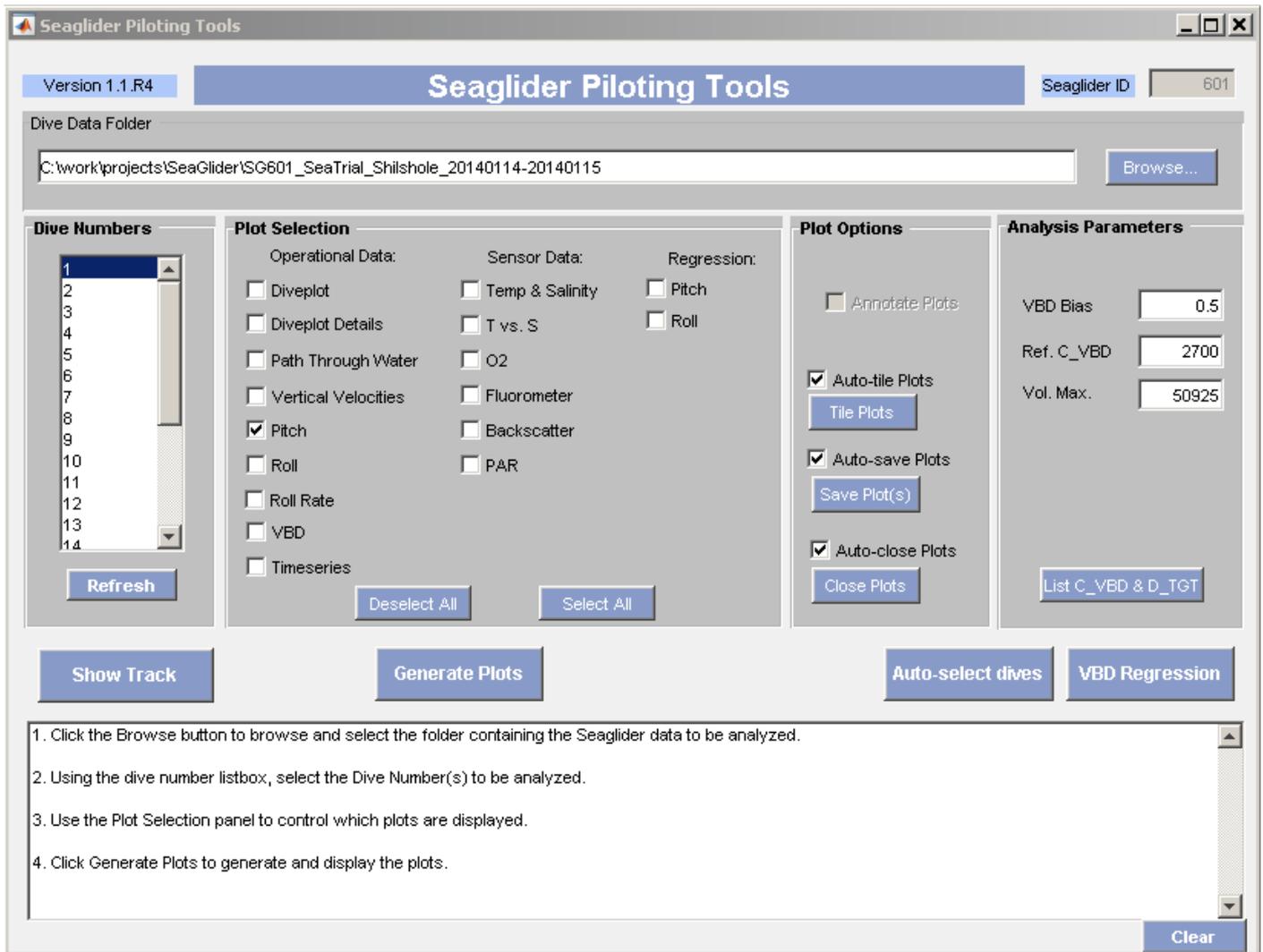
Figure 3 Piloting Tools window

5.1.2 Launching in MATLAB 2011b

The MATLAB IDE contains a window titled, Command Window. Within the Command Window is a command prompt, >>. Refer to the following diagram to familiarize yourself with this window which will be used in the steps that follow.
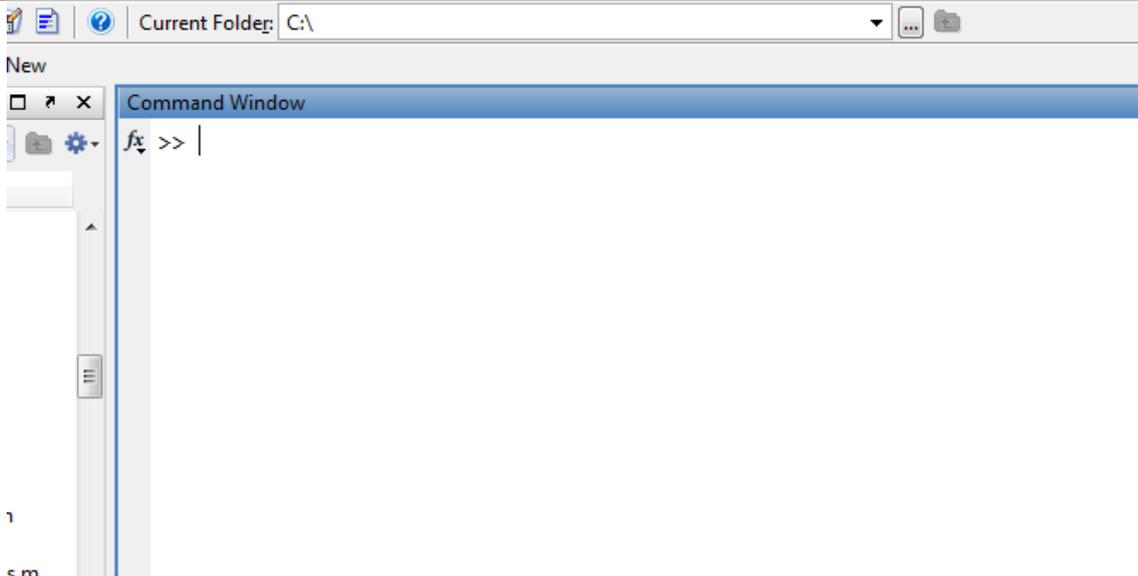
Figure 4 MATLAB command window

At the MATLAB command prompt, start the Piloting Tools program by typing the following:

>> DiveData

This will display the Piloting Tools window as shown in Figure 4:

5.2 Selecting Dive Data to Analyze

To display operational and sensor data from the dives you will need one or more .nc files from the appropriate glider directory on the basestation. One .nc file is generated for each dive.

Click the "Browse" button and select the directory containing the .nc files.

Each dive in the selected directory will be listed in the "Dive Numbers" list. The list can be updated by clicking the "Refresh" button.

The ID number of the Seaglider that performed the dives is shown at the upper right of the Piloting Tools window.

5.3 Plotting Data

The "Plot Selection" section of the window provides a checkbox for each kind of plot available. All of the plots can be checked by clicking the "Select All" button. All of the plots can be un-checked by clicking the "Deselect All" button. Clicking the "Generate Plots" button will create the selected plots.

By default, plots are stacked on top of each other when they are generated, and they must be saved and closed individually. The "Plot Options" section of the window provides buttons to "Tile" the plots across the display, and to save and close all of the plots at once. The plots are saved as JPEG files in a subdirectory of the current data directory. A subdirectory is created for each dive's plots. The subdirectory naming convention is pGGGDDDD_DivePlots where p = processed, GGG = glider ID number and DDDD = dive number.

The plots listed under the "Operational Data" heading display Seaglider's flight performance. The plots listed under the "Sensor Data" heading display data from different sensors that can be used with Seaglider. Note that not every Seaglider has every sensor listed.

5.3.1 The Diveplot plot

This plot (Figure 2) presents a composite graph including a number of dive characteristics: The left side Y-axis is multi-purpose and should be used for all parameters except heading which is displayed on the right side Y-axis. The dive characteristics plotted are:

- Velocities (Horizontal and Vertical). Horizontal velocity is represented by the horizontal speed in the direction of heading (cyan line). Vertical velocity (royal blue line) is presented as a magnitude in the z-direction (perpendicular to the horizon).
- Dive Depth (Height in the legend). The solid read line shows the descent and ascent of the glider as well as the depths where the glider exercised the pitch or roll motor or the VBD system. Pitch changes are indicated by the triangles with one tip pointing up. Roll motor movements are shown by the triangles with one tip falling on the red line. The solid diamonds indicate VBD pumping. For deeper dives there is a multiplier in the height entry in the legend that the value along the Y-axis should be multiplied by.
- VBD (black line). The solid black line shows buoyancy engine activity – bleeding, pumping or holding steady. Oil is bled from the bladder into the reservoir to make the glider negatively buoyant and descend. The maximum amount of oil that can be bled is controlled by the parameter MAX_BUOY. At apogee the buoyancy changes from negative to positive as the buoyancy engine pumps oil from the reservoir into the bladder.
- Pitch (solid green line). At the beginning of the dive the glider is pitched downward at an angle generally between 55 and 65 degrees. When the glider reaches the D_FLARE depth chosen by the pilot, it changes its pitch to the less steep glide angle calculated by the glider just before the dive began to meet the dive objectives of depth and time. At apogee the pitch undergoes a 2 stage operation where it first decreases its pitch angle to that specified in the APOGEE_PITCH parameter (often set to 5 degrees) and then pitches up to the inverse of the pitch angle during the descent. The APOGEE_PITCH angle is used to keep the glider moving forward while it pumps to neutral buoyancy.

- Roll (dashed and solid yellow lines). The dashed yellow lines are the maximum roll allowed (specified by the parameter ROLL_DEGREE). The solid yellow lines are the actual degrees the glider rolled. Positive Y-axis rolls are to starboard, negative Y-axis rolls are to port. If the roll is trimmed well, the glider should roll approximately equal times to port and starboard and the neutral point should overlay '0' on the Y-axis. There is approximately a 3:1 ratio or mass shifter degrees of roll to glider degrees of roll.
- Heading (Desired and Actual). The dashed red line indicates the desired heading for the dive. The red x's are the actual glider heading. The pilot, using HEAD_ERRBAND, controls how far away from the desired heading the glider can deviate before corrective action is taken.

Note that if a dive does not have valid CTD data, then this plot will not contain data for Horizontal or Vertical speed, Buoyancy, or Glide Slope.

Other than acting as a general flight check, this plot primarily aids in providing a value to the pilot for changes in the parameter $C_VBD. This can be determined by looking at the vertical velocity ($w = dz/dt$) versus the VBD. Rule of Thumb: If VBD line (black) crosses 0 depth before w line (royal blue), glider is heavy; if glider is too heavy, decrease $C_VBD. And vice versa: If w line crosses 0 depth before VBD line, glider is light; if glider is too light, increase $C_VBD. To determine how much correction to C_VBD is needed:

1. Find the point where W_D crosses from negative to positive and remains positive.
2. Draw a vertical line between the 'zero point' in step 1 and the VBD line.
3. Using the values on the Y-axis (left side) determine the number of units that separate W_D and VBD vertically.
4. Multiply the value in step 3 by the value in parentheses next to VBD in the legend to convert the number of units to cc's. The multiplier is generally 10cc.
5. Convert the number of cc's calculated in step 4 to A/D counts by multiplying the number of cc's by 4.07 A/D/cc.
6. Using the 50% rule of thumb, whereby only 50% of the calculated change to a parameter value is made, calculate the desired change to C_VBD.
    a. If the VBD crosses '0' depth before W_D, 50% of the desired change should be subtracted from the present C_VBD.
    b. If the VBD crosses '0' depth after W_D, 50% of the desired changed should be added to the present C_VBD.
7. In the example below, VBD is positive at the point where W_D crosses from negative to positive meaning that C_VBD is too heavy.
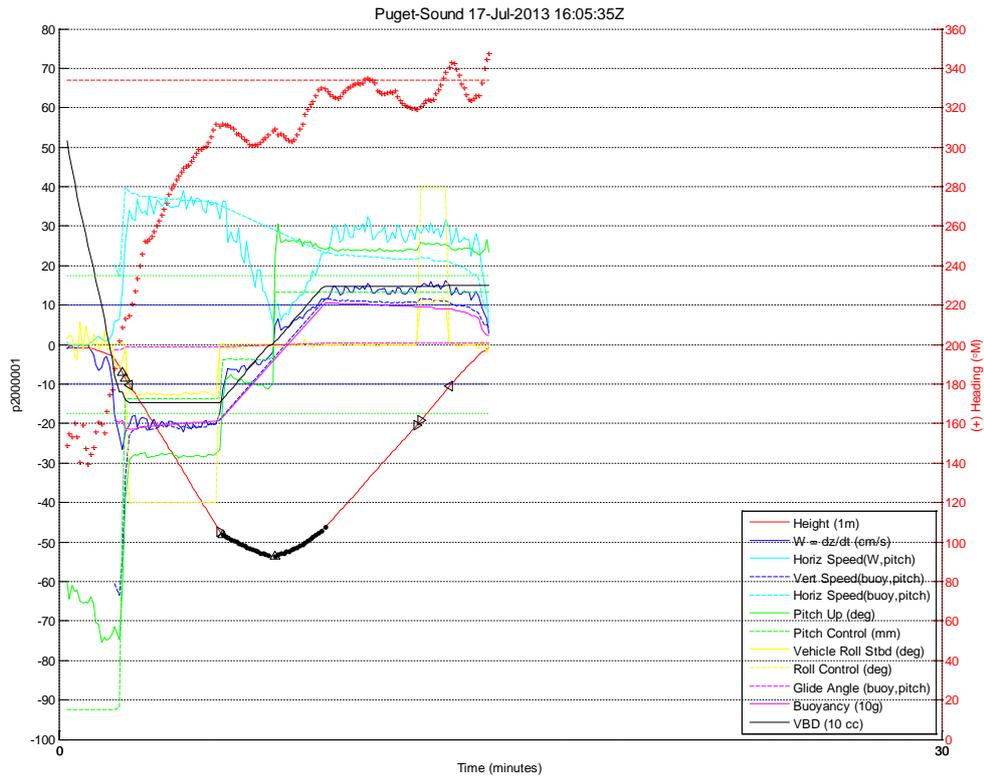
Figure 5 Diveplot

5.3.2 The Diveplot Details plot

This plot displays the same information as the Diveplot, but with each type of data broken out into its own sub-plot.
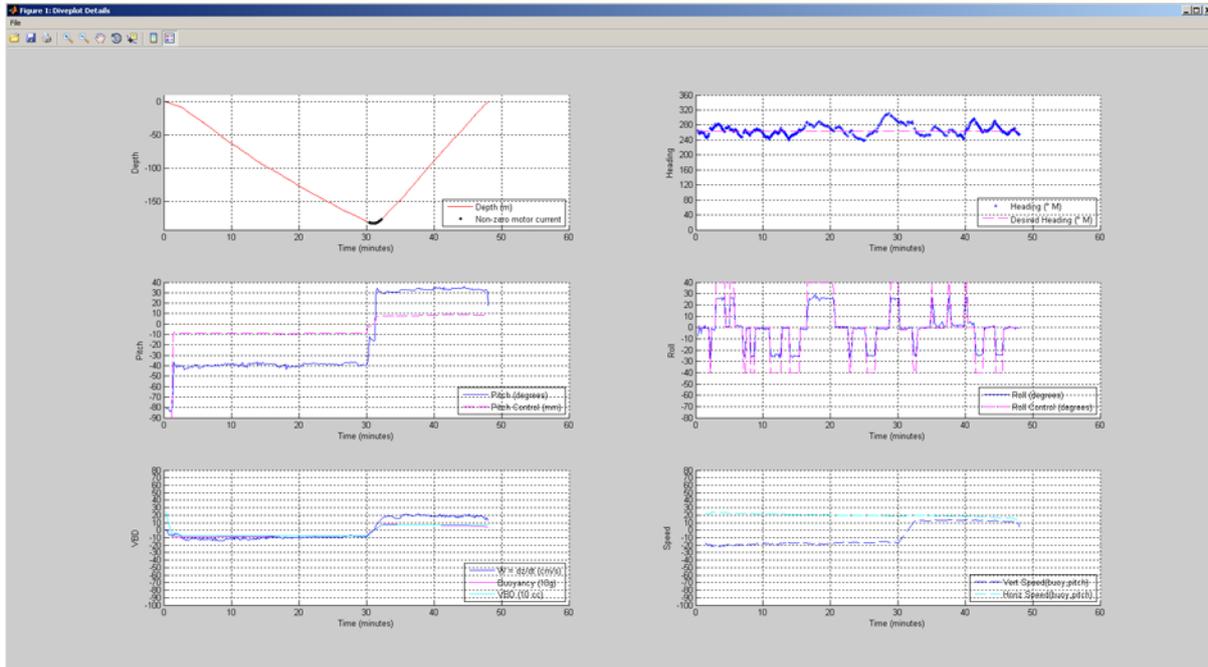

Figure 6 Diveplot Details

5.3.3 The Path Through Water plot

This plot displays the glider track and heading, from an aerial view (Figure 6). It is created from the GPS position obtained at the start of the dive and data gathered underwater by dead reckoning but does not incorporate GPS information obtained at the end of the dive Several flight characteristics can be viewed from this plot:

- Direction glider flew without correction for actual currents encountered
- Average Speed through water
- Distance covered through water
- Maximum Buoyancy (set by pilot)
- Heading deviation – the "V" represents the heading error band from the desired track which bisects the "V"
- Glide Slopes
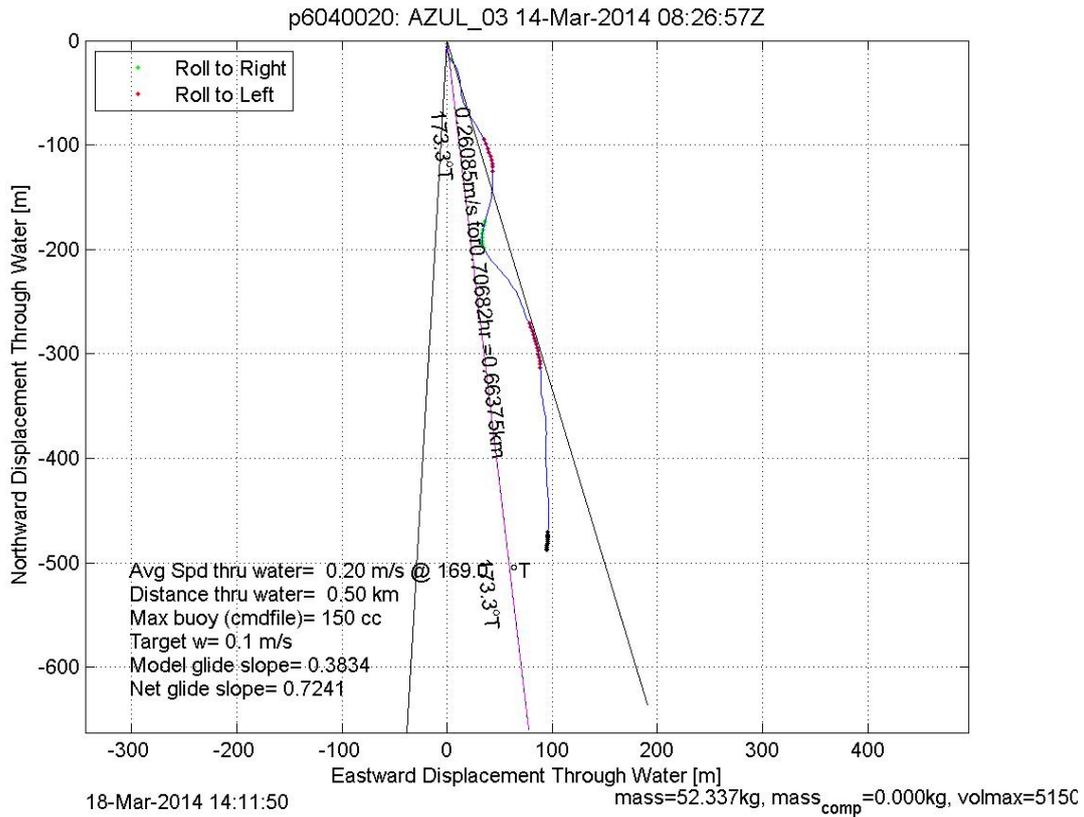- Direction of glider roll – green dots represent rolls to starboard, red dots represent rolls to port

Figure 7 Path Though Water plot

5.3.4 The Vertical Velocities plot

The vertical velocity plot measures vertical velocity (cm/s) on the dive's descent and ascent (Figure 7) using four different calculation methods:

1. Vertical velocity based on pressure change
2. Vertical velocity based on buoyancy and pitch
3. Vertical velocity based on upwelling on descent
4. Vertical velocity based on upwelling on ascent

In a well-trimmed glider the calculated descent and ascent vertical velocities should be similar and centered around zero for all calculation methods. Ex: -15 cm/s on dive and +15cm/s on the ascent.
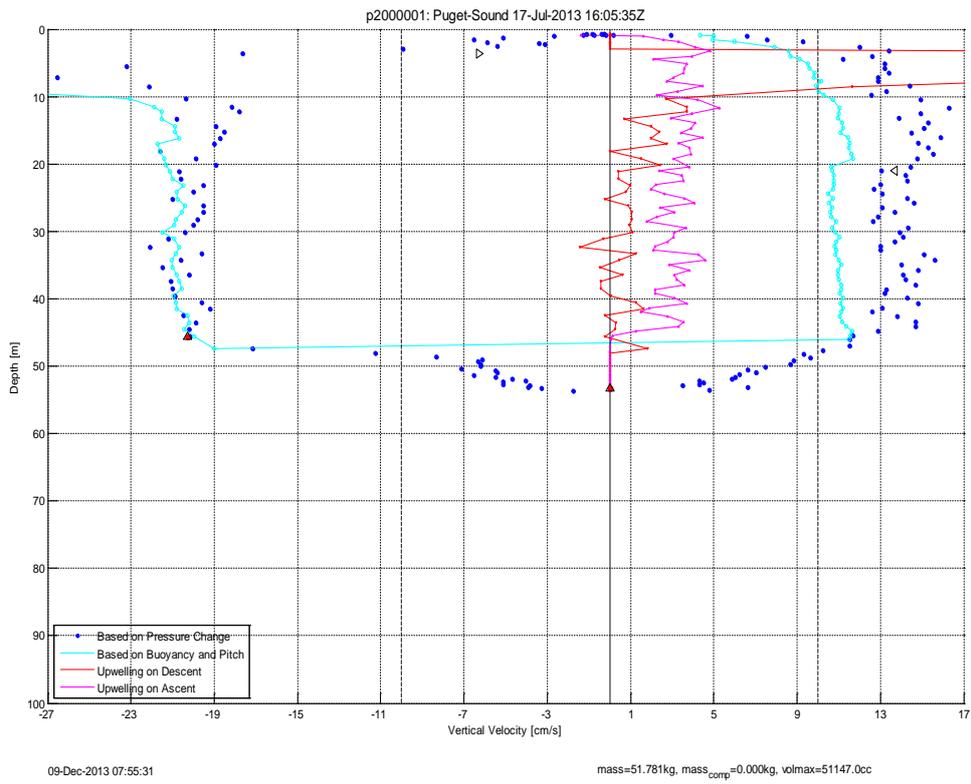
Figure 8 Vertical Velocities plot

5.3.5 The Pitch plot

The pitch control plot displays the current pitch center and gain (C_PITCH and PITCH_GAIN) parameters (Figure 9). Ideally the pilot wants the cm per degree regression line to cross through (0,0). The recommended pitch center and gain is calculated and displayed.
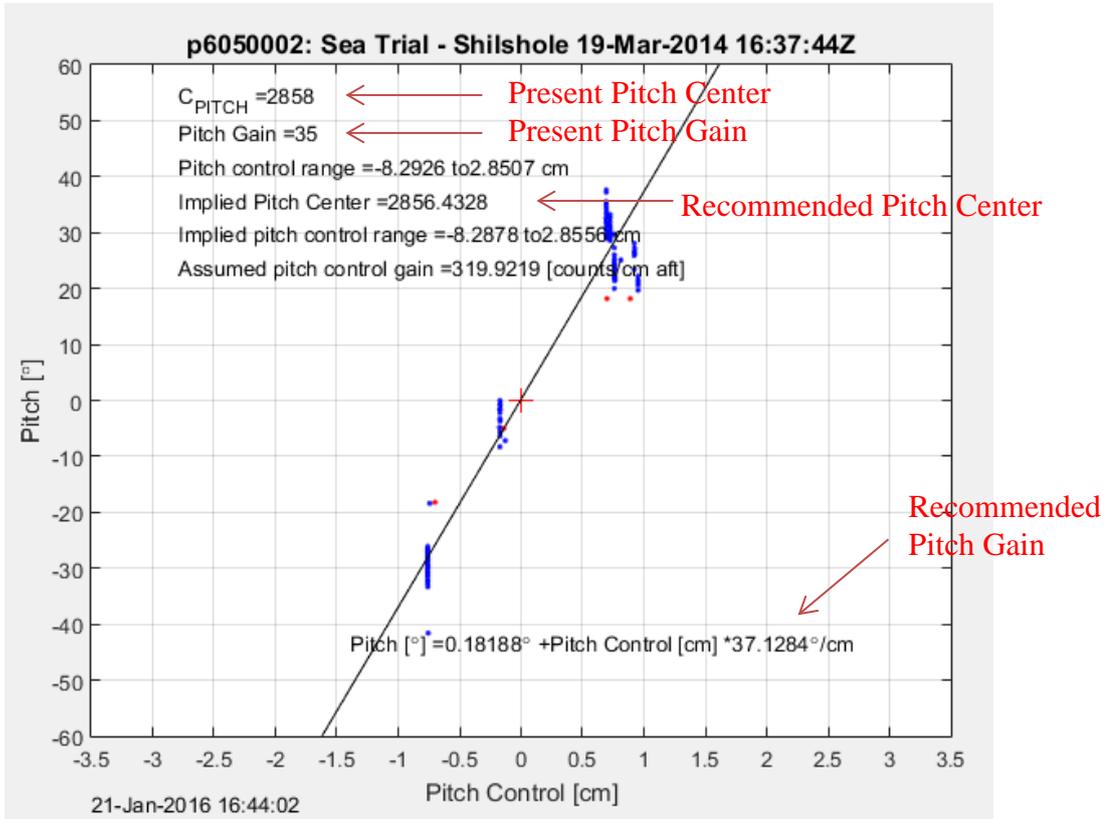

Figure 9 Pitch plot

5.3.6 The Roll plot

Roll control for making the glider fly straight is displayed on plot 10 (Figure 9). The plot displays the roll control on the descent and ascent as well as the current roll centers and gain values. Ideally, both regression lines should pass through (0,0) and be closely aligned. Regression line alignment is a measure of how well the glider is rolling to port and starboard in equal measure. Also included in the information at the top of the plot are the suggested values for C_ROLL_DIVE and C_ROLL_CLIMB. When trimming roll, information from this plot and the Roll Rate Plot should be compared both within and between 3-5 dives before making any adjustments to C_ROLL_DIVE or C_ROLL_CLIMB. Since roll is affected by the Cb:Cg separation and sea conditions (can affect pitch, heading etc.) the suggested corrections to roll trim can vary significantly between both the Roll Control Plot and the Roll Rate Plot within a dive as well as between dives. If there is a consensus in the direction of change between the Roll Control Plot and the Roll Rate Plot within a dive, look at the roll plots from the previous 2-4 dives. If the majority of these dives agree in the direction of change, then a change should be made. Use the 50% change rule on the smallest suggested correction and continue making corrections as needed on subsequent dives until the actual and desired roll centers are with 100 counts of each other. Due to physical asymmetries in Seaglider, the roll center values for C_ROLL_DIVE and C_ROLL_CLIMB will generally be different.
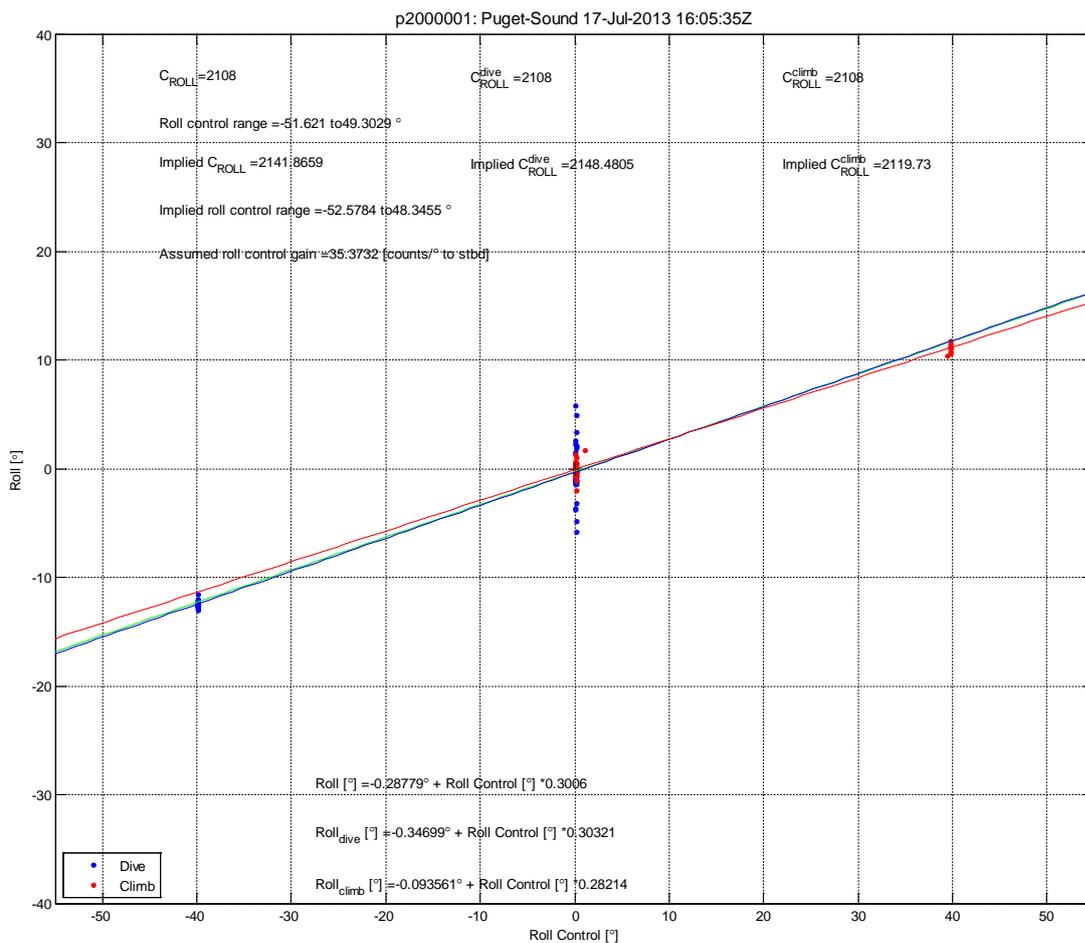

Figure 10 Roll plot

5.3.7 The Roll Rate plot

The turn rate plot (Figure 10) displays Turn Rate (deg/sec) vs. Roll Control (deg). Present roll centers for dive and climb, gain and the implied (suggested) roll centers for dive and climb are also displayed on this plot. Ideally, the descent and ascent regression lines should create a symmetrical X pattern crossing at (0, 0). The red and blue dots should be offset equally from the turn rate = 0 line. The red and blue lines should also run through the center of the red and blue dots, respectively.

When trimming roll, information from this plot and the Roll Plot should be compared both within and between 3-5 dives before making any adjustments to C_ROLL_DIVE or C_ROLL_CLIMB. Since roll is affected by the Cb:Cg separation and sea conditions (can affect pitch, heading etc.) the suggested corrections to roll trim can vary significantly between both the Roll Plot and the Roll Rate Plot within a dive as well as between dives. If there is a consensus in the direction of change between the Roll Plot and the Roll Rate Plot within a dive, look at the roll plots from the previous 2-4 dives. If the majority of these dives agree in the direction of change, then a change should be made. Use the 50% change rule on the smallest suggested correction and continue making corrections as needed on subsequent dives until the actual and desired roll centers are with 100 counts of each other. Due to physical asymmetries in Seaglider, the roll center values for C_ROLL_DIVE and C_ROLL_CLIMB will generally be different.
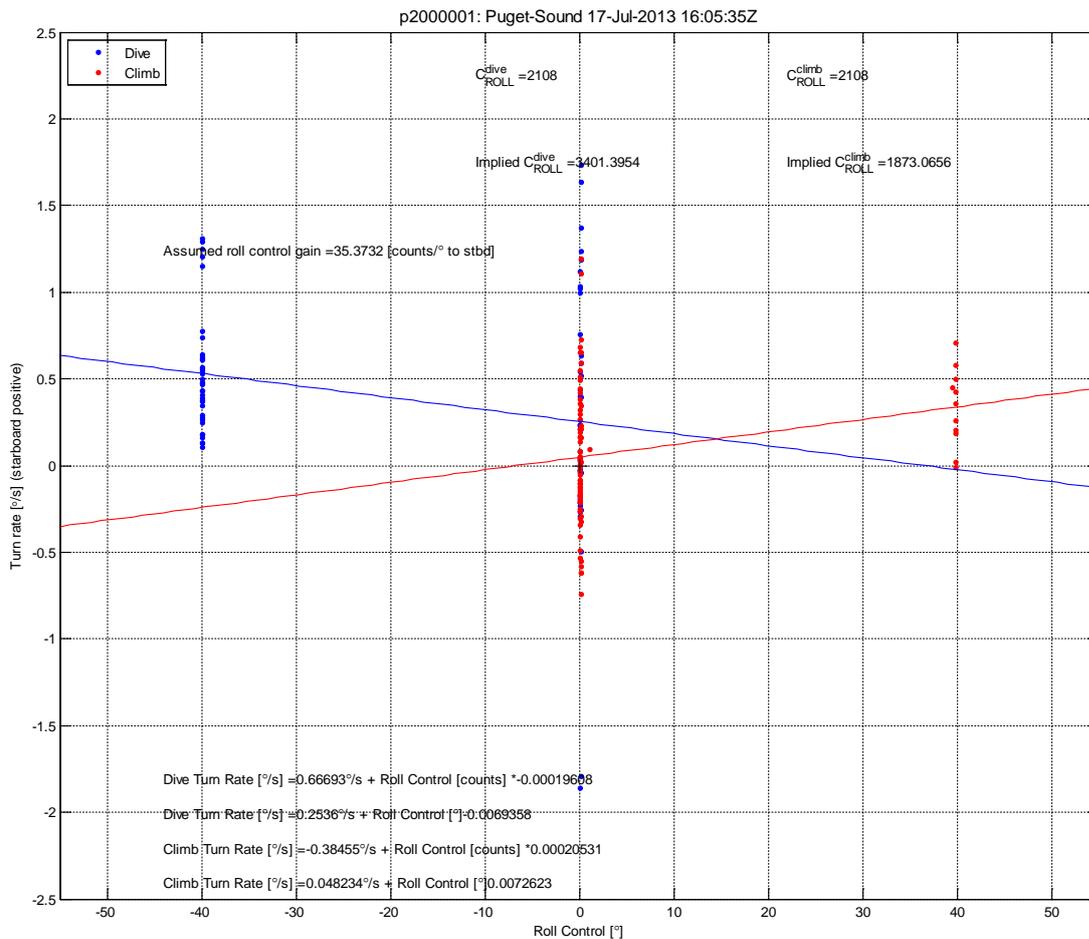
Figure 11 Roll Rate plot

5.3.8 The VBD plot

The VBD plot displays VBD in cc's at different σ, the current C_VBD, SM_CC (surface maneuver cc's) and the cc's, (CC$_{surfmin}$) needed at the surface to get the antenna out of the water. Implied mass at apogee is also displayed however, this is not typically used while piloting.

The CC$_{surfmin}$ can be used as a guide for setting the optimal $SM_CC for energy savings. The $SM_CC value should be 30-50 cc's greater than the CC$_{surfmin}$. Specifying a larger than recommended $SM_CC value means that the glider is pumping more oil than necessary. This not only wastes energy but it can also cause the rudder to break the water surface and act like a sail causing the glider to be pushed by the wind while it is at the surface.

Interpreting this plot: The diagonal multi-colored lines mark the buoyancy of the vehicle at any given time during the dive.

The lower horizontal green line is the glider bleeding as it leaves the surface. Note that there is a stair step in this example. It is caused by the glider reaching $D_FLARE, temporarily stopping the VBD bleed and triggering the pitch to change from nose down to the glide angle computed for the dive. Once the pitch maneuver is completed the glider resumes the bleed until it reaches the desired thrust or $MAX_BUOY, whichever is smaller. The vertical green line on the right side of the plot shows, from bottom to top, the cc's the glider bled to (thrust), the center of buoyancy value taken from the C_VBD parameter and the cc's the glider pumped to begin the climb (the absolute value of the amount the glider bled on the dive).

The upper horizontal green line is the number of cc's the glider pumped to ascend.

If the CVBD '+' located in the center of the vertical green line aligns with the '0' buoyancy diagonal grid line the glider is neutrally buoyant at that C_VBD value and density. This is not the case in the example below. This example shows that the glider is heavy by approximately 25 cc's (the plus is located approximately half way between the 0 and -50 cc diagonal buoyancy lines. The heaviness may be from an incorrectly trimmed VBD or it could be from an incorrect value for mass, maximum volume, or water density. Vehicle mass, $MASS, and water density, $RHO, values are used by the glider (cmdfile) and by the basestation (sg_calib_constants.m). Maximum volume (VOLMAX) is used in the sg_calib_constants.m file on the basestation.
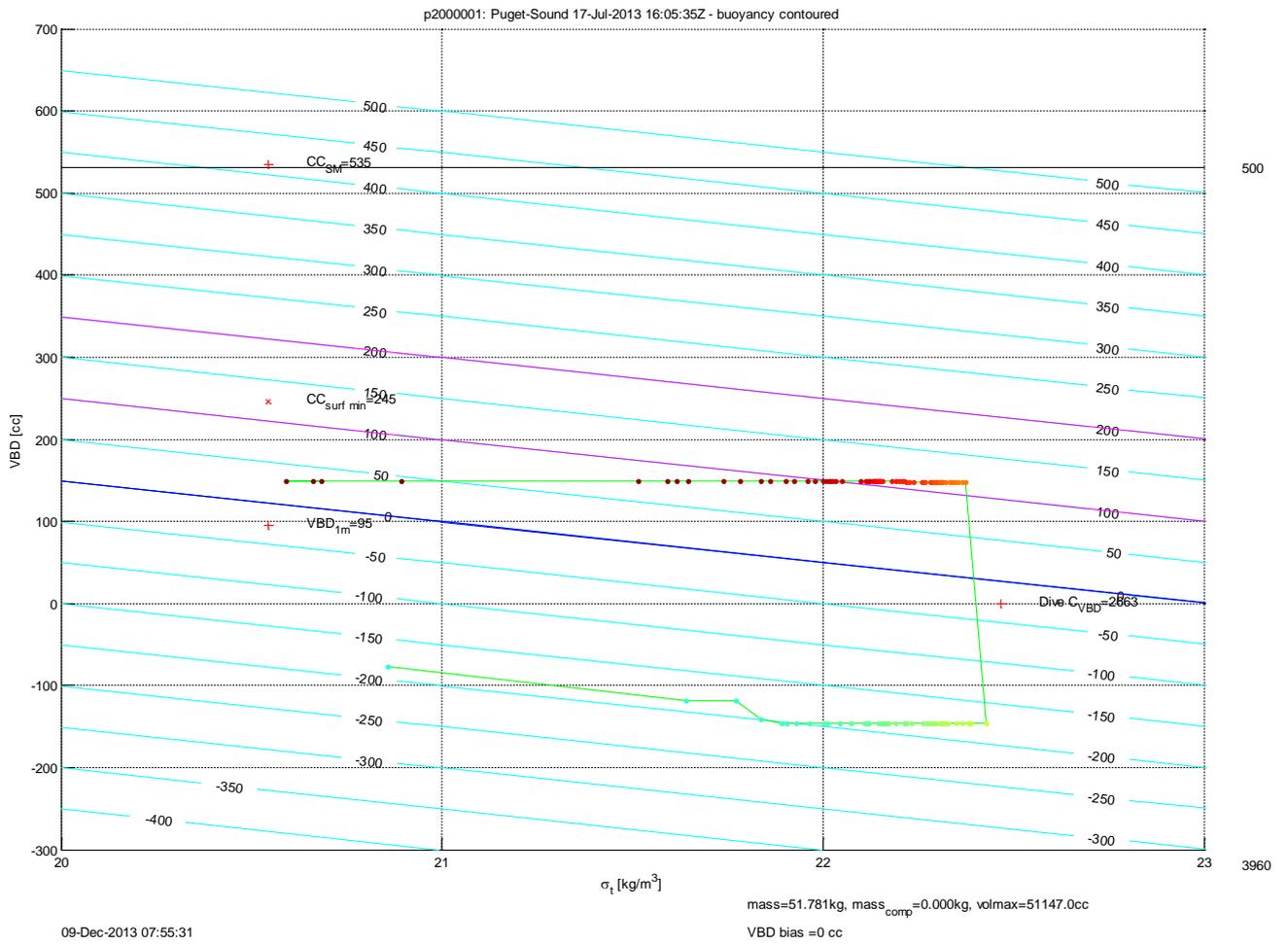
Figure 12   VBD plot

5.3.9 The Temperature and Salinity plot

The Temperature and Salinity plot displays the temperature and salinity as a function of depth for the descent (dive) and ascent (climb).
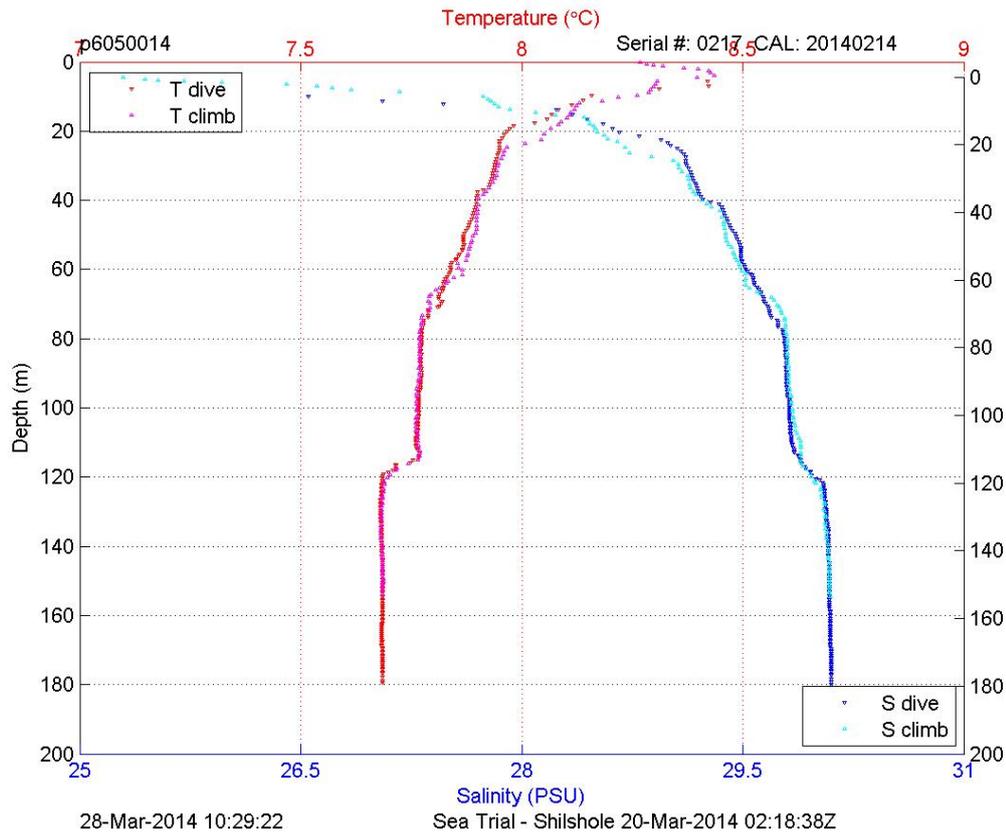

Figure 13 Temp & Salinity plot

5.3.10 The T vs. S plot

The Temperature versus Salinity plot displays the relationship between in situ temperature and salinity, and density at atmospheric pressure (Figure 13)) $P_{(0)}$. Density (in the form of σ_t is displayed on the plot as isopycnal curves. Color coding of the descent and ascent data is defined in the legend.
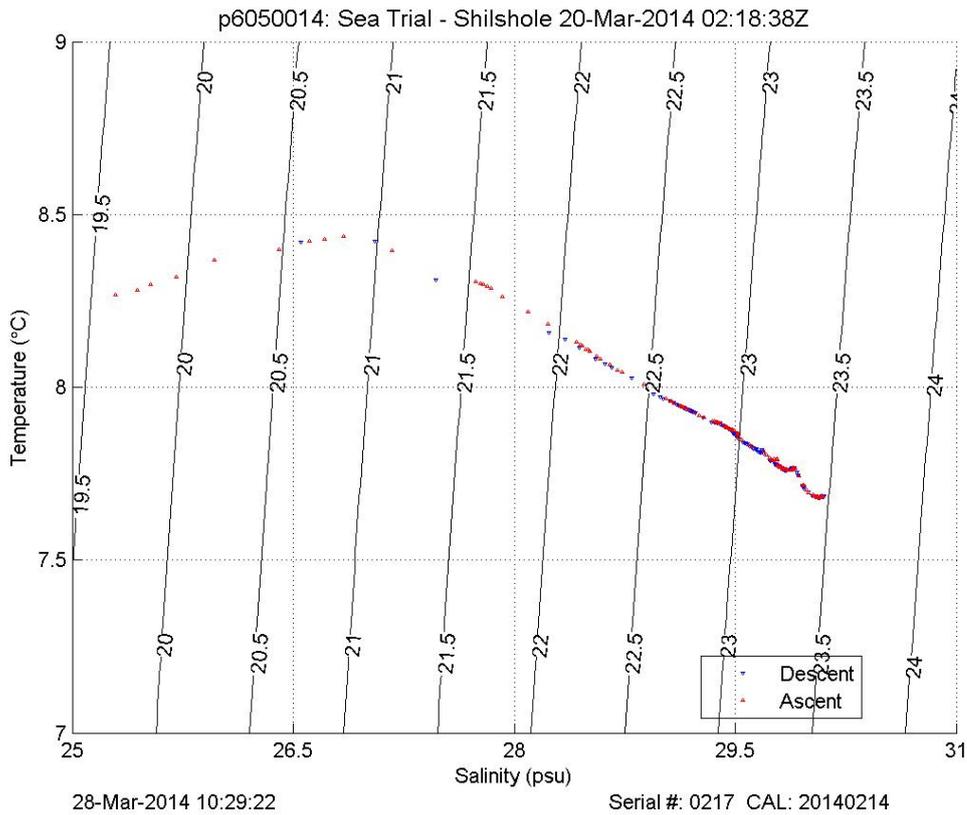

Figure 14 T vs. S plot

5.3.11 The Dissolved Oxygen plot

The Dissolved Oxygen (DO) plot (Figure 15) shows data collected by the Aanderaa Optode. Plotting capability is also present for SBE DO data. Uncorrected and corrected data is shown for both the descent and ascent portions of the dive. Additionally, if DO data is available, the graph will display oxygen saturation data. Oxygen saturation data is calculated using the Seawater library (part of MATLAB scripts). The seawater library uses salinity, temperature, and pressure for this calculation and does not require oxygen data acquired from DO sensor.
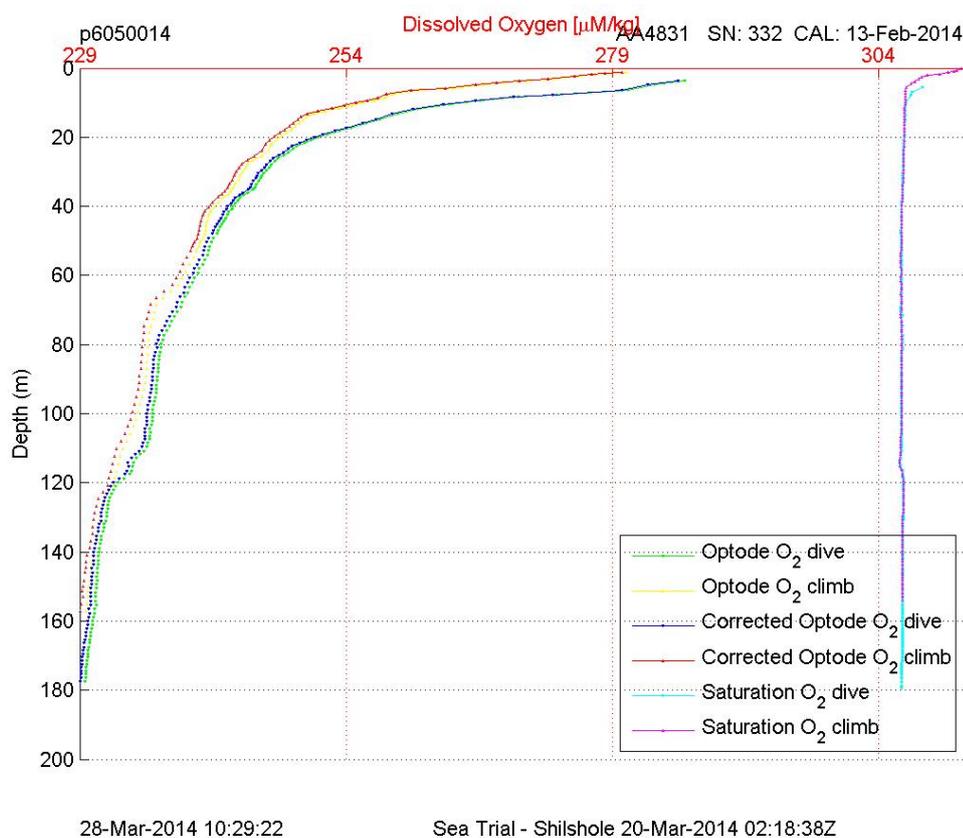

Figure 15 Dissolved Oxygen plot

5.3.12 The Fluorometer plot

The Fluorometer plot displays the fluorescent response of substances in the water. If the sensor is measuring multiple fluorescences, each is displayed in its own plot. The type of fluorescence being plotted, as well as the color coding of the ascent and descent data, is defined in the plot legend.
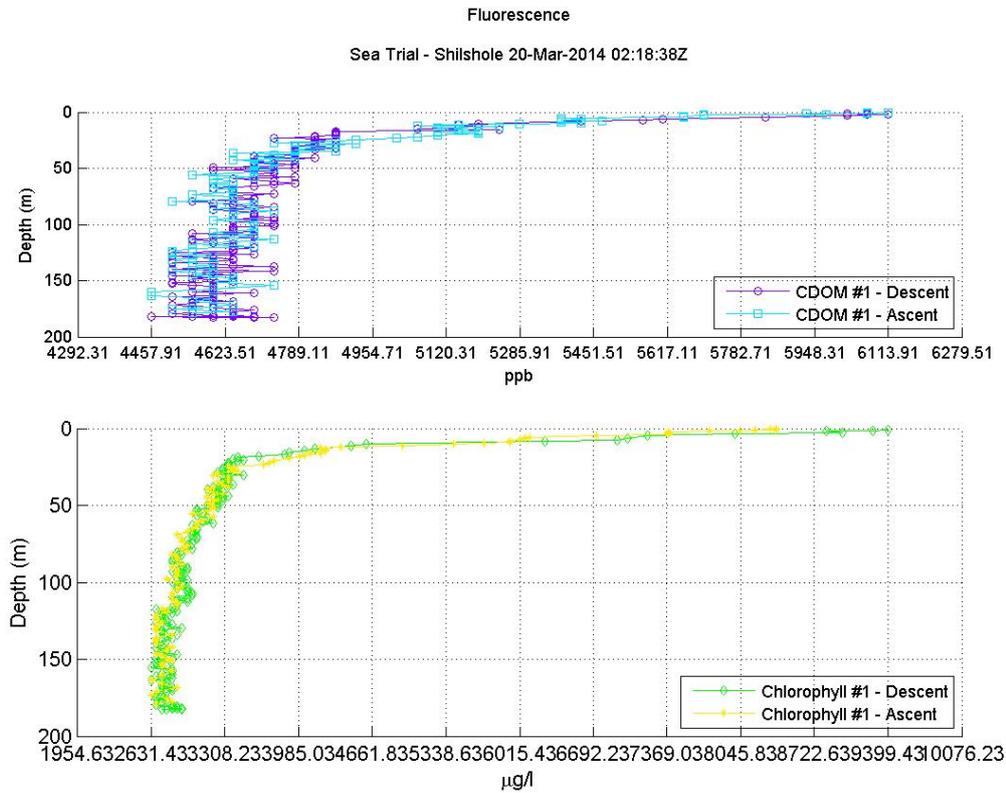

Figure 16 Fluorometer plot

5.3.13 The Backscatter plot

The backscatter plot displays measured wavelengths of signals from concentrations of material in the water. If the sensor is measuring multiple backscatter wavelengths, each is displayed in its own plot. The wavelength being plotted, as well as the color coding of the ascent and descent data, is defined in the plot legend.
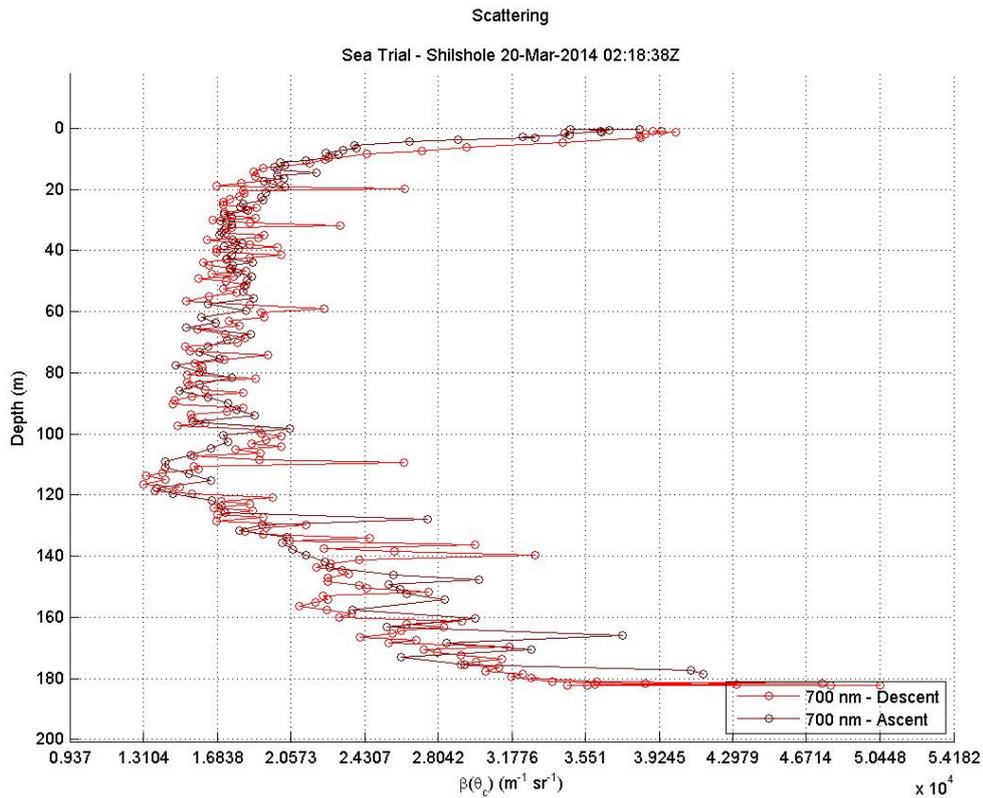

Figure 17 Backscatter plot

5.3.14 The PAR plot

The Photosynthetically Active Radiation (PAR) plot shows the light penetration versus depth as measured by the PAR sensor. Color coding of the ascent and descent data, is defined in the plot legend.
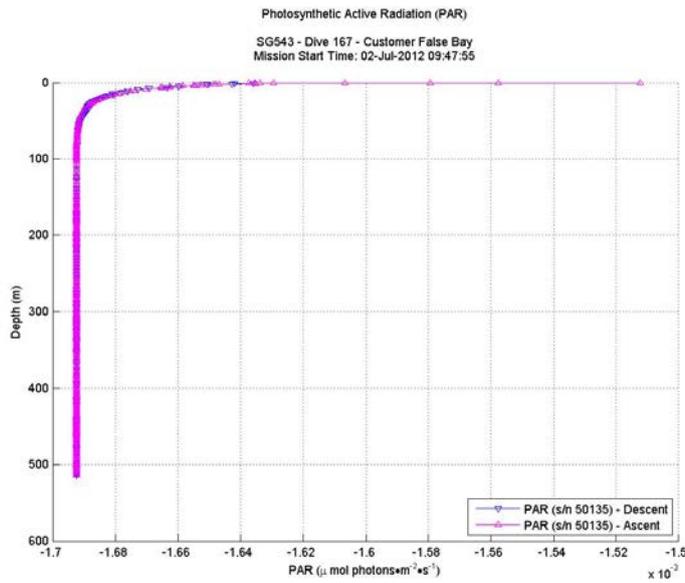

Figure 18 PAR plot

5.3.15 The Internal Humidity and Pressure Timeseries plot

This plot shows the values from all of the dives in the current directory. There is one internal humidity and one internal pressure value for each dive.
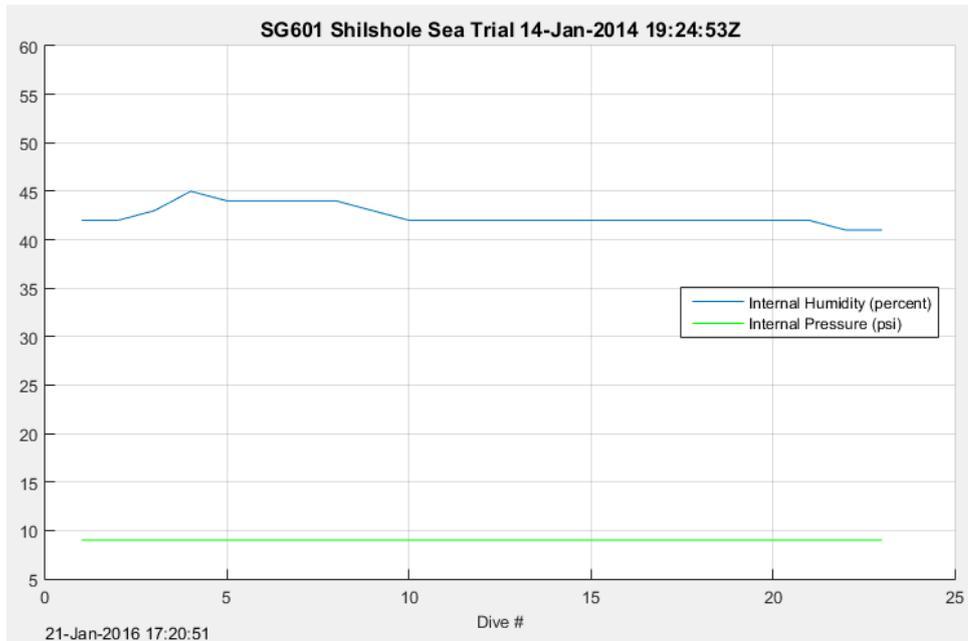

Figure 19 Internal Humidity & Pressure plot

5.3.16 The Voltage Timeseries plot

This plot shows the voltage values from all of the dives in the current directory.
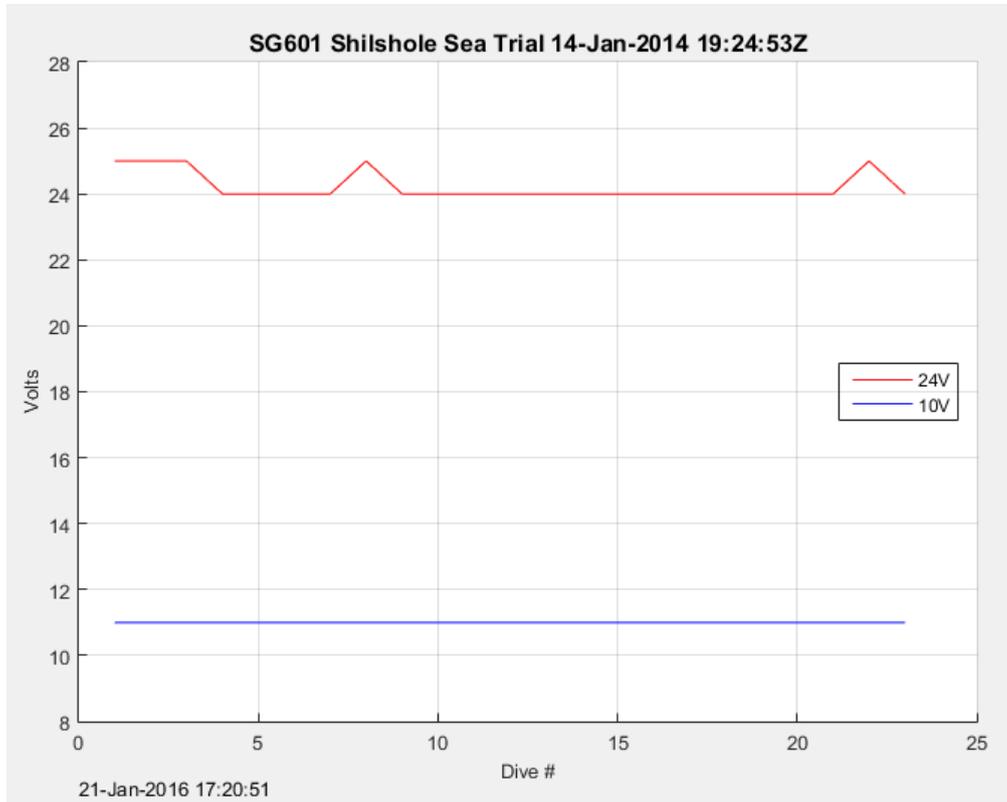

Figure 20 Voltage Timeseries plot

5.3.17 The Timeseries Bar Graphs plot

This plot shows several operation parameters from all of the dives in the current directory. For each dive, the number of transponder pings, the number of phone calls, the number of spurious interrupts, the number of VBD errors, and the number of VBD retries are plotted.
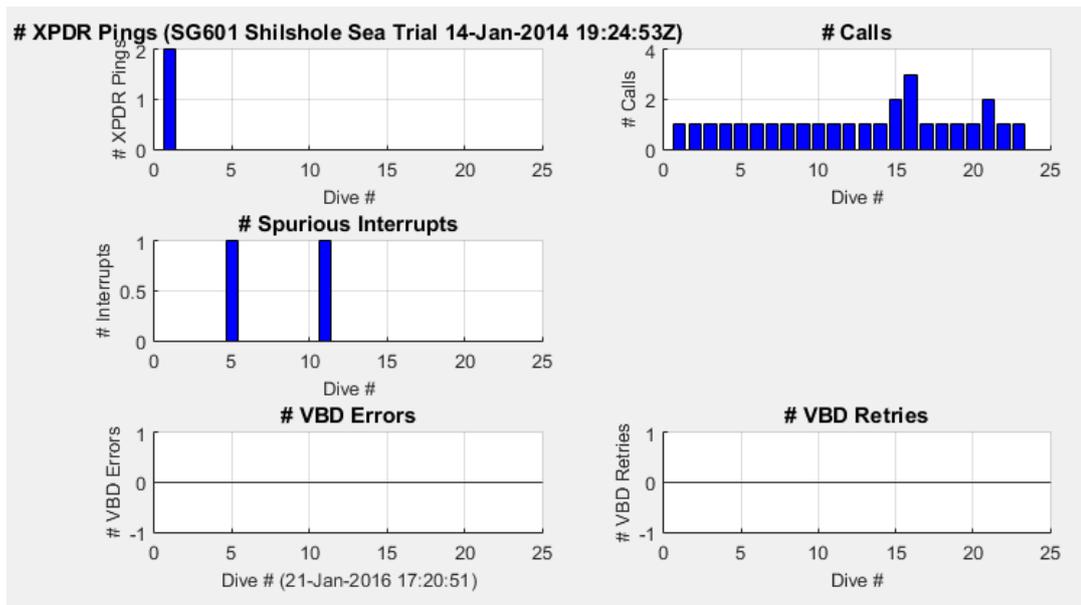

Figure 21 Timeseries Bar Graphs plot

5.4 Show Track in Google Earth

The location of the vehicle at the start and end of a dive can be plotted in Google Earth. First select the set of dives to be plotted in the "Dive Numbers" list, then click the "Show Track" button.

If Google Earth is installed, it will automatically start and display the locations of the dives.
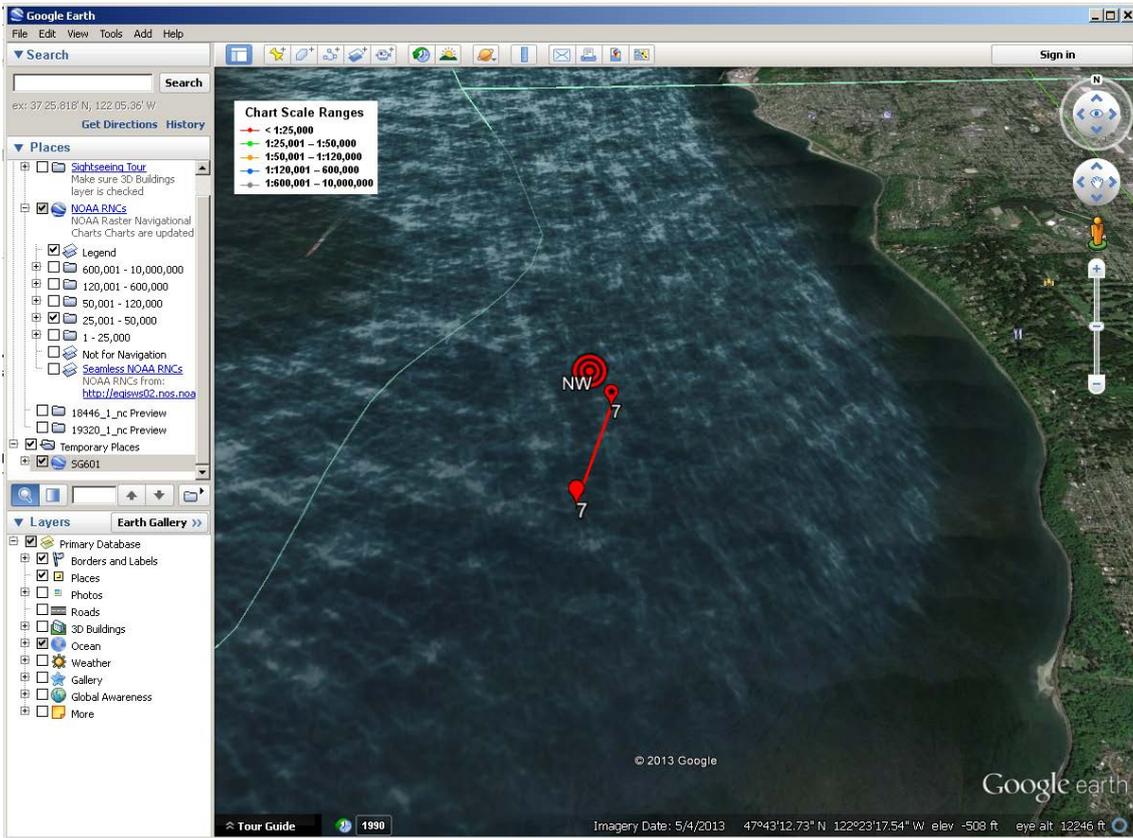

Figure 22 One Dive displayed in Google Earth

The solid-color marker indicates the start of the dive. The dive number is shown next to the marker. The marker containing an asterisk indicates the end of the dive. The "bulls-eye" marker indicates the position of the target of the same name in the "targets" file.

If Google Earth did not automatically start up, look in the dive data directory for a file with a ".kml" extension. Drag and drop this file onto the Google Earth icon to display the dive's locations.