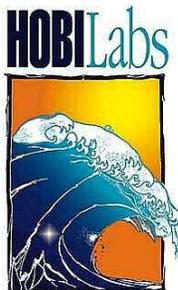# HydroScat-2
Spectral Backscattering Sensor & Fluorometer

User's Manual
Revision I

HOBILabs

Hydro-Optics, Biology & Instrumentation Laboratories

Lighting the Way in Aquatic Science
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Current Firmware Version: 1.92

Other firmware versions may differ in some respects. Contact HOBI Labs for information on how to upgrade HydroScat firmware.

Revisions

I, December, 2011: Correct equation symbols in section 9; formatting; update section 2.2.

H, June 15, 2008: Add notes about factory maintenance and cleaning windows (section 2).

G, June 6, 2007: Correct and clarify sigma correction, sections 9.5 and 9.6

F, October 22, 2004: Update description of sigma correction to reflect changes in HydroSoft 2.7 (section 9.6). Add STARTNOLOG command (8.3.19)

E, December 23, 2002: Remove references to PDI box. Add dimensions of deep sea rated version to Figure 4 (page 7). Corrected time format in "T" packet, section 9.3.2., and checksums in example packets (section 9.1) **.** Add description of exponential sigma correction (section 9.6)

May 20, 2002: Revise Shutter command (section 10) and include more references to shutter throughout; add oil-encapsulated depth sensor (0); add note about preserving data in case of reset (section 11); add to discussion of magnetic switch behavior (section 5.9); update calculation of b_b and add description of Backscattering Parameters in HydroSoft (9.5) recommend minimum start delay and warm-up time of 3 seconds; grammatical and format corrections.

February 20, 2002: Update addresses, contact information

June 15, 2001: Add anti-fouling shutter (section 10 and elsewhere).

February 16, 2001: Start of revision tracking. Extensive reorganization, changes to incorporate HydroSoft, separate HydroScat-2 from HydroScat-6.

TABLE OF CONTENTS

1. INTRODUCTION

1.1. Overview

The HydroScat-2 is a self-contained instrument for measuring optical backscattering (b_b) at two wavelengths in natural waters. Its unique optical geometry and sophisticated electronics also provide simultaneous measurement of the fluorescence excited at the longer wavelength by the shorter wavelength source. The HydroScat-2 includes a depth transducer, rechargeable batteries, a data logger with real-time clock, and an external switch for controlling logging. The data logger supports a wide range of sampling rates, as well as burst-mode sampling for collection over extended periods.

1.2. Optics

This brief overview introduces the key concepts necessary for understanding the HydroScat's measurements. The optical principles are covered in much greater detail in "Instruments and Methods for Measuring the Backward-Scattering Coefficient of Ocean Waters", by Robert A Maffione and David R. Dana, *Applied Optics* Vol. 36, No. 24, 20 August 1997.

The HydroScat-2 has two independent channels, each sensitive to a different narrow range of optical wavelengths. Each channel consists of separate source and receiver optics. The source produces a beam of light in the water, and the detector collects a portion of the light that is scattered out of that beam by the water.

Each source beam originates from a light-emitting diode (LED) selected to match the desired measurement wavelength. The beam from the LED enters the water at an angle approximately 20 degrees from normal. The receiver consists of a prism that bends the field of view toward the source beam, a band-pass interference filter that determines the exact wavelength range of the measurement, and lens that focuses the received rays onto a silicon detector.

The divergences of the source beam and receiver field of view, the angles of the prisms, and the distance between the source and receiver windows, determine the range of scattering angles over which the measurement is made. The HydroScat geometry results in a measurement centered on a scattering angle of 140°.

The fraction of the transmitted light scattered in the desired range of angles is extremely small, and one of the prime considerations in the optical design is

maximizing this inherently low throughput. Thus we maintain at least a 2 cm open aperture throughout the optical path.
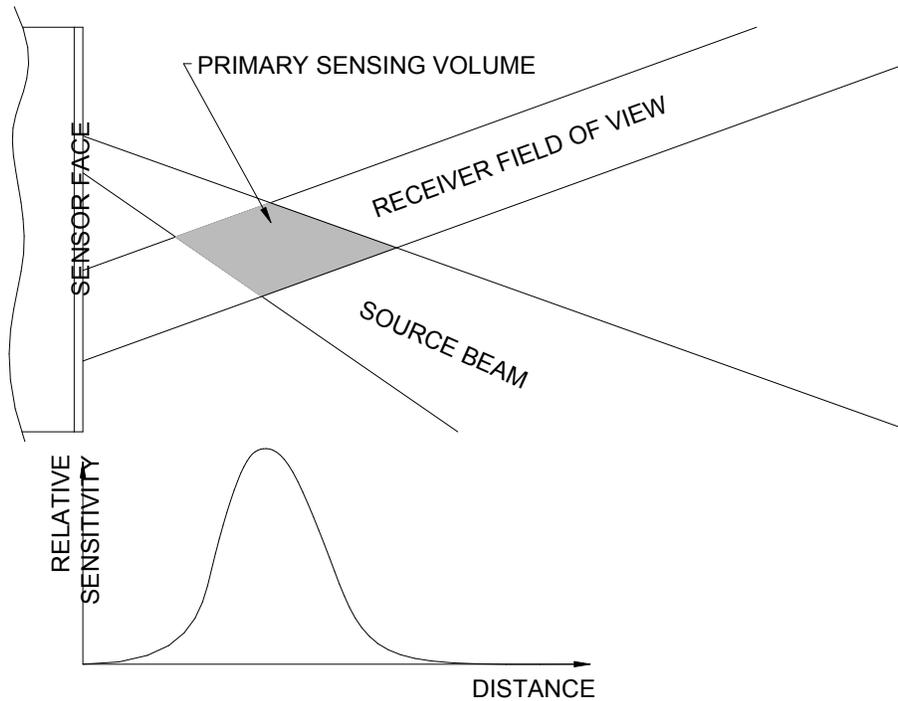
Figure 1 Side View of Backscattering Measurement Geometry

1.3. Electronics

The inherently low optical throughput of the backscattering measurement demands very sensitive electronics. In clear water the backscattering signals arriving on the detector may be as low as a few picowatts. At the same time, natural background light may be orders of magnitude larger.

To separate backscattering signals from background light, the LEDs are modulated at audio frequencies, and synchronous receiver electronics used to discriminate against interfering signals. Each channel has a different frequency to prevent any crosstalk between channels. This also allows us to discriminate between backscattering and fluorescence (see section 1.4).

To allow measurement in a wide range of waters, and to accommodate the requirements of our calibration procedure, the gain of each channel can be set to one of five settings spaced a decade apart. Only three of these settings are used in normal measurement situations; the lowest two are used primarily for calibration. The HydroScat normally selects the appropriate gain automatically, based on the amount of backscattering detected as well as the amount of background light.

In order to compensate for residual electronic offsets, the HydroScat periodically turns off each LED briefly to measure the receiver output in the absence of signal. The LEDs are turned off for 0.1 second approximately every 2 seconds, and the resulting offsets are continuously averaged and subtracted from the signals. Note that this is not the modulation, referred to previously, that separates the backscatter signals from each other and from background radiance; those modulations are too rapid to be visible.
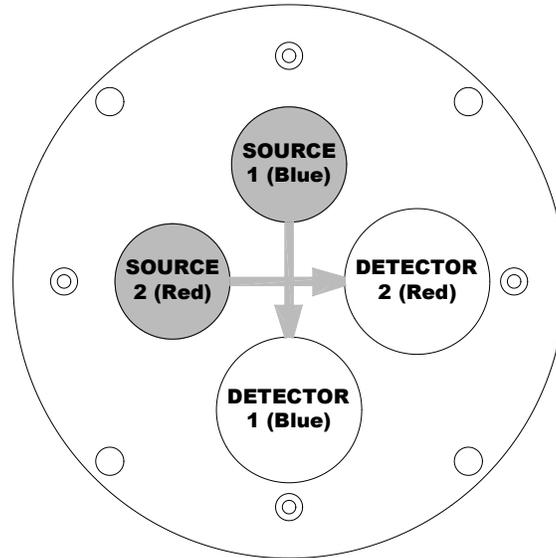
Figure 2 HydroScat-2 Front End Cap

1.4. Fluorescence Measurements

The HydroScat is optimized for measuring elastic backscattering, but offers a secondary capability of measuring fluorescence.

Because each LED in the HydroScat is modulated at its own frequency, fluorescence excited by a particular channel can be identified by the excitation channel's characteristic frequency, even though its emission falls into the optical bandwidth of another channel. The HydroScat receiver channels can be "tuned" under software control to the frequency of another channel's source, allowing them to detect fluorescence instead of backscattering. If the field of view of a channel intersects the beam produced by another channel, it can collect fluorescence from that channel as efficiently as it does backscattering from its own source.

The HydroScat-2's two channels are configured with crossing beams and fields of view (see Figure 2) so that the longer wavelength channel, usually 676 nm, detects both backscattering from its own source, and fluorescence excited by

the shorter wavelength source, usually 470 nm. The received signal from the long-wavelength channel is sent to two sets of detection electronics, one tuned to each source. Thus the HydroScat-2 simultaneously measures backscattering at two wavelengths and fluorescence at one wavelength.

The fluorescence channel is not calibrated to an absolute standard, so its data are reported in arbitrary units.
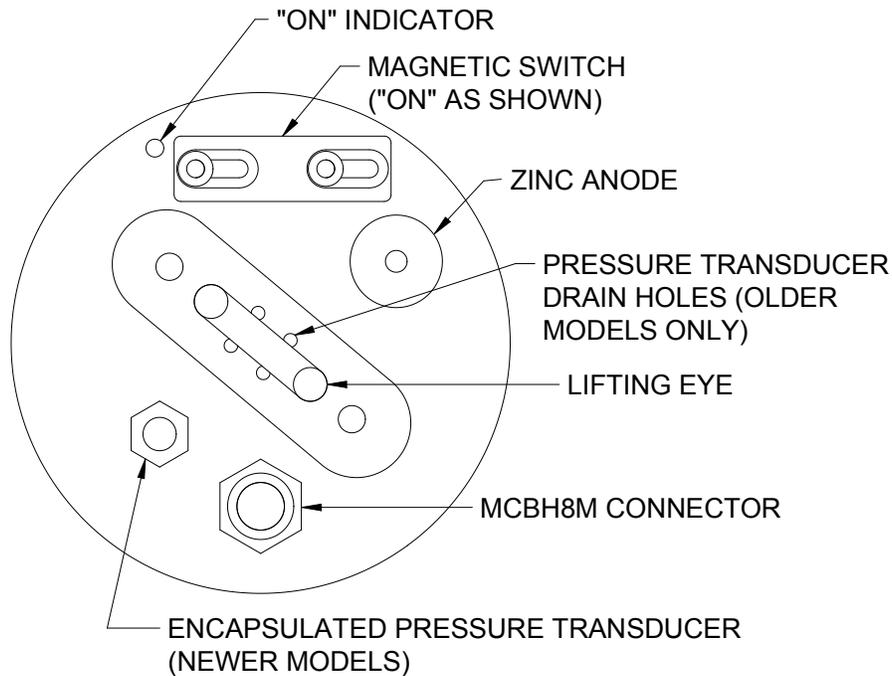
Figure 3 HydroScat-2 Back End Cap

2. PRECAUTIONS AND MAINTENANCE

The HydroScat-2 is a sophisticated optical instrument that requires regular care and calibration. HOBI Labs is not responsible for the accuracy of data if you do not observe the following recommendations.

2.1. Precautions

- Protect the windows. Cover the instrument face whenever possible. Do not use acetone to clean any part of the instrument.

- Thoroughly clean the HydroScat with fresh water before storing it.

- Avoid letting the sensor sit in direct sun on deck. If the water temperature is very different from the temperature on deck, let the instrument stabilize in the water for 10 minutes before collecting data.

- See section 7 for information about maintaining internal batteries.

2.2. Calibration and Factory Maintenance

We recommend calibrating the HydroScat–2 every six months or 200 hours of operation, whichever comes first.

With the proper equipment, available from HOBI Labs, users can perform their own calibrations. For more information about the equipment and procedures involved, see the HOBI Labs Backscattering Calibration Manual (available at www.hobilabs.com).

NOTE: Even if you perform your own calibrations, it is very important to return the HydroScat-2 to HOBI Labs, preferably annually, for a complete functional test and check-out. Inspection and testing by trained factory personnel can uncover items that may not be evident to users, but which can affect the reliability or endurance of the instrument.

2.3. General Cleaning

Upon removing the instrument from the water, rinse it thoroughly with fresh water, and rinse the windows with distilled or deionized water. Periodically inspect the windows for contamination.

2.4. Windows

HydroScats have acrylic windows that are easily scratched. Minor scratches will not seriously compromise the measurements, but the windows must be treated carefully to avoid abrasion. Do not use acetone or abrasive cleaners. Do not over-clean the windows. Unless the windows become visibly dirty during use, it is usually sufficient to rinse them with clean fresh water each time the instrument is removed from the water. If necessary, clean them with a mild liquid soap or lens-cleaning solution. Occasional cleaning with alcohol is also safe, but usually not necessary.

2.5. Pressure Transducer

If your HydroScat-2 has an encapsulated pressure transducer with a plastic wick attached, use care to ensure the wick is not damaged so as to allow the silicone oil to leak out. If your HydroScat-2 has the older style of transducer under the suspension eye (see Figure 3 on page 4), flush the pressure transducer with fresh water when rinsing the instrument. If possible, spray water directly into the drain holes, but not at very high pressure.

2.6. Connector

Occasionally apply silicone lubricant to the connector pins. The connector should mate smoothly without great force. Well-lubricated connectors also disconnect fairly easily, so use the connector locking sleeve during deployment.

2.7. Mounting and Deployment

The HydroScat can be suspended vertically from the metal eye on the connector end cap, or strapped to another support. If mounting it to another structure, protect the finish on the case from direct metal contact.

To ensure that the HydroScat does not detect reflections from any objects, keep a 30-degree cone in front of the windows clear for at least 1 meter. Even objects that appear very non-reflective, or are well out of the nominal sampling volume, can create substantial offsets in the backscattering measurement. It is usually permissible to violate this conservative 30-degree limit, but you should verify by experiment that the instrument's readings are not elevated if you do so.

It is usually preferable for the sensor to face directly down in the water, to minimize the effect of background illumination. However in shallow water over a reflective bottom, under bright solar illumination, light reflected into the windows may cause high noise levels or, in extreme cases, saturation. In such situations it may be advantageous to mount the sensor horizontally so that the backscattering receivers do not face the bottom. Some experimentation may be required in such cases.

HydroScats equipped with internal batteries can be deployed with only a mechanical cable or attached to an existing package without additional cabling. If the HydroScat is attached to an existing package, make sure that the field of view of the sensor is unobstructed as mentioned above.
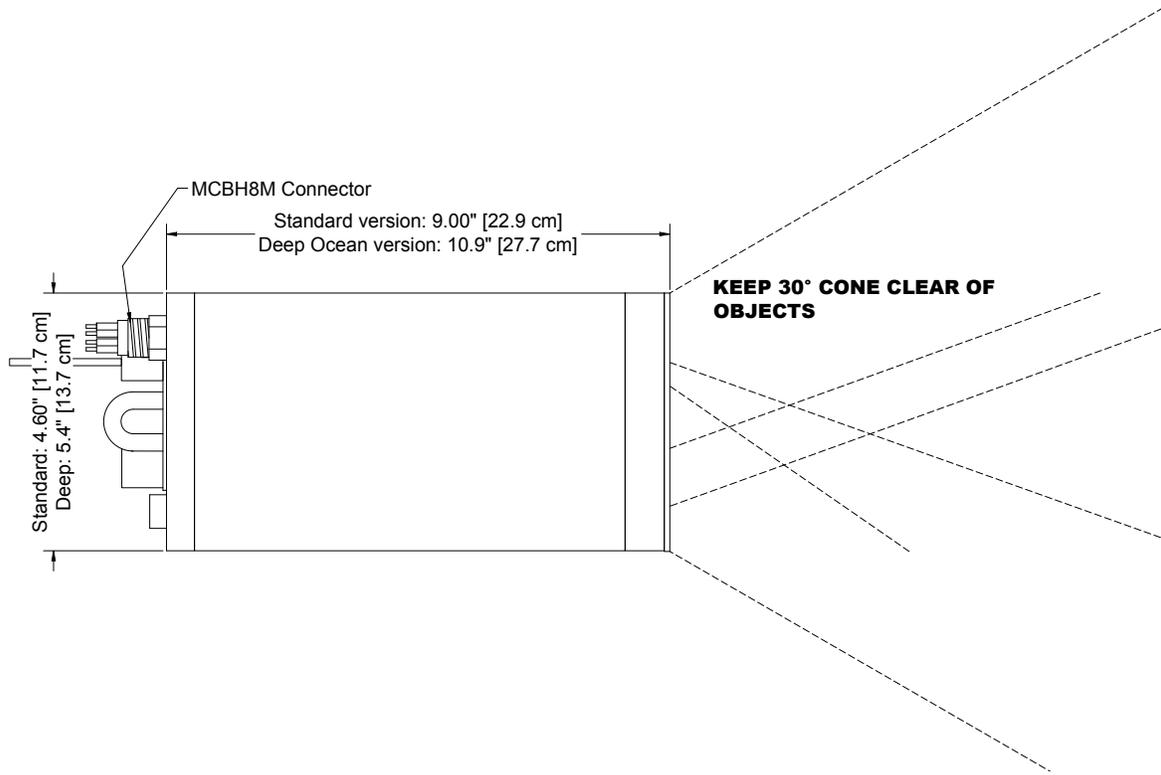
Figure 4 HydroScat-2 Side View

3. QUICK START

3.1. Setup

1) Install HydroSoft on your computer (see section 4.1 or the HydroSoft manual).

2) Connect the supplied data download/charging cable to the appropriate port on your computer.

3) Connect the cable to the underwater connector on the HydroScat.

4) Plug the cord from the battery charger transformer into the barrel connector on the data cable.

5) Plug the battery charger transformer into a 120 VAC jack.

6) Run HydroSoft by selecting it on the Windows **Start** menu.

7) Click |≫| (or select **Connect** from the **Instrument** Menu).

8) Click the **Search** button.

9) After a short time HydroSoft should identify the instrument, load its calibration, and close the Connect dialog box. If your HydroScat is equipped for an anti-fouling shutter (see section 10) and programmed to open the shutter at the time it wakes up, it may not respond to HydroSoft's initial query, and you may need to repeat the search.

10) Select **Set Date/Time...** from the **HydroScat** menu.

11) Click **Set Time** to synchronize the HydroScat clock with your computer's clock. This will take several seconds. Then click **Close** to close the Date/Time dialog box.

3.2. Collecting Data

12) Select **Sampling Options...** from the **HydroScat** menu.

13) For testing purposes, we recommend the following settings:

    Sample Rate: 2 per second

    Start Delay: 0 seconds

    Burst mode: unchecked

14) Select **Plot Vs. Time** from the **Graph** menu.

15) Click ⟨icon⟩ (or select **Start** from the **HydroScat** menu). This will cause data to be logged in the HydroScat's logging memory as well as sent to HydroSoft.

16) If no data are visible after a short time, click ⟨icon⟩, and the plot will zoom as needed to show all data.

17) To adjust the way data are displayed, double-click on the graph, or select **Properties...** from the **Graph** menu.

18) Click ⟨icon⟩ (or select **Stop** from the **HydroScat** menu).

19) Close the open data file by selecting **Close** from the **File** menu, or clicking on the ⟨icon⟩ button. If desired, save the file when prompted.

3.3. Downloading Data From the HydroScat

20) Select **Get Data From Instrument** from the **HydroScat** menu.

21) After several seconds a directory of casts in memory will appear. The last cast listed should be the one you just recorded. If that cast is not already highlighted, click on it to highlight it, or click the **Select All** button.

22) Click the **Browse...** button to select a directory in which to save downloaded data files. In the resulting dialog box, select a directory and click the **Select** button.

23) If it is not already checked, check the **Create calibrated data (.dat) files** option.

24) Click the **Download** button to begin transferring data casts.

3.4. Disconnecting

25) After you are finished communicating with the HydroScat, select **Disconnect** from the **HydroScat** menu. When asked "**Put HydroScat to sleep before disconnecting?**" click **Yes**.

26) Unplug the battery charger from AC power.

27) Unplug the cable from the HydroScat's underwater connector.

3.5. Switch-Activated Logging (see also section 5.9)

28) To start a cast when the HydroScat is asleep and disconnected from the computer, move the magnetic switch to the on position (see Figure 3 on page 4).

29) To end a cast, return the magnetic switch to the off position.

4.   HYDROSOFT SOFTWARE

HydroSoft is HOBI Labs' Windows-based software for communicating with HydroScats as well as other instruments. Instructions in this manual assume you are using HydroSoft to communicate with your HydroScat, and cover its primary functions. You may wish to consult the separate HydroSoft manual for a more complete description and details.

4.1.   Installing HydroSoft

HydroSoft is supplied on a CD-ROM with new instruments, and can be supplied on floppy disks by request. We also recommend you visit our web site (www.hobilabs.com) to check for downloadable updates to HydroSoft.   It is installed using a procedure that is familiar to most Windows users.

1. Run "InstallHydroSoft.exe" from CD-ROM, or from your computer if you have received it through the Internet.
2. Click the "Next" button in the installer's "Welcome" dialog box.
3. Decide whether you would like the HydroSoft application stored in the default directory shown (normally c:\program files\HOBI Labs). If not, click the "Browse" button to select a different directory, or type the name of a new directory you would like to create.
4. Click "Next" to start the installation.
5. When the installation is complete, click "Finish" to exit.

It is not normally necessary to reboot your computer unless the installer program explicitly instructs you to.

4.2.   Removing HydroSoft

1. From the Start menu, select "Settings", then "Control Panel".
2. Double-click on the "Add/Remove Programs" icon.
3. Select HydroSoft from the list of programs.
4. Click the "Add/remove" button.

OR

1. Open the directory into which you installed HydroSoft.
2. Double-click on the "unwise.exe" icon, which runs the uninstaller.

5. COLLECTING AND HANDLING DATA

5.1. Primary Data

The primary data reported in every sample are

- date and time,

- raw scattering for each channel,

- the gain of each scattering channel,

- pressure, and

- internal instrument temperature.

5.2. Housekeeping Data

HydroScats record certain "housekeeping" parameters that are not required for normal data processing, but can be valuable for troubleshooting and for evaluating the health of the sensor. They are

- battery and external supply voltages,

- background radiance on the detectors (in arbitrary units),

- reference measurements of the LED outputs, and

- signal offsets.

Normally the housekeeping data are logged at one-tenth the rate of the main data. That is, every ten samples are followed by one housekeeping sample.

5.3. Calibration Data

HydroScats data are transmitted in a partially processed hexadecimal form, which must be converted to calibrated units. The coefficients required for this conversion are unique to each instrument, and may be revised from time to time when the instrument is recalibrated. HydroSoft requires an appropriate calibration to be loaded before it can plot or store calibrated data from an instrument or raw data file.

5.3.1. Loading Calibrations

Calibrations can be loaded either directly from a connected HydroScat, or from a file on the host computer. To load an instrument's calibration, check the **Load Calibration From Instrument** option while connecting to the instrument

(section 5.4). To load a calibration from a file, choose Select Calibration File from the File menu.

If you select a new calibration file while an instrument is connected, or while a raw data file is open, HydroSoft will only load it if it is of a matching type. HydroSoft will inform you if the type does not match. It will also warn you if the serial number of the instrument does not match that contained in the calibration file, but it will offer you the option of loading it even if the serial numbers do not match.

Once a calibration file is loaded, it remains in effect until a different one is loaded. When you exit HydroSoft, it stores the name of the current calibration file. If the Automatically recall last selected calibration file option is selected in the Preferences dialog box, the file will be reloaded the next time HydroSoft starts up. If you have more than one data window open in HydroSoft, you can select a different calibration file for each one. The most recently selected file in any window will be saved as the default.

5.3.2. Viewing And Editing Calibration Data

You can see the details of the current calibration by selecting View Calibration from the File Menu. Normally you should not need to modify calibration data for an instrument, and the fields in the Calibration dialog box are locked to discourage casual changes. However you can unlock most fields by clicking on the lock icon in the dialog box. Because correct calibration files are critical to the accuracy of your data, use care when modifying them. To reduce confusion we encourage you to enter a description, in the comment field provided, of any changes you make.

To save a copy of the currently loaded calibration, select Save Calibration from the File menu.

5.4. Connecting

To communicate with a HydroScat, HydroSoft must open the appropriate computer port at the correct baud rate. The following dialog box allows you to control this process.

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5.4.1. Connection Dialog Box
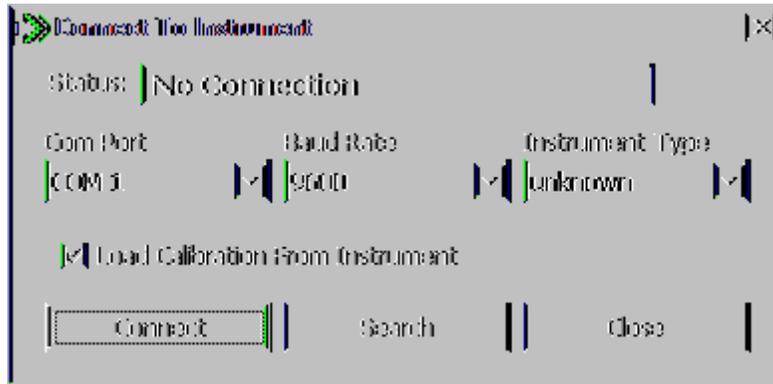
This dialog box appears each time you

- select Connect from the Instrument menu,

- click on the Connect button in a data window,

- attempt an operation that requires a connection, if a connection has not yet been established.

5.4.2. Manual Connection

If you click the Connect button, HydroSoft will open the currently selected port at the selected baud rate. Normally you need not select an instrument type, because HydroSoft will always request identification information from the instrument. If it receives a reply sufficient to identify the instrument, it will proceed with the connection and close the dialog box. If not, it will notify you and ask whether to open the connection anyway. In you instruct it to, it will proceed on the assumption that an instrument of the type you designate is connected.

If your HydroScat is equipped for an anti-fouling shutter (see section 10), under some circumstances its response to HydroSoft's query may be delayed by the process of opening the shutter, and HydroSoft may report that no instrument was detected. In this case, simply click the Connect button again.

5.4.3. Search Connection

If you click Search, HydroSoft will ignore the selected port and baud rate, and attempt a connection to each port, at each baud rate (from 4800 to 57600), until it receives valid identifying information from an instrument. The dialog box will automatically close if a valid connection is found.

5.4.4. Load Calibration From Instrument Option

If Load Calibration From Instrument is checked at the time an instrument is connected, HydroSoft will prompt the instrument to transmit the calibration information stored in the instrument's memory. This will override the currently

selected calibration file, if any. See section 5.3 for more information about calibration files.

5.5. Logging Setup

HydroScats can be programmed to collect data continuously at rates from 0.1 Hz to 10 Hz, or intermittently to allow autonomous logging for long periods. In HydroSoft, you can set these parameters in the following dialog box, which appears when you select Sampling Options... from the HydroScat menu.
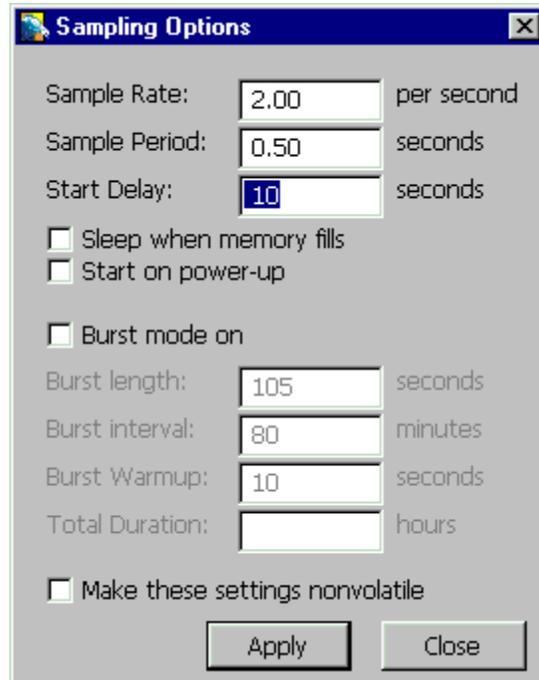
When the Sampling Options dialog is first open, it may take several seconds for the current settings to be retrieved from the HydroScat. Similarly, when you click the Apply button there will be a noticeable delay while HydroSoft transmits, then confirms, the new settings. This confirmation is important because it allows you to check that the settings were entered as you intended. The HydroScat may reject settings it cannot support—for example, burst lengths that are longer than the burst interval.

Sample Rate and Sample Period, by definition, have an inverse relationship. Changes you make to one will automatically affect the other. Note however that the period, which has a resolution of 0.01 second, is the controlling parameter. Therefore some exact sample rates are not available. For example, if you enter a rate of 3 per second, the calculated period will be rounded to 0.33 s, and the rate will be set to 3.03 per second.

When logging is started, either by software command or by turning on the external switch, the HydroScat will wait for the number of seconds specified by

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Start Delay, then data will be logged according to the given **Sample Period**. If burst mode is on, the sampling continues until the **Burst Length** has elapsed, at which time the sensor goes into its low-power sleep state. The bursts repeat according to the period set by **Burst Interval**. At the beginning of each burst, the HydroScat will wait for the number of seconds specified in **Burst Warmup** before collecting its first sample. To guarantee that the first sample is valid and the instrument gains are set properly, the warm-up should be set to 3 seconds or more. Whether or not burst mode is on, sampling stops upon receipt of a software stop command, when the external switch is turned off, or when the battery becomes exhausted.

In the example above, the burst-mode parameters are inactive because burst mode is not on. To edit the burst-mode parameters you must first check the **Burst Mode On** option.

If **Start on power-up** is checked, the HydroScat will begin logging each time power is applied. Note, however that this setting is only relevant after all power sources, including internal batteries, are turned off. For HydroScats with internal batteries (i.e. most HydroScats), you must intentionally disable the batteries (see section 7.4) for this to take effect.

If **Make these settings nonvolatile** is checked, the settings will be stored in semi-permanent memory and will remain in effect even if the internal computer is reset or all power is removed from the instrument.

If your HydroScat is equipped for an anti-fouling shutter (see section 10) the dialog box will expand to show the shutter parameters.

Before logging you may wish to download and clear data from the HydroScat's memory (see section 5.10).

5.5.1. Noise Levels and Sampling Rates

The backscattering measurement involves extremely low light levels, and several factors can contribute to noticeable noise in the measurements, especially in clear water. However, noise in the measurements is unbiased, and uncertainty can be reduced by averaging samples together, or equivalently, lowering the instrument's sampling rate. In conditions with low background light, at a sampling rate of 1 Hz, the RMS noise level is typically from about 0.0003 m^{-1} to 0.001 m^{-1} depending on wavelength. Wavelengths shorter than 470 nm tend toward the higher end of this range, since LED and detector efficiencies fall off at shorter wavelengths. High background light levels can introduce shot noise that degrades these figures.

In many circumstances natural variability exceeds the measurement noise. In water containing significant numbers of very large particles—even schools of

fish—the data may show a background scattering level punctuated by spikes of increased scattering (as individual large particles pass through the sampling volume). Depending on your application, you may or may not wish to include such spikes in averaged measurements. Higher sampling rates preserve the option of evaluating the character of the data before averaging or other processing.

5.6. Setting the HydroScat's Real-Time Clock

Although it is not necessary for the sensor's operation, you may wish to set the real time clock before logging. Select Set Date/Time... from the HydroScat menu. Click Set Time to synchronize the HydroScat clock with your computer's clock. If you wish to set the clock to a different time reference, select the Set Manually option and enter the correct date and time before clicking Set Time. It takes several seconds for HydroSoft to set the clock and reconfirm the setting. When it is finished, click the Close button to close the dialog box.

5.7. Logging Versus Real-Time Data

Whenever collecting data in response to a Start command from HydroSoft, or from its magnetic switch, HydroScats simultaneously transmit them from their serial port. Data can also be collected on demand, without internal logging, by sending "D", "T" or "H" commands each time data are required (see section 8 for information about the commands, and section 9 for the data formats).

5.8. Log Memory Capacity

The base memory of the HydroScat-2 includes 256K of RAM, of which most is reserved for data logging. The base memory can hold about 15,000 samples (we use the terms "sample" and "packet" interchangeably to indicate a set of simultaneous measurements from all the channels). The optional 1M RAM expands this to about 65,000 samples. Both RAM options depend on power from the internal batteries or another source to retain logged data.

5.9. Using The Magnetic Switch

The magnetic switch located on the back end cap of the HydroScat (see Figure 3 on page 4) signals the sensor when to start and stop data logging. An indicator dot is machined into the end cap and is exposed when the switch is in the "on" position. When switched on, the HydroScat will wake and begin collecting data as if the START command were sent to it. When switched off, it will stop sampling and go to sleep, as if the STOP and SLEEP commands were sent.

By using the magnetic switch, one can collect an extended series of casts without connecting to a computer. The starting and ending times of each cast are recorded in the log memory so that casts can be later downloaded individually or

as a group. The sensor may be wakened from sleep by command from the serial port regardless of whether the switch is "on" or "off". However the software SLEEP command will not work if the switch is "on."

Because the switch was designed to support operation from the internal batteries, the switch as originally designed may not operate if an external source of power (including batteries) is connected, and its voltage exceeds the voltage of the internal batteries. A design change in March, 2002 overcomes this limitation on instruments built since then, and can be retrofitted to older instruments. You can test this on your instrument by applying 14V from a power supply to the external supply input, then operating the switch.

5.10. Downloading Logged Data

HydroSoft's Get Data From Instrument command enables you to view a list of casts stored in an instrument's memory, transfer casts from the instrument to files on your computer, and erase the instrument's memory. Casts you transfer are stored in individual files whose location and base name you specify. The cast number is appended to the name of each file.

5.10.1.   Basic Procedure

- Connect the HydroScat to your computer's com port using the supplied data download cable, start HydroSoft, and use HydroSoft's Connect command to establish communication.

- Select Get Data From Instrument on the HydroScat menu.

- A dialog box like the following will appear.

HydroScat   Logged Data   [x]

Loaded

Memory Status: 97833670/100141471 bytes (97%) free.   Read Directory

Cast   Start time   Duration Samples   Delete All
  1   12/12/2000 23:18:26   20 secs   171
  2   12/12/2000 23:18:48   14 secs   111   Select All
  3   12/12/2000 23:19:04   36 secs   311
  4   12/12/2000 23:21:22   2.1 minutes 1053

Use Shift-click to select
groups of casts.
Ctrl-click to select or
deselect individual
casts.

Download

Base File Name: D:\Soft\Test Files\   Browse...

[✓] Create calibrated data (.clist) files (raw files are always stored)   Close

- After the directory is loaded, select the cast or casts you wish to retrieve.

- Enter a base file name for the downloaded files. The cast number will be appended to this base name to create a unique name for each cast you download.

- If necessary, click Browse and select a destination directory for the downloaded files.

- Click Download. Depending on the quantity of data and baud rate, downloading may take some time. Status messages and a graphical indicator will show the download progress.

- To clear the instrument's memory after verifying the desired casts were downloaded, click Delete All.

- Click Close to dismiss the dialog box.

5.10.2.   Details

Depending on the number of casts stored, loading the directory may take a number of seconds. The status message in the upper left corner indicates if the directory is loaded, as above, or if it is in the process of loading.

The memory status line indicates how much of the instrument's memory is presently used.

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You can select arbitrary groups of casts for downloading. To select a contiguous group of casts, click on the first item in the group, then shift-click on the last item; or hold down the shift key while using the arrow keys. To select or unselect non-contiguous casts, control-click on them; or hold down the control key while using the arrow keys to move through the directory, and press the space bar to select or unselect casts.

Data are always collected in raw form. If the **Create calibrated data (.dat) files** option is checked, a calibrated file will also be created for each downloaded cast. The calibration currently in effect for the main data window will be applied to these data (see section 5.3 for more information about calibrations).

Because of the way the HydroScat's memory is configured, it is not possible to delete individual casts—you can only erase the instrument's entire memory.

5.11. Processing Downloaded Data

While HydroSoft allows you to save calibrated data automatically at the time you collect or download data from a HydroScat, you can also process raw data files using HydroSoft's **Process Raw Files** command. This command also allows you to convert raw hexadecimal data to decimal form without calibrating them.

When you select **Process Raw Files**, the following dialog box appears:
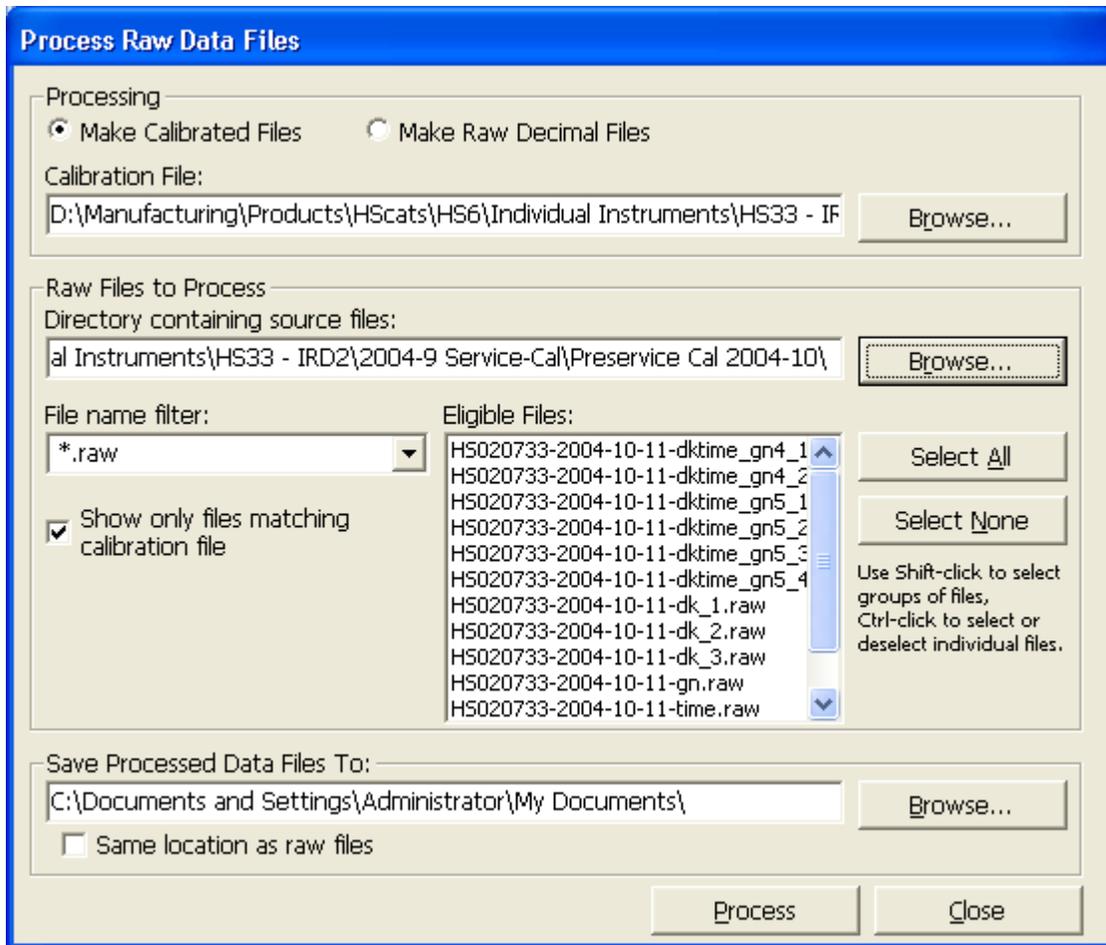
5.11.1. Making Calibrated Data Files

When **Make Calibrated Files** is selected, you need to specify a calibration file to be used (see section 5.3 for more information about calibration files). You can type the path and name of the file directly, or use the **Browse...** button to open an **Open File** dialog box. You must also select the file or files you wish to process, using the familiar browsing controls. The list in the center right of the dialog box shows those files that are contained in the drive and directory you specify, and whose names match the **File name filter** you specify. If **Show only files matching calibration file** is checked, as it is by default, HydroSoft will check the contents of the files and list only those that contain data from the instrument type and serial number specified by the selected calibration file.

You can select a single file or an arbitrary group of files from the list. Select a contiguous group of files by shift clicking, and select or deselect individual files by Ctrl-clicking. Once you start processing, all the selected files will be processed.

The processed files will use the same base names as the source files, with their extensions set to ".dat". They will be saved in the directory you specify. If

you wish to save them in the same directory as the raw files from which they are generated, you can avoid having to select that directory manually by checking the **Same location as raw files** option.

5.11.2. Making Raw Decimal Files

The process for making raw decimal files is identical to that described above, except that there is no need for a calibration file. Controls relating to the calibration file will thus be disabled.

When you select the Make Raw Decimal Files option, an additional **Include Housekeeping** checkbox will appear, allowing you to control whether housekeeping data will be included in the file in addition to the primary optical data.

5.12. Raw Data File Format

HydroSoft names raw data files with the extension ".RAW". Raw files start with a header like the following:

```
[Header]
HydroSoftVersion=2.02
CreationDate=02/12/01 23:00:55
FileType=raw
DeviceType=HydroScat-2
DataSource=HydroScat-2
CalSource=D:\Program Files\HOBI Labs\temp.cal
Serial=H2000123
Config=S2B3
[EndHeader]
```

Future versions of HydroSoft may include additional information between the `[Header]` and `[EndHeader]` markers. In any case, everything following the end marker is included in the exact form in which it was received from the HydroScat. For information on the raw data formats, see section 9.

5.13. Calibrated Data File Format

HydroSoft normally names calibrated data files with the extension ".DAT". Calibrated data files start with a header like the following:

```
[Header]
HydroSoftVersion=2.02
CreationDate=02/12/01 23:28:42
FileType=dat
DeviceType=HydroScat-2
DataSource=Instrument Cast 3
```

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```
CalSource=D:\Program Files\HOBI Labs\temp.cal
Serial=H20001
Config=S2B3
[SigmaParams]
ad400=.01
aStarFile=D:\Program Files\HOBI Labs\aStar.csv
awFile=D:\Program Files\HOBI Labs\aw.csv
bbTildeValue=.015
C=.1
gammad=.011
gammay=.014
[Channels]
"bb440"
"bb676"
"fl676"
[ColumnHeadings]
Time,Depth,bb440,bb676,fl676,bb440uncorr,bb676uncorr,fl676uncorr
[Data]
36872.9715856481,-29.388,0,1.5536E-04,0,0,1.5536E-04,0,
```

Future versions of HydroSoft may include additional information between the [Header] and [Data] markers.

The lines following [SigmaParams] are the parameters used for "sigma" correction of the calibrated backscattering, described in section 9.6.

The line following [ColumnHeadings] names the parameters included in the calibrated data lines. Future HydroSoft files may include additional column headings and data parameters, but if so the parameters shown here will remain in the same order.

Times are stored as double-precision real numbers corresponding to the number of days since midnight, January 1, 1900. This is the native format of dates and times in Microsoft Excel.

Depth is in meters, b_b is in inverse meters, and is shown first in its "sigma-corrected" form, then in uncorrected form. $\beta(140°)$ values, with and without sigma correction, are also included if the "include beta in .dat files" option is selected in the Backscattering Parameters dialog (section 9.5).

6. ELECTRICAL CONNECTIONS

A HydroScat can be powered from three sources:

1) external 10V to 15V supply,

2) internal battery,

3) battery charger.

Any combination of these source may be safely connected simultaneously. Power will be drawn from the source with the highest voltage. Nominal operating power draw is 1W.

HydroScats can be configured to use either RS232 or RS485 protocols for communication.   In the RS232 configuration the HydroScat can communicate directly through a standard computer serial port. In the RS485 configuration, a converter or interface card must be provided to allow communication with an RS232 port.

The HydroScat-2 has a single SubConn MCBH8M connector (mate: MCIL8F) for power and data connections, as shown below.

MCBH8M
FACE VIEW OF PINS
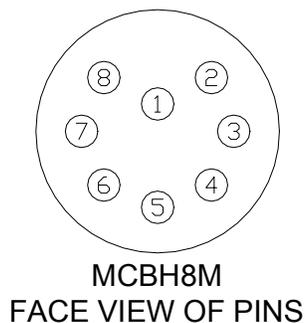
PIN	FUNCTION
1	Supply voltage (10 to 15 V)
2	Common
3	RS232 Receive or RS485A
4	RS232 Transmit or RS485B
5	Battery charging input (12 to 24 V)
6	Shutter Drive (optional)
7	Shutter Drive (optional)
8	Battery Disable

The standard Power/Data Interface cable supplied with HydroScats splits into a DB9 for communication, a "barrel" connector for the battery charger, and a BNC connector with a binding post adapter for an external DC supply.

7. INTERNAL BATTERY

HydroScat-2's are equipped with an internal rechargeable battery, except upon special request. The battery consists of 9 nickel-cadmium (Ni-Cd) cells that provide capacity sufficient for a day of intensive data collection. With intermittent sampling and proper use of the HydroScat's low-power modes, it is possible to operate for days, weeks, or months between charges.

7.1. Battery Capacity

The actual capacity of the battery depends on the temperature at which it is charged, stored, and discharged. Capacity is improved by charging and storage at temperatures of 20 C or less. On the other hand, low temperatures during discharge lower the realized capacity. Peak capacity for a battery charged and discharged at room temperature is over 20 hours of continuous operation. When discharged at 0 C, the same charge provides at least 14 hours of operation.

Internal leakage causes the battery to slowly discharge even with no load. The self-discharge rate is highly temperature-dependent. After one month at 0 C, the battery may lose 10% of its charge. The loss at least doubles at 20 C, and continues to increase at higher temperatures. Capacity also decreases slowly as the battery ages. The capacity loss depends greatly on charging conditions, but is typically less than 10% after 200 charge/discharge cycles, and 20% after 500 cycles.

Approximate discharge time for the battery can be calculated as follows. **Please note** however that it is not possible to accurately account for all the factors that affect battery capacity, so you should use these calculations with caution and temper them with your own experience.

First, calculate the equivalent total current drain for your sampling schedule:

$$I_{equiv} = I_{standby} + I_{sample} \frac{t_{active}}{t_{total}}$$

where t_{active}/t_{total} is the fraction of the deployment time during which the sensor will be active. In burst mode, this will be the sum of the burst warm-up time and burst length, divided by the burst interval. For continuous collection, its value is 1. I_{sample} typically averages 95 mA over the course of the battery's discharge. Given I_{equiv},

$$t_{total} = \frac{C_B}{I_{equiv}}$$

where C_B is the battery capacity, with units of current * time. $I_{standby}$ and C_B both vary with temperature. The following table shows typical values for a new battery.

Temperature	C_B	$I_{standby}$
0 C	2000 mAhr	1.0 mA
10 C	2100 mAhr	1.1 mA
20 C	2200 mAhr	1.2 mA
30 C	2300 mAhr	1.6 mA

For example, in continuous use at 10 C we would predict endurance of about 2100 mAhr / 96 mA = 22 hours.

For a burst-mode application with active time of 20 seconds per hour, at 30 C, I_{equiv} would be 1.6 mA + 95 mA * (20/3600) = 2.1 mA. Total duration would be 2300 mAhr / 2.1 mA = 1100 hrs or about 45 days.

7.2. Low-Voltage Cutoff

When the battery voltage falls to a degree that indicates it is nearly exhausted, the firmware will automatically put the HydroScat into an indefinite low-power sleep state. In this state the contents of the RAM will be preserved, but no further data will be collected. With its load thus reduced, the battery voltage will typically recover and the battery will usually be able to preserve the memory for several weeks or longer.

7.3. Charging

The HydroScat-2 includes a trickle charger that recharges the battery in a maximum of 15 hours. Charging continues at the same rate as long as the charger is plugged in. It is safe to charge the battery indefinitely, although repeated, prolonged charges can eventually degrade battery capacity. For best battery life we recommend that you charge, on average, not more than 1.5 times the time that the sensor is operated from the battery (not including "sleep" time), and occasionally allow the battery to discharge completely. The actual charging time required is roughly one half the discharge time.

7.4. Battery Disable

The internal battery can be disconnected from the circuitry by shorting pins 2 and 8 of the bulkhead connector (see section 6), using the special dummy plug

supplied. This special plug, distinguished by a red handle, must be removed and replaced with the black generic dummy plug (or a suitable cable) to permit battery-powered operation.

Some HydroScat-2's manufactured before June 1999 did not include the battery disable function.

8.   DIRECT COMMUNICATION AND COMMANDS

HydroScats are configured and controlled with commands sent via their serial communication port. When you use HydroSoft, the commands needed for routine operation are generated automatically and you do not need to know the details. However you can type commands manually, and view the HydroScat's replies directly, via HydroSoft's terminal window or a generic terminal program. Some less-common commands are accessible only through this method.

8.1.   Communication Protocol

HydroScats communicate through a standard RS-232 serial connection, with 8 data bits, no parity, one stop bit, and no handshaking. The default baud rate is 9600, but it can be set to other standard rates up to 57600 (see section 8.4.2).

8.2.   Command Conventions

The HydroScat waits until it receives a carriage return, line feed, or other control character before responding to a command. It responds to every command, but does not echo characters when it receives them. If it receives a command it does not understand, it will echo the command followed by a question mark.

The HydroScat's responses usually start with an apostrophe ('). Error messages start with an exclamation point, and primary data messages start with an asterisk (*).

Commands are insensitive to case. They are shown below in upper case for clarity.

Some commands accept arguments, which are separated from the base command, and from each other, by commas. Arguments may be individually omitted, in which case they will have no effect. For example, if a command accepts three arguments, in the form `COMMAND,arg1,arg2,arg3`, you may adjust only *arg3* by entering `COMMAND,,,arg3`.

8.3.   Routine Commands

8.3.1. BURST,*on,warmup,duration,cycle,totalDuration,logPeriod,start Delay,autoStart,sleepOnMemFull*

Similar to LOG, but lists the burst parameters first to make them easier to enter.

In burst mode (i.e. if *on* is nonzero), upon receipt of the START command (or activation of the magnetic switch) the HydroScat waits for the number of seconds specified by the LOG command's *startDelay* parameter. It then collects data until *duration* seconds have passed. At the end of the burst it goes into low-power sleep mode until *cycle* minutes have passed since the beginning of the previous burst. At the beginning of each subsequent burst it waits for *warmup* seconds before resuming collection. To guarantee the first sample is valid, *warmup* should be set to at least 3 seconds. When *totalDuration* hours have passed since the beginning of the first burst, the HydroScat will go into an indefinite low-power sleep.

If *duration* is zero, burst mode will be disabled regardless of the value of *on*. If *cycle* is zero, the HydroScat will sleep indefinitely after only one burst. If *totalDuration* is zero, the total duration will not be limited.

```
'Burst mode: 1 (ON)
' Warmup time: 5 seconds
' Burst duration: 15 seconds
' Burst cycle: 10 minutes
' Total duration: 0 hours (not in effect)
'Sampling and Logging Parameters:
' Log Period: 1 seconds
' Start delay: 60 seconds
' Sleep when memory full: 1
' Start on power up: 0
```

8.3.2. CHANNELS

Lists the wavelengths and functions of the 3 channels of a HydroScat-2, in the order in which the HydroScat produces them.

```
Reply:
'1: bb442
'2: bb671
'3: fl671 (excitation: bb442)
```

8.3.3. CLEARRAM

Erases the contents of the log memory. Before proceeding, displays the memory status (the same information as displayed by the ram command) and asks for confirmation.

```
Reply:
'339960/1017856 bytes (33%) used in log RAM
'10059/29976 packets logged
'First packet logged 05/01/97 13:40:42
'Last packet logged 05/01/97 14:28:02
```

'ERASE ALL DATA IN RAM (Y/N) [N]?

Press "y" to clear the memory, or any other key to abort.

8.3.4. CLEARLOG

Identical to CLEARRAM.

8.3.5. CLOSE,*time*

Closes the optional anti-fouling shutter. See section 10.5.3.

8.3.6. D

Transmits a "D" packet of hexadecimal data. See section 9.2 for a description of the format.

8.3.7. DATE,*mm/dd/yyyy hh:mm:ss*

Sets the real-time clock to the given date (and time if provided). If no date is given, simply reports the current setting. The year may be entered either as two or four digits. If only two digits are entered, years from 00 to 43 will be assumed to be in the 21st century. The real-time clock is reset whenever power is turned off to the sensor. Setting it accurately is not necessary to the operation of the sensor, but may be useful for keeping track of logged data.

In the Crosscut terminal program, the host computer's date and time for this command can be entered by pressing Alt-D.

```
Reply:
'05/01/97 14:51:02
```

8.3.8. DIR

Displays a directory of the casts currently stored in memory.

```
Reply:
'Cast        Start Time       Duration Samples
'   1   mm/dd/yyyy hh:mm:ss    2.3 hrs  12,345
'   2   mm/dd/yyyy hh:mm:ss  23.1 mins   3,456
```

Note that the duration is calculated from the time tags associated with the first and last packets in the cast. If the user changed the setting of the HydroScat clock while a cast was in progress, the duration displayed may not make sense.

8.3.9. DOWNLOAD,*cast*

Causes the HydroScat to transmit data stored in its log RAM. *Cast* is the number of a cast to transmit. Use DIR to view the available casts. If no argument

is given, transmits the entire contents of memory. This command does not change the contents of the log memory.

Reply: If a valid cast number is specified, raw data packets in the same form as produced by the sensor in real time.

You can interrupt a download in progress, without affecting the contents of memory, by sending a control-C character to the HydroScat. (Because RS485 cannot support simultaneous two-way transmission, this works only on sensors with RS232 interfaces).

8.3.10. H

Transmits a hexadecimal packet of housekeeping information. See section 9.4 for details of the packet format.

8.3.11. ID

ID displays identifying information about the sensor. This information can only be set at the factory, except for the address which can be set with the GCF command (section 8.4.4). It replies in this format:

```
'Identification:
' Model: HS2
' S/N: H297074
' Config: W1B2R1I2P2
' ID: Hobi One
' Address: *
' Maximum Depth: 200 m
' Firmware: 1.77
' Cal Time: 13660
```

Model and serial number are self-explanatory. The "config" string describes the sensor's hardware configuration. Among other things, it indicates the wavelength set, quantity of RAM, communication protocol, and whether it has an internal battery. ID is simply an identifying name, which we usually fill with the name of the purchasing institution.

Address is used when several instruments share communication lines. The default setting for all HydroScats is *, which indicates no address is required. If an address other than * is specified, the HydroScat will respond only to commands that begin with that address.

Not all HydroScats have the same warranted depth rating, so maximum depth is recorded here along with the sensor's other attributes.

The firmware version number displayed is programmed into the firmware's source code, and therefore cannot be changed except by installing different firmware.

The calibration time shown is in the real-time clock's raw reading (in seconds since midnight Jan 1, 1970) at the time the calibration or configuration parameters were last changed. This cannot be directly entered, but is updated automatically.

8.3.12.   LOG,*period,delay, sleepOnMemFull,autostart,burstMode,burstWarmup,burstDuration,burstCycle,totalDuration*

Period is the time, in seconds, between samples that are logged (and transmitted on the serial port). *Delay* is the number of seconds the instrument will wait after a START command, power-on, or magnetic switch activation before the first sample is logged. To guarantee that the first sample collected is valid, *Delay* should be set to at least 3 seconds. A nonzero *sleepOnMemFull* value indicates that the sensor will stop logging and go into a low-power sleep when the log memory fills. *Autostart*, if non-zero, indicates that logging will start (with the given delay) automatically when power is applied to the sensor. *Autostart* applies primarily to HydroScats without batteries; those with batteries are usually powered continuously, even in sleep mode.

The burst mode parameters are described under the BURST command, although they can also be modified using LOG.

The reply to the LOG command shows the settings of all the applicable parameters:

```
'Sampling and Logging Parameters:
' Log Period: 1 seconds
' Start delay: 60 seconds
' Sleep when memory full: 1
' Start on power up: 0
'Burst mode: 1 (ON)
' Warmup time: 5 seconds
' Burst duration: 15 seconds
' Burst cycle: 10 minutes
' Total duration: 0 hours (not in effect)
```

NOTE: Changes you make to the log parameters remain in effect only as long as the sensor is powered, unless you make them permanent with the STORELOG command (section 8.3.21).

8.3.13.   OPEN,*time*

Opens the optional anti-fouling shutter. See section 10.5.2.

8.3.14.   RAM

Displays information about the log memory, in the following form:

```
'339960/1017856 bytes (33%) used in log RAM
```

```
'10059/29976 packets logged
'First packet logged 05/01/97 13:40:42
'Last packet logged 05/01/97 14:28:02
```

The first line shows how many bytes are used and the total memory in the system.

The second line shows how many packets (samples) are stored, and the approximately maximum number of packets that can be stored.

If the memory is empty, the last two lines are omitted. The accuracy of the dates and times presented depends on the HydroScat's real-time clock being set accurately. See DATE (8.3.7) and TIME (8.3.23)..

8.3.15. SHUTTER,*auto,time* [Firmware 1.80]
SHUTTER,*enable,auto,time,direction* [Firmware 1.84 and later]

Controls parameters for the optional anti-fouling shutter. See section 10.5.1.

8.3.16. SLEEP,*secs*

The SLEEP command causes the HydroScat to immediately cease any data collection and go into a low-power sleeping state. In this state the current consumption is reduced to a level similar to the battery's self-discharge rate. The *secs* argument, if included, specifies the duration of the sleep in seconds. If no duration is specified, the sleep interval defaults to an essentially infinite 200,000,000 seconds (about six years).

The HydroScat wakes from its sleep when:

- the specified number of seconds has passed, or

- it receives characters through its communication port, or

- the magnetic switch is moved to the "on" position.

8.3.17. SLEEPINFO

SLEEPINFO displays the time and cause of the HydroScat's last sleep, and of it subsequent waking. Possible causes of sleep include:

- receipt of the SLEEP command,

- movement of the magnetic switch to its off position,

- log memory filling up,

- battery voltage falling too low,

- scheduled sleep during burst-mode logging.

8.3.18.   START,*delay*

Causes the HydroScat mark the beginning of a new cast in log memory, and to begin logging and transmitting data according to the parameters set with the LOG or BURST command. Logging will start after *delay* seconds, or if no *delay* is specified, after the start delay specified by the LOG command. START has no effect if the HydroScat is already logging.

Reply:
```
'Sampling starts in [delay] seconds.
```

8.3.19.   STARTNOLOG,*delay* [added in firmware 1.80]

Identical to START, except that data collected will not be logged in internal memory.

8.3.20.   STOP

Causes the HydroScat to immediately cease logging and transmitting data. Also marks the end of the current cast (if any) in the log directory.

Reply:
```
'Sampling stopped.
```

8.3.21.   STORELOG

Stores the current settings of the log parameters (see the LOG command on page 22) in non-volatile memory, so that they will remain in effect even when power is removed from the sensor.

Reply:
```
'Storing…OK
```

8.3.22.   T

Transmits a "T" packet of hexadecimal format. See section 9.3 for details of the data format.

8.3.23.   TIME,*hh:mm:ss*

Sets the real-time clock to the given time (does not affect the date). If no time is given in the command, simply reports the current setting. The real-time clock is reset whenever power is turned off to the sensor. Setting it accurately is not necessary to the operation of the sensor, but may be useful for keeping track of logged data.

Reply:
```
'05/01/97 14:51:02
```

8.3.24. TIMERES,*mode*

Causes the HydroScat to report time in high-resolution (0.01 s) or low-resolution (1 s) mode. Specifying a *mode* of H ("high") or 1 ("on") will enable the high-resolution mode. Specifying a *mode* of L ("low") or 0 ("off") will disable the high-resolution mode. In high-resolution mode, the data packet format is slightly different and is denoted by "*T" instead of "*D" at the beginning of the line. See section 9.1 for details of the data formats.

Reply (to TIMERES,H or TIMERES,1):
```
'Time Resolution: high (0.01 second)
```

Reply (to TIMERES,L or TIMERES,0):

8.4. 'Time Resolution: low (1 second)Special-Purpose Commands

The following commands are not needed for routine operations and should be used with great care.

8.4.1. AGAIN,*channel,auto*

Turns automatic gain control on (if *auto* is nonzero) or off (if *auto* is zero). The *channel* argument specifies to which channel the auto argument applies. The channels are numbered 1 through 3. Setting *channel* to zero causes the auto argument to apply to all channels.

Reply (for the default setting of autogain active for all channels):
```
'autogains: 111
```

8.4.2. BAUD,*rate*

Immediately sets the baud rate at which the instrument communicates. If sent without an argument, reports the current baud rate setting. Valid rates are 4800, 9600, 19200, 38400 and 57600. The actual baud rate set by the instrument is usually slightly different from these rates, although you must specify one of the standard rates exactly. When the HydroScat states a baud rate, it shows both the nominal and actual values. The deviation in actual baud rates is well within the acceptable tolerances for communication with a computer.

Reply (if no rate specified):
```
'Baud rate: 9583 (9600)
```

Reply (if rate is 19200):
```
'Changing rate to: 19166 (19200)
```

8.4.3. GAIN,*channel,gain*

Sets the given *channel* (1 through 3) to the given *gain* (1 through 5). If *channel* is zero, all channels are set to the given *gain*.

Because channels 2 and 3 (channel 3 measuring fluorescence) share an optical front end, their gains are always identical.

Reply:
```
'gains: 544
```

Gain is reported as zero when a channel is disabled.

8.4.4. GCF,*address,Baudrate*

GCF stands for global configuration. This command displays and sets certain parameters that pertain to the HydroScat-2 as a whole. Note that not all the parameters displayed can be set with this command.

Reply:
```
'Global Configuration:
' Address: *
' Baud Rate: 9600
' Data prefix: *
' Info prefix: '
' Error prefix: !
' Cal Temp: 0.000000
' Depth Offset: 14.1
' Depth Coefficient: 0.0089
' Maximum Depth: 200 m
' ID: Institution
' Model: HS2
' S/N: HS97074
' Config: W1B0R1I2P2
' Firmware: 1.10/256K
' RAM size: 256K
' Config Version: 2
' Cal Time: 10/01/97 11:03:41
```

The address should normally be set to *. If it is set to any other character or string, the HydroScat will only acknowledge commands that begin with that string.

Baud rate is the rate to which the sensor is set upon startup, not necessarily the current rate. Use BAUD to view or adjust the current rate.

The three prefix characters are used to distinguish almost all messages produced by the HydroScat-2. The Data Prefix character precedes all standard data messages (see D, H and T), and is used by the HydroScat Windows software to identify them as such. The Info Prefix precedes most informational displays (including those shown in this example). The Error Prefix marks important warnings that demand the user's attention.

Cal Temp is not used in present HydroScat-2's. It is intended to serve as a reference temperature for correcting temperature-related drift, should such corrections be needed.

Depth offset and depth coefficient are used to translate raw depth data to units of meters. These are not used within the HydroScat firmware, but are stored there for reference.

The maximum depth, ID, model, S/N and Config fields can only be set with the ID command, and are described under ID.

The firmware version shows not only the sequential version number, but which memory configuration it is compiled for. This should match the RAM size displayed on the next line. Neither of these parameters is editable, but is determined within the compiled firmware.

The calibration and configuration data that are unique to each HydroScat-2 are stored in nonvolatile memory in a format that has changed as more information was added in successive firmware versions. The configuration version number identifies the format in which the current information was stored.

Finally, the cal time shows the date and time at which the configuration and calibration data were last altered. This is updated automatically and cannot be edited. The same parameter is displayed in raw form by the ID command.

8.4.5. X

X is used extensively during testing and troubleshooting, since it displays a comprehensive report of the HydroScat-2's most recent raw data as follows. Raw data are also discussed in section 9.1)

```
'time: 2856  error: 2
'samples: 733 on, 11 off
'bb440  4611  4546  8840  2393   -4    47
'bb670 13110  1707 12730  1557   -1  8128
'fl670 10724  1722 16239  2031   -3  5068
'gains: 555
'depth:1661 temp:176 VA:135 VB:79 VBk:53 Aux:120
'gain status: -1 0 -1
```

Time is the current raw setting of the real-time clock (in seconds since midnight, 1/1/1970). Error is a one-byte variable in which each bit is a flag for a particular error condition (described in section 9.2.10). In the display above, error has the value 2, indicating that one or more of the signal channels saturated at some point during the sampling time.

The second line shows how many samples were averaged to produce the displayed data. In this case, the signals were averaged over 733 samples (about 7 seconds at the sensor's internal 100 Hz rate), and 11 samples were averaged to produce the offset figures. Since the LEDs must be turned off to measure offsets, only about 5% of the sensor's time is devoted to them, and the number of offsets averaged is usually smaller than the number of signals. In general, the number of

samples differs slightly from channel to channel. The sample quantities shown are averaged over all channels.

The next three lines show the name of each channel, followed by its signal, signal offset, reference, reference offset, background radiance, and normalized signal (*SNorm*). The background radiance is usually small in laboratory conditions. The background saturates at approximately 85 on some sensors, and 120 on others, depending on which components are installed on the motherboard. *SNorm* is the normalized signal sent in the standard data packets (see section 9.2.6). It is calculated by

$$S_{norm} = R_{nom} \frac{Sig - SigOff - SigDark}{Ref - RefOff}$$

where *Rnom* and *SigDark* are parameters from the channel calibration record. *Snorm* is a 16-bit signed integer.

The next line shows the gain settings of all the channels. Gains may range from 1, the lowest, to 5.

The depth value shown is in raw digital counts. The temperature shown is scaled to fit into an unsigned byte, as when it is transmitted in the normal "D" data packet. To convert it to degrees C, divide by 5 and subtract 10. For example, 176 corresponds to 25.2 C.

VA is the external voltage supplied via the HydroScat-2's bulkhead connector. This may be zero when the instrument is operating from its internal battery. VB is the voltage of the internal battery. VBk is the voltage of a secondary internal battery, if any. All these voltages are expressed in hundredths of volts. For example, VA above is 13.5V.

Aux is used to measure the battery charge current. The value shown is 840 times the current in amps. In this case, the current is 120/840 = 0.14A. In sensors without batteries, Aux is not used.

Gain status indicates whether the current gain settings are appropriate to the measurement conditions. A value of zero indicates the gain is suitable. Positive one means it should be increased, and negative one means it should be reduced. In this example, channels 1 and 3 are judged to have too much gain, and will be reduced by the autogain algorithm if it is enabled. The next sample displayed would show those channels set to gain 4. The averaged signal levels in this example are well below saturation, but, as indicated by the error value of 2, some channels must have received excessive signals at some point during the sampled interval.

9. DATA PROCESSING REFERENCE

9.1. Raw Data Formats

HydroScats can produce several data packet formats, as well as reply to many commands (see section 8). The "D" data packet described below contains the primary optical and supporting data for routine data collection. The "T" packet, which was introduced in firmware version 1.60, is identical to the "D" packet except that it includes higher-resolution time values. "H" packets contain housekeeping data that are not needed for normal data processing, but provide extra information that could be useful for trouble-shooting. It is advisable to save all the raw data in case any special post-processing is needed.

For troubleshooting purposes, you can view raw decimal data by using the X command (section 8.4.5).

Packets consist of ASCII characters. Numbers are represented in hexadecimal notation. Signed numbers are in 2's complement format. Transmissions always end with carriage return and line feed characters.

9.2. "D" Packet Format

9.2.1. Example "D" Packet:
`*D346A023C055613CC1606000000000000000000000555000000648870071<CR><LF>`

9.2.2. "D" Packet Structure

Parameter	Type	ASCII	ASCII Bytes	Example
Packet Flag		*	1	*
Packet ID	char	D	1	D
Time	signed	HHHHHHHH	8	346A023C
Snorm1	signed	HHHH	4	0556
Snorm2	signed	HHHH	4	13CC
Snorm3	signed	HHHH	4	1606
Snorm4*	signed	HHHH	4	0000
Snorm5*	signed	HHHH	4	0000
Snorm6*	signed	HHHH	4	0000
Snorm7*	signed	HHHH	4	0000
Snorm8*	signed	HHHH	4	0000
Gain/Status1	nibble	H	1	5
Gain/Status2	nibble	H	1	5
Gain/Status3	nibble	H	1	5
Gain/Status4*	nibble	H	1	0
Gain/Status5*	nibble	H	1	0
Gain/Status6*	nibble	H	1	0

Gain/Status7*	nibble	H	1	0
Gain/Status8*	nibble	H	1	0
DepthRaw	signed	HHHH	4	0648
TempRaw	unsigned	HH	2	87
Error	byte	HH	2	00
Checksum		HH	2	71
Terminator		<CR><LF>	2	
* Field set to zero by HydroScat-2		**TOTAL:**	**62**	

9.2.3. Packet Flag

Each data packet begins with an asterisk character. Other transmissions, for example replies to commands, may begin with other characters.

9.2.4. Packet ID

The packet described here is identified by a 'D' in this position. HydroScats may produce other packets, of various lengths, with other identifiers.

9.2.5. Time

TIME is in seconds. If the HydroScat's real-time clock has been set accurately (See section 5.6), a time of zero represents Midnight, January 1, 1970. The time shown in the example above, 346A023C, corresponds to November 12, 1997 at 19:23:40.

When power is first applied to the HydroScat the time may proceed from a random value. It is not necessary to set the time if absolute time data are not required.

9.2.6. Snorm

There is one 16-bit Snorm value for each of the 3 optical data channels. Note that some channels may be disabled, as indicated by their Gain/Status values, in which case the Snorm value is meaningless. It is calculated by the HydroScat from

$$S_{norm} = R_{nom} \frac{Sig - SigOff - SigDark}{Ref - RefOff}$$

where *Sig* and *Ref* are the raw signal and LED reference measurements. *SigOff* and *RefOff* are the signal and reference measured during the time when the LED is off. *Rnom* and *SigDark* are parameters from the HydroScat's calibration record. *Snorm* is a 16-bit signed integer.

Snorm is used to calculate backscattering as shown in section 9.5.

9.2.7. Gain/Status

There is one 4-bit gain/status value for each of the optical data channels. The three LSB's comprise a gain setting, and the MSB indicates status.

A gain setting of zero indicates that the channel is disabled and its data should be ignored. Gains of 1 to 5 are used to select one of five coefficients to be applied to Snorm. Gains 6 and 7 are undefined.

The status bit is zero under normal conditions. The status bit for a channel may be set to 1 if the HydroScat detects a condition that may affect the quality of the data on that channel. However a status value of 1 does not necessarily indicate invalid data.

9.2.8. DepthRaw

DepthRaw is reported as a signed 16-bit integer. The depth in meters is calculated by

depth (m) = DepthRaw * depthCal – depthOff

The values of depthCal and depthOff are specified in the calibration file provided with each instrument.

9.2.9. TempRaw

TempRaw indicates the HydroScat's internal temperature. The actual temperature is calculated by

Temp (C) = TempRaw / 5 – 10

Note that TempRaw is an unsigned byte with a range of 0 to 255, giving the calibrated temperature a range of –10 to 41 C.

9.2.10.   Error

Each bit in the one-byte error code corresponds to a particular error condition:

weight	condition
1	high background
2	high signal
4	reference out of range (not yet implemented)
8	temperature out of range (not yet implemented)
16	primary voltage out of range (not yet implemented)
32	battery voltage out of range
64	log memory full
128	undefined

9.2.11. Checksum

Checksum is the least significant byte of the unsigned sum of all the ASCII bytes preceding the checksum in the packet, not including the packet flag (*).

9.2.12. Terminator

This packet and all other transmissions are terminated with a carriage return and line feed.

9.3. "T" Packet Format (firmware 1.60 and later)

The "T" packet is identical to the "D" packet, except that the resolution of the time value is extended by 2 hex digits. The added digits indicate the fractional time in hundredths of seconds. In the example below, the fractional time of 1A indicates 0.26 seconds. Fractional time values greater than 99 decimal, 63 hex, are undefined.

9.3.1. Example "T" Packet:
`*T346A023C1A055613CC16060000000000000000000005550000006488700F3<CR><LF>`

9.3.2. "T" Packet Structure

Parameter	Type	ASCII	ASCII Bytes	Example
Packet Flag		*	1	*
Packet ID	char	T	1	T
Time	signed	HHHHHHHH	8	346A023C
Fractional Time	Unsigned	HH	2	1A
Snorm1	signed	HHHH	4	0556
Snorm2	signed	HHHH	4	13CC
Snorm3	signed	HHHH	4	1606
Snorm4*	signed	HHHH	4	0000
Snorm5*	signed	HHHH	4	0000
Snorm6*	signed	HHHH	4	0000
Snorm7*	signed	HHHH	4	0000
Snorm8*	signed	HHHH	4	0000
Gain/Status1	nibble	H	1	5
Gain/Status2	nibble	H	1	5
Gain/Status3	nibble	H	1	5
Gain/Status4*	nibble	H	1	0
Gain/Status5*	nibble	H	1	0
Gain/Status6*	nibble	H	1	0
Gain/Status7*	nibble	H	1	0
Gain/Status8*	nibble	H	1	0

DepthRaw	signed	HHHH	4	0648
TempRaw	unsigned	HH	2	87
Error	byte	HH	2	00
Checksum		HH	2	F3
Terminator		<CR><LF>	2	
* Field set to zero by HydroScat-2		**TOTAL:**	**64**	

9.4. "H" Packet Format

9.4.1. Example "H" Packet:

```
*H346A023C060F4B510647FE04A6545C066EFF04F34007050EFE06C837AF06B5FE05857
89705C6FF04F35A8807C9FF0000000000000000000000000000077210B069122<CR><LF>
```

Param	Type	ASCII	ASCII Bytes	Example
Packet Flag		*	1	*
Packet ID	char	H	1	H
Time	signed	HHHHHHHH	8	346A023C
SigOff1	signed	HHHH	4	060F
Ref1	signed	HHHH	4	4B51
RefOff1	signed	HHHH	4	0647
Back1	signed	HH	2	FE
SigOff2	signed	HHHH	4	04A5
Ref2	signed	HHHH	4	545C
RefOff2	signed	HHHH	4	066E
Back2	signed	HH	2	FF
SigOff3	signed	HHHH	4	04F3
Ref3	signed	HHHH	4	4007
RefOff3	signed	HHHH	4	050E
Back3	signed	HH	2	FE
SigOff4*	signed	HHHH	4	06C8
Ref4*	signed	HHHH	4	37AF
RefOff4*	signed	HHHH	4	06B5
Back4*	signed	HH	2	FE
SigOff5*	signed	HHHH	4	0585
Ref5*	signed	HHHH	4	7897
RefOff5*	signed	HHHH	4	05C6
Back5*	signed	HH	2	FF
SigOff6*	signed	HHHH	4	04F3
Ref6*	signed	HHHH	4	5A88
RefOff6*	signed	HHHH	4	07C9
Back6*	signed	HH	2	FF
SigOff7*	signed	HHHH	4	0000
Ref7*	signed	HHHH	4	0000
RefOff7*	signed	HHHH	4	0000
Back7*	signed	HH	2	00
SigOff8*	signed	HHHH	4	0000
Ref8*	signed	HHHH	4	0000
RefOff8*	signed	HHHH	4	0000

Back8*	signed	HH	2	00
VsupA	unsigned	HH	2	77
VsupB	unsigned	HH	2	21
Vback	unsigned	HH	2	0B
Aux	signed	HHHH	4	0691
Checksum		HH	2	22
Terminator		<CR><LF>	2	
*Field set to zero by HydroScat-2		**TOTAL**	**136**	

9.4.2. Time

Same as "D" packet time.

9.4.3. SigOff, Ref, RefOff

These three values (one set for each of the optical channels) are incorporated into the calculation of Snorm, and are not needed for normal post-processing.

9.4.4. Back

This signed integer indicates the amount of background radiance incident on the detectors. Its value is normally a small positive number for the HydroScat-2. A large value indicates bright background light (presumably sunlight), which may contribute to noise in the backscattering data.

9.4.5. VsupA, VsupB, Vback

These show the voltages of up to three power supplies for the instrument. The HydroScat only draws power from the source with the highest voltage, and only one need be supplied for normal operation. Different sensor configurations may assign the voltages differently. The value reported is 10 time that actual applied voltage. For example, VsupA above is 77 Hexadecimal, 119 Decimal, representing 11.9 Volts.

9.4.6. Aux

Indicates charging current, if any, supplied to the internal batteries. The value is 840 times the charging current in amperes, and normally ranges from 0 to approximately 200 mA.

9.4.7. Checksum

Same as "D" packet.

9.4.8. Terminator

Same as "D" packet.

9.5. Calculating ß and b_b

Each optical channel of each HydroScat has a unique set of calibration coefficients needed to convert its data to engineering units. These coefficients are measured at the factory and stored in the instrument's memory, as well as supplied in a ".CAL" file that can be used by HydroSoft or other software. The file format is described in section 9.7.

The first step in processing is to convert the raw signal to the value of the volume scattering function, ß(140°), using

$$\beta_{140u} = \frac{S_{norm} \cdot \mu}{\left(1 + k_T\left(T - T_{cal}\right)\right) \cdot G_g \cdot R_{nom}}$$

with the following input variables

S_{norm} Normalized backscatter value from HydroScat

μ `Mu` from .cal file

k_T `TempCoeff` in .cal file

T Instrument temperature (calculated as shown above)

T_{cal} `CalTemp` from .cal file

G_g Gain ratio for gain g, (`Gain1` − `Gain5` from .cal file)

R_{nom} Nominal reference value (`Rnom` from .cal file)

The u subscript here stands for "uncorrected", indicating that the sigma correction described in section 9.6 has not yet been applied.

The backscattering coefficient b_b is estimated from ß(140) using the method described in "Instruments and Methods for Measuring the Backward-Scattering Coefficient of Ocean Waters", by Robert A Maffione and David R. Dana, *Applied Optics* Vol. 36, No. 24, 20 August 1997, according to the following expression.

$$b_b = 2\pi\chi_{bb}\left[\beta(140) - \beta_w(140)\right] + b_{bw}$$

with the following additional inputs

χ_{bb} Constant of proportionality between *ß(140)* and b_b for particle scattering. The default value is appropriate for most cases, but can be changed in the backscattering parameters dialog box shown below. In .cal files, the value $2\pi\chi_{bb}$ is stored with the name `Beta2Bb`.

$ß_w(140)$ Volume scattering of pure water at 140 degrees

b_{bw} Backscattering coefficient of pure water

Normally the value of β_{140} used in this equation would include the sigma correction explained in the following section.

The pure-water scattering values β_{140w} and b_{bw} are calculated by HydroSoft, according to parameters set in the dialog shown below. This is displayed in response to the **Backscattering Parameters** command on the **File** menu. The default values are from A. Morel, "Optical Properties of Pure Water and Pure Sea Water," *Optical Aspects of Oceanography*, M. G. Jerlov and E. S. Nielsen (eds.), Academic Press, New York, 1974, chap. 1, pp 1-24. However by selecting the "custom" option you can modify the model. For special applications you can also remove the pure water factor entirely by setting the custom parameters to zero.
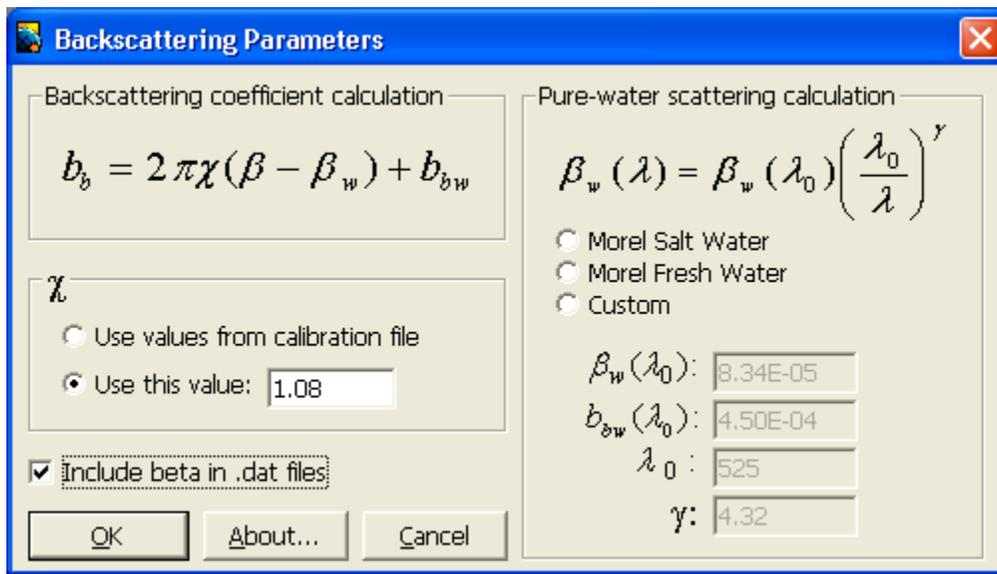
9.6. Sigma Correction

Sigma correction is an adjustment to improve the accuracy of backscattering measurements in highly-attenuating water. Some light that would otherwise be detected as backscattering is lost to attenuation in the water between the instrument and the detection volume, causing backscattering to be underestimated. We compensate for this applying the following correction[1]:

$$\beta = \sigma(K_{bb}) \cdot \beta_u$$

where β_u is the uncorrected backscattering. The sigma-corrected β can be used in the equation for b_b above, to produce sigma-corrected b_b.

---

[1] Versions of HydroSoft prior to 2.5 used a third-order polynomial approximation for sigma, and the current version still uses this if the constant k_{exp} is not present in an instrument's calibration data.

$\sigma(K_{bb})$ is a complicated function of the sensor's optical geometry, but can be closely approximated by

$$\sigma(K_{bb}) = k_1 \exp(k_{exp} K_{bb})$$

where K_{bb} is the coefficient of attenuation for light traveling from the sensor to the sensing volume and back. k_{exp} is characteristic of the specific instrument, and is included in its calibration file. k_1 is set so as to satisfy the requirement that

$$\sigma(K_{bbw}) = 1$$

where K_{bbw} is the attenuation, excluding that of pure water[2], of the water in which the instrument was calibrated. That is,

$$k_1 = \exp(-k_{exp} K_{bbw})$$

When the calibration is performed with well-filtered water, K_{bbw} is near zero and k_1 is for practical purposes 1 at all wavelengths.

Since HydroScats do not make a direct measurements of attenuation, their K_{bb} is estimated from

$$K_{bb} = a + 0.4b .$$

If measurements of a and b are available, they can be used to calculate sigma corrections with the best possible accuracy. However within HydroSoft, a is estimated from *a priori* data, and b is estimated from the measured b_b. a is calculated from the following model: [3]

$$a(\lambda) = 0.06a^*(\lambda)C^{0.65}\left[1 + 0.2\exp(-\gamma_y(\lambda - 440))\right]$$
$$+ a_d(400)\exp(-\gamma_d(\lambda - 400))$$

where the first term accounts for the contribution of chlorophyll and other factors that correlate with chlorophyll, and the second term accounts for detrital material. $a^*(\lambda)$ is a function determined empirically by Prieur and Sathyendranath[4] and modified by Morel[5]. C is the chlorophyll concentration in mg/m^3 which can be set by the user, as can γ_y, γ_d, $a_d(400)$.

---

[2] Prior to HydroSoft 2.7, K_{bb} was reckoned including the contribution of pure water. Thus it, and k_1, differed considerably at different wavelengths and the value of k_1 appropriate to each channel was included in the calibration file. Starting with version 2.7, K_{bb} is defined to include only attenuation above and beyond that of pure water.
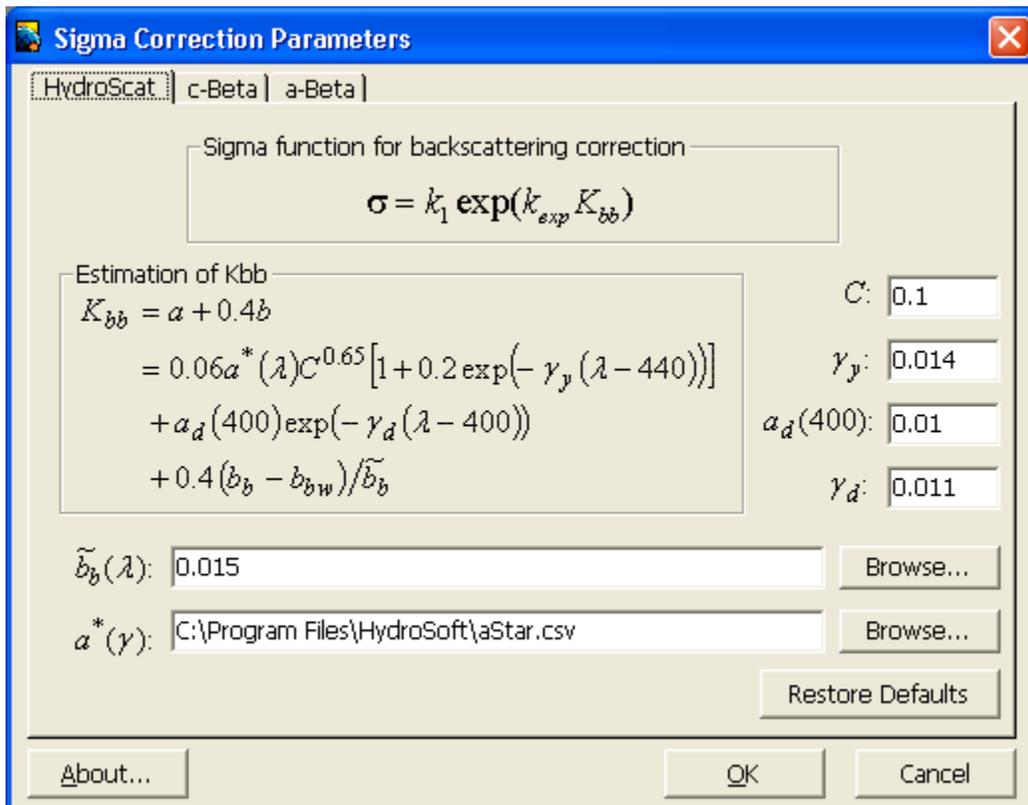
[3] Prior to HydroSoft 2.7, the equation for absorption also included a term for pure water.

[4] "An optical classification of coastal and oceanic waters based on the specific spectral absorption curves of phytoplankton pigments, dissolved organic matter, and other particulate materials, *Limnol. Oceangr.*, 26(4), 671-689

[5] "Light marine photosynthesis: a spectral model with geochemical and climatological implications," *Prog. Oceanogr.*, 26, 263

b is estimated from $b = (b_{bu} - b_{bw})/\tilde{b}_b$, where $\tilde{b}_b$ is the backscattering probability, which can be set by the user. The numerator of this expression is the uncorrected b_b excluding that of pure water.

The **Sigma Correction Parameters** dialog box is shown below, with typical settings for a HydroScat sensor. The default settings are appropriate for most cases. The main exception is it may be appropriate to adjust the value of C if Chlorophyll levels are high and can be estimated. HydroScats that are appropriately configured may provide this information, but the user must provide a calibration to translate the HydroScat's readings into Chlorophyll concentrations.

Sigma Correction Parameters

HydroScat | c-Beta | a-Beta

Sigma function for backscattering correction

$$\sigma = k_1 \exp(k_{exp} K_{bb})$$

Estimation of Kbb

$$K_{bb} = a + 0.4b$$
$$= 0.06a^*(\lambda)C^{0.65}\left[1 + 0.2\exp(-\gamma_y(\lambda - 440))\right]$$
$$+ a_d(400)\exp(-\gamma_d(\lambda - 400))$$
$$+ 0.4(b_b - b_{bw})/\tilde{b}_b$$

C: 0.1

γ_y: 0.014

$a_d(400)$: 0.01

γ_d: 0.011

$\tilde{b}_b(\lambda)$: 0.015   Browse...

$a^*(\gamma)$: C:\Program Files\HydroSoft\aStar.csv   Browse...

Restore Defaults

About...   OK   Cancel

9.7. CAL file format

Note that not all the parameters included in the CAL file are needed for the calibration procedure described above. Some parameters not shown here may also appear, and the sequence of parameters may change, depending on the firmware version. Each line may also include a comment, preceded by a double slash ("//").

```
[Start]
[General]        //Comment
Serial=H2991014
Config=W4B0R0F0S0I2
Label=U South Florida-4
CalTime=940441065 (10/20/99 17:37:45)
CalTemp=25.1
DepthCal=0.011509
DepthOff=27.776199

[Channel1]
Name=bb470
Gain1=0.105786
Gain2=1.000000
Gain3=9.814222
Gain4=97.364861
Gain5=994.677307
Mu=11.57230
Sigma1=0.998000
Sigma2=0.128000
Sigma3=0.012800
SOutOff=0.000000
SInOff=0.000000
ROutOff=0.000000
RNominal=10000.000000
Beta2Bb=6.790000
Bb2c=64.000000
TempCoeff=0.000000

[Channel2, etc. in same format]
.
.
.
[End]
```

10.   ANTI-FOULING SHUTTER OPTION

During long deployments in biologically active waters, organisms can grow on the windows and severely degrade the HydroScat's performance. To prevent this the HydroScat-2 can be equipped with a mechanical shutter that covers the windows with a copper plate when the sensor is not sampling. The shutter is powered and controlled by the HydroScat-2 (whether from its internal batteries or from an external source).

10.1. Description

The shutter is a separate device that mounts beside the HydroScat-2. The body of the shutter is 5.7 cm (2.3") in diameter and 12.1 cm (4.8") long. The shutter blade covers the four windows on the face of the sensor when it is closed, and rotates approximately 70 degrees when fully open. It does not touch the face of the sensor, but leaves a gap of a few millimeters. When equipped with a shutter, the HydroScat-2 is normally also outfitted with a copper face plate so although water can flow through the gap, it provides a very inhospitable environment for growth.
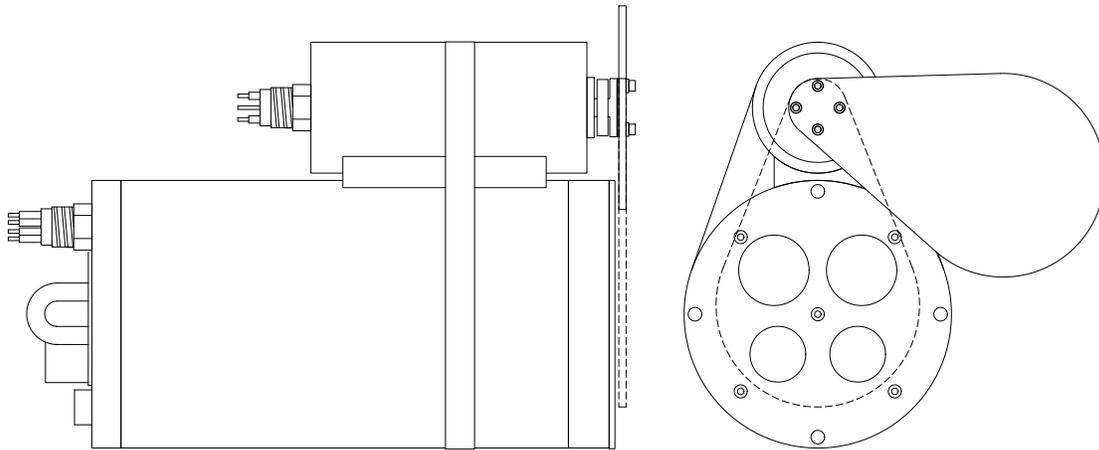

Figure 5 Side View and Face View of HydroScat-2 with Shutter

10.2. Wiring

Pins 6 and 7 on the HydroScat-2's MCBH8M connector must be wired to pins 1 and 2, respectively on the shutter's MCBH2M connector. For a deployment powered by the HydroScat's internal batteries, a short jumper cable can be used to make these connections.   If power must be supplied externally, or if

communication with the HydroScat is required while it operates, a Y-cable must be used.

10.3. Operation

The HydroScat-2 controls the shutter by simply supplying a voltage to it for a fixed length of time. The polarity of the voltage determines whether the shutter opens or closes. Electronics within the shutter sense when it reaches the intended position, and disconnect power from the motor at that time.

Although the HydroScat-2 does not sense the shutter's actual position, it keeps track of whether it was last sent an open or close command. Unless it receives a direct OPEN or SHUT command (see below) it will not attempt to open or close a shutter that is already in the desired state.

10.4. Operation Time

Since the length of time it takes to reach the open or closed position varies somewhat depending on temperature, pressure, and wear, the HydroScat applies power for at least the expected maximum time. The default time is user-programmable and can be stored in non-volatile memory along with the sensor's other operating parameters. The actual operation time is normally about 3 to 5 seconds, depending on temperature, voltage and pressure. However the programmed time should be set well above this to ensure that adequate time is available under all circumstances. We recommend a setting of 8 seconds.

10.5. Shutter-Specific Commands

These commands were introduced in version 1.80 of the HydroScat firmware. These will not take effect unless the HydroScat's internal configuration memory indicates it is equipped to handle a shutter.

10.5.1.　　SHUTTER,*auto,time* [Firmware 1.80]
　　　　SHUTTER,*enable,auto,time,direction* [Firmware 1.84 and later]

Sets and displays parameters controlling the operation of the shutter. If *enable* is zero, the HydroScat-2 will behave as if it is not equipped for a shutter. This is useful if you choose to deploy a shutter-ready instrument without a shutter. If *auto* is nonzero, the shutter will open or close when casts are started or stopped, and, if burst mode is in effect, when a burst is started or stopped.

Every time the shutter opens or closes, power will be applied for *time* seconds. During this time no sampling will occur, and the time is not counted as part of the warm-up time or burst length in burst mode. The recommended setting is 8 seconds (see the discussion above).

The value of *direction* determines the polarity of the voltage sent to the shutter when it is opened and closed, and therefore the direction in which it rotates. *Direction* is entered and displayed as either "CW" for clockwise or "CCW" for counterclockwise. These directions are defined with respect to the view looking at the end of the shutter shaft (as pictured in Figure 5 on page 57), and the default is counter-clockwise. Note however that some shutters are configured for special applications to rotate with the opposite sense.

To make the shutter settings completely nonvolatile, use STORELOG (section 8.3.21).

10.5.2.　　OPEN,*time*

Opens the shutter, applying power for *time* seconds. The power will be applied for this time even if the firmware's memory indicates the shutter is already open. If *time* is zero or unspecified, the default time (set by SHUTTER) will be used.

10.5.3.　　CLOSE,*time*

Closes the shutter, applying power for *time* seconds. The power will be applied for this time even if the firmware's memory indicates the shutter is already closed. If *time* is zero or unspecified, the default time (set by SHUTTER) will be used.

10.6. Other Relevant Commands

The shutter settings and current state are reported after the other logging parameters in response to the LOG (8.3.12) and BURST (8.3.1) commands. The shutter settings are also stored along with the log and burst parameters in response to STORELOG (8.3.21).

The response from GCF (global configuration, 8.4.4) indicates whether the HydroScat is equipped for a shutter.

11. TROUBLESHOOTING

If your HydroScat-2 does not respond to its external switch and HydroSoft is unable to wake and detect it, you may need to reset its microprocessor. This process will preserve logged data in RAM.

1) Connect the battery charger or another external power source.

2) Check that the HydroScat is properly connected to the computer.

3) Select the Reset command from HydroSoft's Instrument (or HydroScat) menu, making sure that it is addressing the port to which the HydroScat is connected.

4) Wait for 60 seconds after the reset completes before attempting to reconnect.

If the instrument still does not respond, use this alternate procedure. NOTE THAT THIS PROCEDURE WILL ERASE ANY DATA IN THE INSTRUMENT'S RAM! It will not affect data in flash memory, if your instrument is so equipped.

1) If it is possible the battery is discharged, connect the charger for at least 30 to 60 minutes.

2) Disconnect the charger from AC power.

3) Disconnect the data cable from the HydroScat's underwater connector.

4) Plug the special dummy plug (designated by a red handle) into the underwater connector for 10 seconds. If the special plug is not available, directly short pins 2 and 8 together (see section 6).

5) Remove the dummy plug and reconnect the data cable to the computer.

6) Attempt to connect using HydroSoft.

12. CUSTOMER SERVICE

If your HydroScat needs to be returned to HOBI Labs for repair, maintenance or calibration, contact HOBI Labs customer service (service@hobilabs.com, or call the main office, or go to the support section at www.hobilabs.com) with the following information:

- Instrument Serial Number

- Reason for return

- Method of return (Federal Express, United Parcel Service, etc.)

- Point of contact

- Date needed (standard turnaround is three weeks)

- Delivery address

HOBI Labs will provide you with a returned material authorization (RMA) number so that your instrument will be properly identified when we receive it. PLEASE DO NOT RETURN ANY EQUIPMENT TO HOBI LABS WITHOUT AN RMA NUMBER.

As soon as possible after receiving the instrument, HOBI Labs will inspect it and provide you with an estimated cost for required or recommended repairs (if any). Repairs will not be started until you approve the cost estimate and turnaround time.

For technical support or questions about your instrument, contact our technical support department at support@hobilabs.com, or consult the support section of www.hobilabs.com.