

SDR

Satellite-Linked Time-Depth Recorder

Version 3.14



Wildlife Computers

INSTRUCTION MANUAL

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Wildlife Computers
Satellite-Linked Time-Depth Recorder
SDR

INSTRUCTION MANUAL

Overview of the manual

Wildlife Computers satellite-linked time-depth recorders (SDRs) are available in a variety of hardware and software configurations.

Hardware configurations include:

- Transmitter model
- Housing type and shape (anodized aluminum housings, titanium tubes or epoxy-cast units)
- Power supply (2/3A- or C-cells)

Software configurations define data collection and transmission characteristics of the unit. Three "types" of software are available:

- Type 1 (customized for ice seal studies)
- Type 2 (customized for Stellar sea lion studies)
- Type 3 (standard software suitable for most species)

This manual describes the operational characteristics of all SDRs with Type 3 software. The operation of Type 3 SDRs is generally the same regardless of the hardware configuration; information pertaining only to certain hardware configurations will be noted (*e.g., One-watt transmitters, 2/3A cells, Aluminum pressure housings*).

The manual is divided into several chapters and appendices:

- Chapter 1 contains a general description of the SDR, and set-up and deployment instructions.
- Chapter 2 provides detailed descriptions of all the available commands.
- Chapter 3 describes the format of the transmitted data for those who wish to write their own analysis software, although such software (SATPAK) is available from Wildlife Computers.
- The appendices provide additional technical information. The troubleshooting appendix concentrates on communications between the SDR and your personal computer; other sorts of problems would probably require the return of the SDR to Wildlife Computers.

It is highly recommended that you carefully read the start of Chapter 1 beginning on page 5, and through the descriptions of Command O and Command P, pages 28 through 32. These commands define the way the SDR collects and transmits your data. The values set by these commands are critical to the success of your project.

Notation Conventions

The following notation conventions are used:

KEY Press the key(s) in this typeface. For example, **ENTER** means press the "enter" (or "return") key.

text Enter the text in this typeface exactly as shown. For example, **d** means press the letter "d".

text Replace the text in this typeface with the appropriate values, and enter. For example, **d dd/mm/yy** means to type the letter "d" and the day, month, and year as "d 31/01/90" (for January 31, 1990).

CHAPTER 1

Preparing the SDR for Deployment

How your Satellite-linked Time-depth recorder works

It is helpful to have an understanding of how Wildlife Computers SDRs work to better appreciate the importance of the various options and parameters that can be set by the user.

The SDRs are designed to provide both at-sea and on-land locations through the Service Argos system. In order for the Argos system to locate your animal, the SDR must transmit many messages to a low-orbiting satellite. Generally at least three messages must be received by the satellite during a pass for a location to be calculated. Data can be encoded into these messages, and we use this facility to provide information on behavior.

During deployment, the SDR spends most of its time in a low-power "sleep" mode which is powered by a backup battery. While asleep, only the memory chips (which contain your data) and a clock chip are powered. This clock chip is responsible for waking up the computer at a pre-programmed time interval. When wake-up occurs, all the components in the SDR receive 5 Volts which is regulated from the main battery pack. This causes the light-emitting diode (LED), located on the circuit board, to turn on. The wakeup period is usually very short (about 25 ms) and during this period decisions are made about how the SDR should behave (e.g., determine if it is time for data to be sampled, summarized and/or transmitted). The flash that you observe from the LED represents the entire time that power is being drawn from the main battery pack. You can tell by the length of the flash whether or not a transmission is being performed - wake-ups last significantly longer when transmissions are sent.

The SDR maximizes battery life by managing when the SDR should make a transmission and varying the wake-up rates.

Data transmission causes the largest drain on the batteries; power consumption for data collection is minimal in comparison. Transmissions are managed via user-definable options and parameters as follows (see *Command O*, page 28, and *Command P*, page 32 for full details):

- 1) The SDR will only transmit when "dry" (as determined by the conductivity sensor).
- 2) Two transmission rates are employed, one for when the animal is "at sea", and one for when it is "on land". The "at sea" rate is the Argos-provided "repetition rate" which was assigned with your PTT id. This is the maximum rate at which Argos authorizes your instrument to transmit, and is generally between 40 and 60 seconds. The "on land" transmission rate is slower (approximately every 90 seconds).
 - a) A transmission is made if the conductivity sensor reads "dry" at the scheduled transmission interval.
 - b) If the conductivity sensor reads "wet" at a scheduled transmission interval, the transmission is delayed and the unit changes to the "at sea" rate (if it is not using that rate already). The unit will transmit as soon as the animal surfaces (conductivity reads "dry").

- c) The SDR changes to the "on land" transmission rate after a consecutive, user-defined number of transmissions are made at the "at sea" rate without any delay caused by an intervening "wet" reading.
- 3) While the SDR is on the "on land" transmission rate, the animal is considered to be "hauled-out". The SDR suspends all transmissions after the animal has been hauled-out for a user-defined number of hours. The SDR resumes transmissions after a consecutive, user-defined number of wet readings.
- 4) Probable satellite coverage (yes or no) can be set on an hour by hour basis. If the coverage for the hour is "no", the SDR will not transmit.
- 5) A maximum number of transmissions per day can be set. The SDR no longer transmits once this number is met; however, data continue to be collected. This daily maximum can vary by month (*i.e.*, each month can be set to have a different number of maximum daily transmissions).
- 6) A "days on" and a "days off" value can be set. The "days on" value represents the number of consecutive days during which transmissions are made, and the "days off" value represents the number of days where transmissions are suppressed. The SDR will duty cycle, transmitting for the number of "days on", then suppressing transmissions for the number of "days off" (which can be set to zero). Data collection continues during the "days off" cycle.
- 7) ***Half-watt transmitters only:*** The SDR controller turns off the power to the Telonics ST-6 transmitter whenever transmissions are disabled to further extend battery life.

Three wake-up rates are used. The normal wake-up rate is every 10 seconds. This is the rate at which data are recorded and summarized for the transmitted messages. If it is time for a transmission, the SDR changes to a 1-second wake-up rate as the study animal nears the surface (depth is less than a user-defined value). If the animal continues towards the surface (depth readings become less than another user-defined value), the SDR changes to a 1/4-second wake-up rate. Changing to a faster wake-up rate as the animal moves towards the surface when a transmission is pending improves the chances that the SDR will recognize that it is dry and begin transmitting as soon as the animal clears the surface. Power is conserved, however, by using the 10-second rate while the animal is diving.

The SDR monitors the main battery pack's voltage at the beginning of each 10 second "wake-up", and throughout each transmission. Transmissions cause the greatest battery drain. All battery configurations lose voltage at lower temperatures, regaining voltage once the temperature rises. Precautions are taken when a low voltage is detected, since the SDR might "lock up", or fail, at voltages below 6V. If the voltage drops below 7V anytime during a transmission, that transmission is immediately terminated, and all subsequent transmissions are suspended for one hour. Data are still collected during this time, however. The SDR will try to transmit after the hour elapses (the voltage may increase if the animal has moved from colder to warmer water); if the voltage again drops below 7V, transmissions are suspended for another hour, and so forth. If, however, the voltage is below 7V at the beginning of a 10-second wakeup, the SDR will permanently suspend all future wake-ups and transmissions. Voltage below 7V at the beginning of a wake-up indicates the batteries are very nearly exhausted, thus the unit is programmed to maintain collected data in memory via the back-up battery, just in case the unit is retrieved.

The standard SDR has about 30 Kbytes of extra memory which are used to archive either histograms or depth readings. The archived histograms provide the complete histogram record (which can be downloaded to your PC if you are lucky and are able to recover the SDR). Archiving of depth readings is useful for pre-deployment testing if you wish to verify the depth calibration. The SDR stops archiving data once the extra memory is filled.

In addition, there is a TDR data-logging option available for the SDR. This option stores an additional 128K or 512K of depth readings. The SDR must be recovered for these data to be downloaded.

SDR transmitted message overview

Type 3 SDRs can transmit three classes of messages: "histograms", "timelines" and "status messages".

Histograms. Summary information on maximum dive depths, dive durations and/or the amount of time the study animal spends at certain depths ("time-at-depth") are collected and encoded into what we call "histograms". A histogram is a set of "bins" (accumulators), each of which contains counts for a given range of depth or time. The counts are accumulated for a "histogram period" (which is usually defined as 6 hours). The maximum count that can be held by a bin is 255. Thus a depth histogram bin contains the number of dives whose maximum depth fell within that bin's range during that histogram period. A duration histogram bin contains the number of dives whose duration fell within the bin's range. Time-at-depth histogram bins are slightly different: the count in each bin, as a fraction of the total counts of all the bins, represents the fraction of the 6 hour period that the animal spent in each depth range. For example, if a six-bin time-at-depth histogram has $n1$, $n2$, $n3$, $n4$, $n5$, and $n6$ in bins 1 through 6, respectively, the time spent in bin 1's range is:

→ 6 hours times $n1 / (n1 + n2 + n3 + n4 + n5 + n6)$

The number of bins assigned to each type of histogram message is user-definable. The SDR supports 0, 6, 10 or 14 bins per type of histogram. Once the number of bins is programmed into the SDR, the user then sets the upper limit of each bin. For example, one could program the SDR to have 6 depth bins, then set the upper limit for the bins to be 10m, 40m, 80m, 120m, 160m, ∞ (∞ = infinity). The SDR will sample depth every 10 seconds and determine the maximum depth of each dive. At the end of each dive the appropriate depth bin is incremented accordingly. Therefore, if the maximum depth of a dive were 100m, the fourth (120m) bin would be incremented by one.

At the end of a histogram period, the counts in the histograms are moved to the "transmit buffer", and new counts are accumulated. The transmit buffer contains histograms from the previous four histogram periods (last 24 hours for 6-hour histogram periods); the SDR cycles through the transmit buffer, transmitting each histogram in sequence (e.g., oldest depth, oldest duration, oldest time-at-depth, next oldest depth, next oldest duration, etc.), one histogram at each transmission interval. You should, therefore, get multiple transmissions of the same histogram during the 24 hours the histogram is in the transmit buffer.

The histograms may be compressed and/or concatenated into a histogram message. This optimizes the amount of data in each transmission. When histograms are formatted for transmission, empty bins are not used. In addition, two histograms may be concatenated into one message. See *Command O - Set Options*, page 28.

Timeline messages. These messages provide information on when the animal is hauled-out. Each timeline message covers a 24 hour period (midnight to midnight). The 24 hours are divided into 20-minute increments. The SDR assesses the conductivity readings for each 20-minute period and reports whether the majority of the readings during that period were "wet" or "dry". Timelines for the previous four days (24-hour periods) are transmitted.

Status messages. These messages contain information on the operating conditions of the recorder, the total number of transmissions sent, the maximum depth recorded over the last 24 hours, and the amount of time the animal spent at the surface over the last six hours. They are interspersed with the histogram messages and timeline messages.

Configuration Notes

Aluminum pressure housings:

"Open" versus "Sealed" SDRs

SDRs in aluminum or titanium housings can be shipped to you with the pressure housing "opened" (you will set the parameters via a personal computer and serial interface and seal the unit) or "sealed" (we program the parameters and seal the pressure housing for you) depending upon your request at the time of order.

If you specified "open", the SDR is shipped in the "Kill" mode (see *Command K - Kill the SDR Unit* on page 25). The unit will be "resurrected" when you establish communications (see *To Establish Communications* on page 11).

If you specified "sealed", the SDR has the parameters you specified at the time of order programmed, the pressure housing is sealed, and the unit is ready for deployment. All transmissions are disabled via the application of a magnet to the outside of the SDR's pressure housing. See **Appendix C, Disabling the SDR with a Magnet**, on page 61 for details.

A note about "O" rings

The "O" rings on your SDR are critical in keeping seawater out. They must be inspected before deployment. The "O" rings must show no signs of nicking; if they do, replace them. The "O" ring groove should be carefully examined to ensure that it is free of all debris, including any lint from a cleaning cloth! Dress the "O" rings with a little silicone grease if they appear to be dry (stopcock or vacuum grease is fine). Do not use regular grease to dress these "O" rings as it degrades them. Also, do not leave the "O" rings exposed for longer than absolutely necessary, small particles of dust and hair will adhere to the silicone grease and may provide a track for water to seep into the SDR. Also do not trust new "O" rings (including those that we supply) to be perfect, on a bad day I once discarded 25% of a new shipment!

2/3A CELLS:**Cold temperature "lock up" potential**

Cold temperatures cause the 2/3 A battery cells to be drained at a faster rate. The nominal capacity of 30,000 transmissions at +10°C is reduced to 27,000 transmissions at 0°C, and to 20,000 transmissions at -20°C. Once temperatures fall below -20°C, transmissions can cause the battery voltage to drop precipitously, causing the SDR's computer to irreversibly "lock-up" (fail).

SDRs powered by 2/3 A cells are provided with a low-temperature cutoff facility. This feature should be enabled and the cutoff temperature set to a value no lower than -20°C. The cutoff temperature can be set to a higher value if you wish to extend the battery life at the expense of low-temperature transmissions (*e.g.*, the SDR will not transmit when the animal is hauled-out where the air temperature is below this minimum).

The C battery cells do not exhibit the same potential "lock up" at low temperatures.

Standard Rectangular Epoxy-Cast Half-Watt SDR

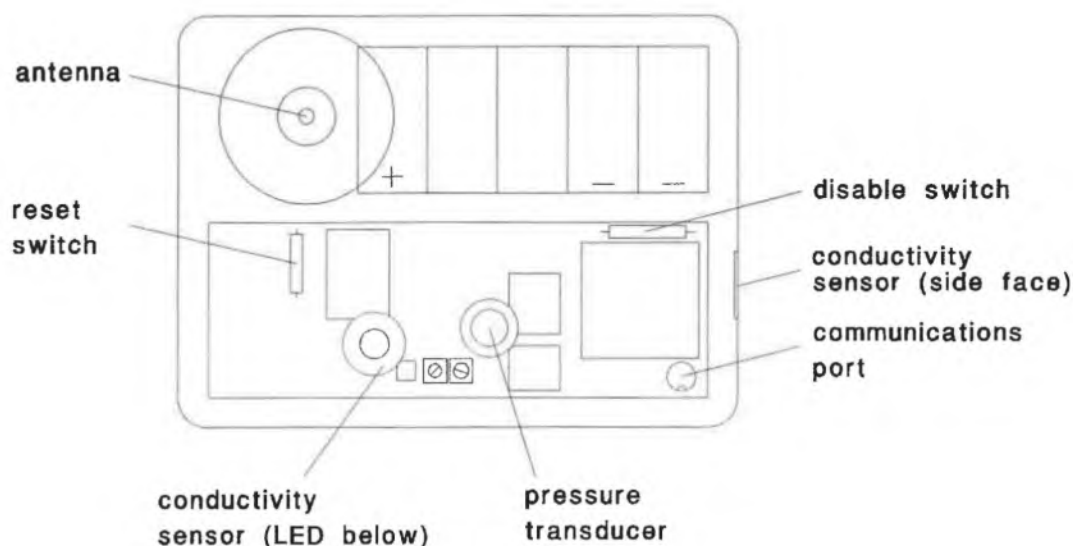


Figure 1: This figure shows a simplified layout of the half-watt, standard rectangular epoxy-cast SDR and the visible internal components (the batteries and the Wildlife Computers controller, which is overlaid on the Telonics epoxy-cast ST-6 satellite transmitter). The batteries, controller and transmitter are cast in an epoxy block, measuring approximately 3.6" x 4.8" x 1". The components on the boards that are referenced elsewhere in this manual are labelled. Note that the conductivity sensors (metal washers), pressure transducer, and the antenna might be oriented differently on your particular unit.

NOTE: If your SDR is cast in a custom-shape (*i.e.*, not the standard rectangular-block shape), the communications port, pressure transducer and conductivity sensors are in positions different from the above figure. The internal components, however, are in the same relative positions on the board.

The relevant components are marked on your actual SDR.

Getting Started:

You should have received the following items in your shipment:

Cast SDRs

- The SDRs (epoxy/urethane blocks with antennae). See Figure 1 on page 10.
- Communication port plugs
- Silicone grease to seal the communications ports

To communicate with the SDR and set the user-definable parameters, you will also need:

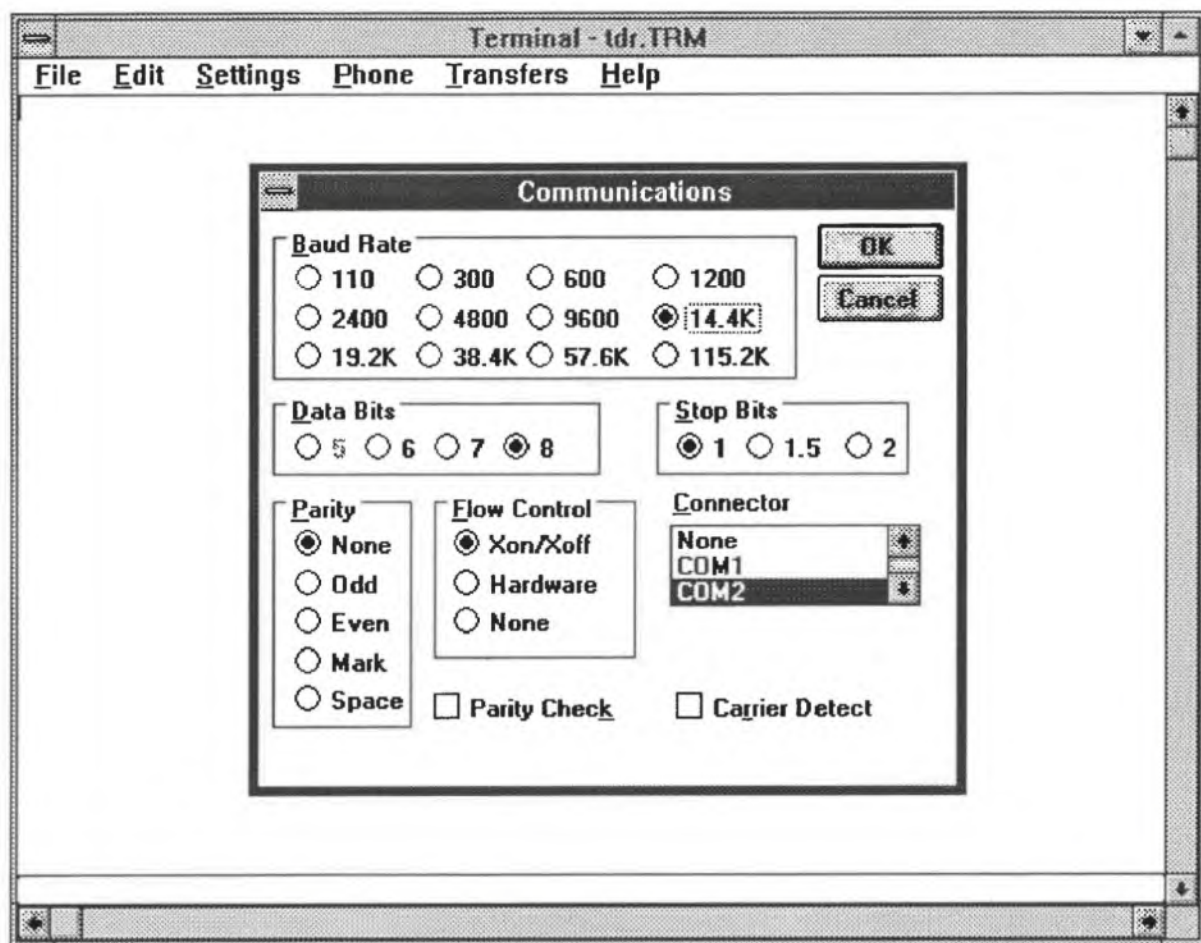
- A PC (almost any computer running MS-DOS or PC-DOS version 2.0 or later will do).
- A serial (RS-232) interface (this is a male 25-pin or 9-pin outlet on the back of your PC, sometimes referred to as an asynchronous communications interface).
- A Wildlife Computers communications interface with voltmeter (so your personal computer can talk to the SDRs). It consists of a blue plastic box, an 8 or 10-pack plastic holder for AA (external) batteries, an adaptor to fit the SDR's communication plug, and attached cables. This item is purchased separately from your recorders.
- A copy of PROCOMM communication software. This software is supplied by Wildlife Computers when you purchase a communications interface. Please note that you are responsible for registering this software with Datastorm Technologies Inc. A copy of the registration form is included on the PROCOMM diskette.

In order to verify the SDR is transmitting correctly, we highly recommend you purchase an uplink receiver which operates on the satellite's 401.65 MHz frequency (available from Telonics for about \$100.00).

Step 1: Establish Communications

Establishing communications between with your PC and the SDR is similar to using your PC to log onto a mainframe, only in this case the SDR will act as the "host" computer.

- 1) Connect the special SDR communications cable to the RS-232 (serial) port of your PC. This port is generally marked COM1 or COM2.
- 2) Load your communications program.
 - a) If you use Windows Terminal, use the Settings / Communications dialog and set up the parameters as shown on the following example. Note that you will need to set the Connector to the port to which the communications interface is connected on your PC. Generally, if your PC was shipped with an internal modem, the modem will be assigned to COM1, and the serial port setting will be COM2. Otherwise, it generally is COM1.



Use the File / Save As dialog and save these settings to a filename. The next time you use terminal, use the File / Open dialog and open the file to retrieve these settings.

- b) If you are using PROCOMM (supplied with your order), install it onto your hard drive using hinstall.bat. It is already correctly set up and ready to run - just type `procomm` at the DOS prompt.
- c) If you decide to use some other communications software, it should be set up as follows:
 - i) to communicate with 8 data bits, no parity bits and 1 stop bit,
 - ii) to enable XOFF/XON (`CTRL-S/CTRL-Q`) software handshaking,
 - iii) to disable any hardware handshaking,
 - iv) to display all received characters verbatim using the full 8-bit IBM character set (all "filtering" disabled),
 - v) to communicate at one of the following baud rates: 300, 600, 900, 1200, 1800, 2400, 3600, 4800, 7200, 9600, 14400, or 28800 baud. Generally a baud rate of 9600 is recommended, however, see the **Selecting maximum baud rate** appendix on page 60 for tips on selecting the maximum baud rate that your software can reliably handle.

- 3) Connect a power supply (pack of AA cells or a battery eliminator) to the communications interface box. The idea is to have the SDR draw its power from the interface box during communications, thus saving the internal batteries for sampling, storing and transmitting data. In order for this to happen, the communication power supply's voltage must exceed that of the SDR's own battery pack by one-half Volt. The recommended voltages are:
 - *SDRs using Telonics ST-6 transmitters powered by either $5 \times 2/3A$ or $4 \times C$ cells:* 14 - 16 Volts. You may use either a 10-pack of AA batteries or a 15V battery eliminator (available from Radio Shack).
 - *SDRs using Telonics ST-10 transmitters powered by $2 \times 2/3A$ cells.* 9 to 16Volts.
 - *SDRs using Telonics ST-10 transmitters powered by $2 \times C$ cells:* 9 - 16 Volts.
 - *SDRs using Seimac one-watt SSC3 powered by $3 \times C$ cells:* 12 - 16Volts.

One set of AA batteries should last for a complete season, but it is a good idea always to have an extra set along.
- 4) Turn the communications "on" using the switch to the right of the voltmeter on the communications interface box.
- 5) Check the voltage on the interface box. If this voltage too low, replace the AA batteries because communications may become erratic. If the voltage is high (in the case of an inappropriate battery eliminator), do not continue, your SDR will be damaged. The voltage should be as stated above.
- 6) Check the connecting cable assembly by typing several characters on your PC keyboard; they should echo to the screen (although sometimes not reliably at baud rates above 9600). If characters do not echo at baud rates of 9600 or less, see the **Troubleshooting** appendix on page 58.
- 7) Turn the communications "off" at the communications interface box. Type several characters. They should *not* echo on the screen when the communications box is turned off.
- 8) Make sure the appropriate adaptor is connected to the end of the ribbon cable. Some instruments have a circular communications port. These instruments require an adapter which converts the standard 4-pin sockets (used in our Time-depth recorders).
- 9) *Half-watt SDRs, versions prior to 3.10 only:* Place a magnet over the communication/disable reed switch (see **Figure 1** on page 10). This magnet must be in place until communications are established; it may be removed once communications are established. The magnet is not required for communications on version 3.10 and later.
- 10) Turn the communications "on" at the communications interface box.
- 11) Press the **SPACE** bar of your PC once or twice and the SDR identification and copyright notices should appear on your PC's screen. If you get no response, pass a second magnet over the reset switch location. If the screen looks garbled, you are probably trying to communicate faster than your communications program can manage: Try reducing the baud rate. If the copyright notice is not surrounded by a box, check that your communications program is set for 8 data bits, and/or disable any character filtering.
- 12) Press a **RETURN** to accept the limit of liability displayed.

- 13) You will now get a brief listing of the default settings of the SDR followed by the SDR> prompt. Instructions to the SDR are all given at this SDR> prompt.

Communications with the SDR:

NOTE: All SDR commands must be followed by **RETURN** or **ENTER**, case (lower or upper) is immaterial. While using **PROCOMM**:

- Press **CTRL-C** or **ESC** to stop listings
- Press **CTRL-S** to pause a listing
- Press **CTRL-Q** to resume a paused listing
- Press the **BACKSPACE** key to delete the last character typed
- Press **CTRL-U** or **CTRL-X** to delete the last line typed
- Press **ALT-F7** (which transmits a **BREAK** code to the SDR) to return to the baud rate sensing part of the program. Press the space bar to continue as in step 10, above. The **BREAK** acts as an immediate abort and can also be used for changing the baud rate.
- When presented with a question, type **Y** **RETURN** for "yes", all other input is interpreted as "no".
- You may type ahead of the character echo without losing characters.

NOTE: On-line HELP

Type **H** at the SDR> prompt; there are many simple commands listed on the help menu. Only a few of these commands are necessary to set up the SDR for data collection and transmission; they are described in the following sections. A full description of all the commands appears in Chapter 2.

Step 2: Set the Date and Time

Type **D** at the SDR> prompt; the current date will appear on the screen (or what the SDR thinks is the current date). To set the date, type **D dd/mm/yy** (note that the date is coded day first followed by month then year; e.g., Feb 4th 1987 would be entered **4/2/87**). To set the time type **T hh:mm:ss** (seconds are optional); press **ENTER** at the moment the time matches what you have just typed. The SDR uses a 24-hour clock so 9:05 am should be entered 9:05, 9:05 pm should be entered 21:05. The time can be checked by just typing **T** again.

Note that date and time must be set in GMT (otherwise known as Greenwich Mean Time, UT, or Zulu time) units.

Step 3: Program the user-defined variables

Refer to *Command O* and *Command P* beginning on page 28 for details on setting these variables.

Always set the options in Command O before setting the parameters via Command P. The values set in Command O influence the parameters set by Command P. If you change anything in Command O, be sure to verify that the parameters in Command P are what you want.

Step 4: Check the voltage of the internal battery pack

Invoke Command V to check the internal battery pack's voltage. This gives an approximate indication of the overall state of the SDR's internal battery pack. A new battery pack should read about:

- *SDRs using Telonics ST-6 transmitters powered by $5 \times 2/3A$ cells:* 12 Volts.
- *SDRs using Telonics ST-6 transmitters powered by $4 \times C$ cells:* 14 Volts.
- *SDRs using Telonics ST-10 transmitters powered by $2 \times 2/3A$ cells:* 6 Volts.
- *SDRs using Telonics ST-10 transmitters powered by $2 \times C$ cells:* 7 Volts.
- *SDRs using Seimac one-watt SSC# powered by $3 \times C$ cells:* 10.5 Volts

Any voltage below this indicates that the batteries are suspect.

A more accurate and reliable method of assessing the state of the batteries is to measure the battery voltage when data are being transmitted. The quickest way to perform this test is to by initiating a test transmission by following these steps:

SDRs using Telonics ST-6 or ST-10 transmitters:

- 1) Establish communications
- 2) Press **X**, **ENTER** at the SDR> prompt to enter the Half-watt Transmission Submenu (see page 43).
- 3) Press **8**, **ENTER** for the number of bytes to transmit
- 4) Enter any numbers for the data values to transmit
- 5) Press **+**, **ENTER** to provide power to the ST-6
- 6) Press **?**, **ENTER** at the X-SDR> prompt to verify the ST-6 is communicating with the SDR controller
- 7) Press **T**, **ENTER** to generate a transmission
- 8) The recorder will report a series of battery voltage readings during and after the transmission. You should notice the voltage dropping during the transmissions as power is drained from the batteries, then rising after the transmission completes. The lowest voltage reading reported by SDRs with new batteries should be no less than:

SDRs using Telonics ST-6 transmitters powered by $5 \times 2/3A$ cells: 11 Volts.

SDRs using Telonics ST-6 transmitters powered by $4 \times C$ cells: 12.5 Volts.

SDRs using Telonics ST-10 transmitters powered by $2 \times 2/3A$ cells: 5 Volts.

SDRs using Telonics ST-10 transmitters powered by $2 \times C$ cells: 5.5 Volts.

If the voltage begins to fall precipitously (e.g., you are testing a SDR that has been recovered to see if there is enough battery power left for another deployment), the

batteries are nearing the end of their capacity. Voltage tends to drop steeply as the batteries near exhaustion.

- 9) Press **-**, **ENTER** to remove power to the ST-6 (the SDR controller will ensure the ST-6 has power when it should be "on")
- 10) Press **X**, **ENTER** to exit the Transmission submenu and return to the SDR> prompt

SDRs using Seimac SSC3 Transmitters:

- 1) Establish communications
- 2) Press **X**, **ENTER** at the SDR> prompt to enter the One-watt Transmission Submenu (see page 45).
- 3) Press **8**, **ENTER** for the number of bytes to transmit
- 4) Enter any numbers for the data values to transmit
- 5) Press **T**, **ENTER** to generate a transmission
- 6) The recorder will report the lowest battery voltage measured during the transmission. SDRs with new batteries should report:
 - *with 3 × C cells:* 9 Volts

If the voltage approaches 7V (*e.g.*, you are testing a SDR that has been recovered to see if the batteries need replacement), the batteries are nearing the end of their capacity. Voltage tends to drop steeply as the batteries near exhaustion.
- 7) Press **X**, **ENTER** to exit the One-watt Transmission submenu and return to the SDR> prompt

Step 5: Disconnect the SDR

Having verified the time, date, programmable parameters and battery voltage, you are ready to exit communications and disconnect the SDR from the communications interface.

- 1) Exit communications by pressing **E** (see Command E, for exit, on page 22). Follow the prompts carefully!
- 2) You are finally told to disconnect the communications cable. Disconnect and deploy as follows:
 - a) **Turn "off" the communications on the interface box.** Make sure this is done before you disconnect the connector.
 - b) Remove the communications connector from the SDR by pulling on the ribbon connector (not the cable).
 - c) Observe the small red light (LED) on the circuit board. It should flash every 10 seconds (which is the fundamental sampling interval), and whenever a transmission occurs. If it does not flash, re-connect the communications connector and verify that the light works, and re-exit as before. If the light stays on constantly at any time after the communications connector is removed, you have a bad SDR which needs to be repaired by Wildlife Computers. A regularly flashing light is your indication that the SDR is working correctly.

- 3) Disconnect the battery pack from the interface box after you have set up all your recorders. Even when the box is "off", there is a current drain which will flatten the batteries over time.

Step 6: Deploy the SDR

Epoxy-cast SDRs:

- 1) Place the teflon plug in the communications port and cover with 5-minute epoxy.
- 2) Using a "Q-tip" or cotton bud, clean the conductivity sensors (metal washers) with some alcohol to ensure that the conductivity sensing will work.
- 3) Immerse the recorder in a bucket of seawater, ensuring that no bubbles get lodged around the conductivity sensors. Leave it submerged for a couple of minutes, then bring the unit to the surface and verify that it transmits within one second of breaking the surface.
- 4) The SDR is now ready for deployment. The SDR can be inhibited from transmitting by applying a magnet in the correct manner to the DISABLE location on the housing. See **Appendix C, Disabling the SDR with a Magnet** on page 61.
- 5) Mount the SDR to your study animal.

The attachment of the SDR depends upon the study animal and your personal experience in attaching equipment. The SDR can be attached to the animal's fur with epoxy; you may wish to epoxy some netting to the underside of the SDR first, giving yourself more surface area to attach to the fur. Alternately, you may prefer to design a harness to hold the SDR to the animal. In any case, make doubly sure that you remove the disable magnet before releasing your animal!

CHAPTER 2

The SDR's Commands in Detail

Once you have established communications between your PC and the SDR you can invoke any of the following commands in almost any order; each is described in some detail below. The only restriction is that Command E or Command K must be the last command invoked before disconnecting the communications cable.

A	transmit A /d conversions
B	get B rief status information
D	set or enquire D ate
E	E xit and start data sampling
H	H elp Summary
K	K ill unit: disables all sampling
L	L ist sampled data
M	perform M emory test
O	Set O ptions
P	P rogram user-defined variables
R	R e-initialize the SDR
S	Set the sampling interval (for TDR data-logging option)
T	set or inquire T ime
U	set the dUty cycle (for TDR data-logging option)
V	check the battery V oltage
X	Enter Transmission Sub-menu

NOTE: When a command prompts you for a **Y** or **N** response, pressing **Y** **ENTER** means yes; all other input is interpreted as **N**.

Command A - Analog-to-digital conversions

Description: Command A allows the state of the conductivity sensor, the state of the magnet switch, and the depth channel to be sampled and displayed at specified time intervals. The results of the conversions are displayed on the host computer. This command is invoked when you want to observe the SDR in action (*i.e.*, to make note of the current zero-pressure offset, test the conductivity sensor (seawater resistance), and/or test the magnet switch). The sampling interval for this display is specified by a numeric code which takes a value between 1 and 7, and corresponds to sampling intervals between 0.1 and 60 seconds as follows:

1	= 0.1 seconds
2	= 0.5 seconds
3	= 1 second
4	= 5 seconds
5	= 10 seconds
6	= 30 seconds
7	= 60 seconds

The values are reported as followed:

- Seawater resistance is reported as a number which should range from about 4 (an indication that the conductivity sensor may be shorted out) to 255 (open circuit, which you normally get when the sensors are dry or in fresh water). The resistance should read around 20 when the sensors are in seawater.
- Status of the magnet switch
- "Magnet=1" Magnet is in place at the communications/disable position
- "Magnet=0" Magnet has been removed
- Depth reading in meters
- Temperature (if the SDR is powered by 2/3 A cells)

Format: Type **A** to invoke this command. You will then be prompted for the sampling interval.

Example of conversion:

S.W. resistance = 255, magnet = 1, Depth (m) = 0

If Depth is showing a value other than "0" during the conversion (and there is no pressure on the pressure transducer), press **z** to set the depth to zero.

To terminate conversions, press the **SPACE** bar.

Command B - Brief status report

Description: Command B provides the user with a brief listing of the following useful information:

Version of the SDR Software.

ARGOS geolocation id.

Date and time the unit was started.

Current values of user-defined variables (see Command P, page 32)

Sampling Protocol (if the SDR has the TDR data-logging option installed)

Format: Type **B** to get the brief status report.

Command D - Report/set SDR's date

Description: Command D is used to report or set the date of the SDR's clock. The date should be set to **GMT** (Greenwich Mean Time) when the SDR is first switched on.

Format: To set the date, a string of numbers representing the date must be included in the command line. The format is `D dd/mm/yy` where *dd* represents the day, *mm* represents the month and *yy* represents the year. If no numbers follow the `D` command, the current date will be reported in an unambiguous form.

NOTE: The order for date entry is day, month, year - not month, day, year. Years less than 50 are interpreted as in the 21st century (e.g., 15/03/40 = March 15, 2040).

Command E - Exit communications and deploy SDR

Description: Command E is used to exit the communications commands and start sampling and transmitting data. This command will display the SDR's current parameter values for confirmation. It also sets the unit's start-up time and date reported by Command B.

Format: Type **E** to invoke this command. The following prompt will be displayed:

It is strongly recommended that you log the following information to a disk file so that you have a permanent copy of this setup. In PROCOMM you do this by pressing the ALT-F1 key combination. You will then be prompted for a filename, a suggested name is *SDR-serial-number.SET*. After you have entered a filename, press return to continue.

A record of the values that you set in Command O and Command P are critical for the analysis of your data. This prompt instructs you to turn disk logging on in the communications package, so that all information that appears on the screen will also be written to a file. A suggested name for this log file is *SDR-serial-number.SET*, where *SDR-serial-number* is the unit's serial number as assigned by Wildlife Computers. Following this prompt, the SDR will list a control block in hexadecimal format (for use by Wildlife Computers analysis programs), followed by all the parameter settings in a readily-readable format. *Carefully review these parameters to ensure the values you want were programmed into the SDR.*

We highly recommend that you print a copy of the disk log file to store in your experiment's notebook, and keep a copy of the file in a safe place. This file will be essential if you use Wildlife Computers analysis programs when analyzing your data.

If the SDR has the TDR data-logging option and has stored data (e.g., from testing), you are asked if you want to overwrite the data.

Type **Y** to overwrite, or **N** to append new data to the existing data.

You are then asked:

Ready to deploy?

If you type **N** (for No), you will be returned to the SDR> prompt.

A response of **Y** (for Yes) sets up the SDR for data collection and transmission.

- You will be presented with one more prompt:

Type **D** to archive depth data, **H** to archive histograms:

The SDR has about 30 Kbytes of spare memory, which is used to archive either depth readings (one byte per reading) or the transmitted histograms. The depth readings are useful if you are pressure-testing the unit and wish to verify the depth calibration. Generally you should choose **H** (the archived histograms give you a complete histogram

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record if you are lucky enough to recover the instrument!). The archived data are downloaded via Command L9.

Finally you get a message to disconnect the communications cable and go for it... See *Disconnecting the SDR*, page 16, for details of the disconnection and deployment sequence.

If you opened a log file in Procomm as suggested above, press `ALT-F1` to close it.

Command H - "On-line" help

Description: Command H is used to display a summary of the SDR's commands. The help information should be surrounded by neat boxes; if they are not, you need to adjust your communications program as detailed in the **Selecting maximum baud rate** appendix on page 60.

Format: Type **H** to get the command overview.

Command K - Kill the SDR unit

Description: Command K is used to disable or suspend the SDR from all further sampling and transmissions. This will generally be used when the SDR is to be stored or during shipping. Command K minimizes the battery drain while maintaining the contents of memory, the time, and the date.

Format: Type **K** to invoke the disabling of the SDR. You will be asked to confirm this function. If you do confirm this function, you will be prompted to disconnect the SDR. The SDR will now do nothing other than maintain the contents of memory and the correct time and date until communications are re-established. See **Disconnecting the SDR**, page 16, for details of the disconnection sequence - it is the same as for command E. SDR's are "resurrected" by re-establishing communications following the same connection procedure as used when communicating with a SDR which has been collecting data - see **To Establish Communications**, page 11.

NOTE: If you do not wish to "kill" the SDR but merely restrain it from transmitting data (*e.g.* after programming and testing, but before deployment), you should place a magnet on the **DISABLE** location on the housing. See **Appendix C, Disabling the SDR with a Magnet** on page 61 for details.

Command L - List sampled data

Description: Command L is used to list collected data. The following listing formats are available:

All SDRs

- 8 list the current histograms in hexadecimal format
- 9 list the archived histograms or depth readings in hexadecimal format
- 10 List control variables (for Wildlife Computers testing purposes only)

In addition, if your SDR has the TDR data-logging option installed:

- 0 list sampled data in decimal
- 0c list sampled data in compressed decimal
- 1 list entire memory in decimal
- 1c list entire memory in compressed decimal
- 2 list sampled data in hexadecimal
- 3 list entire memory in hexadecimal
- 7 list TDR hour markers and sampled battery voltage

Full details of the format of these listings are given on page 54.

Format: Type **Ln** to invoke this command where **n** corresponds to one of the listing formats above. If **n** is absent, you will be prompted with the above alternatives and asked to choose one.

If you are listing data collected by the TDR data-logging option, **L2** is generally recommended as it is moderately fast and can be handled by all communications packages, however you will need some additional software to decipher this hexadecimal file (available from Wildlife Computers). **L0** is verbose, but readily readable. Under some circumstances the **L0c** command will remove blank lines from an **L0** listing making it less verbose- see page 54.

NOTE:	Listings can be paused by typing CTRL-S , resumed by typing CTRL-Q , or aborted by typing CTRL-C or ESC .
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Command M - Memory Test

Description: Command M is used to test the memory of the SDR. Testing is performed by writing a standard test pattern to all of memory and then checking that the test pattern reads back correctly. The memory test may also be performed without the writing phase. In this manner it can be used to check memory a few days after the test pattern was written to check for long-term data integrity. If some data have been collected since the last M command, then the collected data will show up as errors on this test.

Program memory is also tested for integrity.

Format: Type M to invoke the memory test which includes the writing phase. You will be warned that this test will overwrite any collected data. Data are then written to all addresses and read back to check that they are the same. If a discrepancy occurs, the bad data address, original data and bad data are reported.

Type M0 to invoke the memory test without the writing phase. The progress of this test is displayed.

Generally, a failed memory test indicates that the memory chip may be bad; if so the SDR will need to be serviced. Contact Wildlife Computers for further assistance.

Command O - Set Options

Description: Command O is used to set certain options on the SDR. The options available may vary based upon the software version installed on your SDR. Following are the options that were implemented in SDR Software version 3.10. Not all of the options presented below are available if you have a lower SDR version.

The selection of these options will define what variables you will be prompted for in Command P.

NOTE: *If you change any option, make sure you run Command P and update the parameters accordingly.*

Format: Type o (alphabetic "oh", not the number zero) to invoke this command. The prompts for the options are (where *c* is the current value of the variable):

Do you wish to allow any unused portion of your daily transmission allowance to be added to the next day's allowance? [y]

You can limit the number of transmissions the SDR makes in a 24-hour period (via the *daily transmission allowance* parameter set in Command P). This option allows you to choose whether any unused allowance should be added to the next day's allowance.

For example: Your daily transmission allowance is 500. On "Day One" the SDR only transmitted 400 messages during the 24-hour period, not transmitting more because of either being wet or bad coverage hours. Thus the unused portion of the daily transmission allowance for "Day One" is 100.

Press **y** if you wish to add the remaining allowance added to the next day's allowance (in the above example, add the remaining allowance of 100 to the next day's allowance of 500, giving "Day Two" a daily allowance of 600 transmissions).

Press **n** if you do not wish to accumulate unused transmission allowances (in the above example, not adding the remaining allowance of 100 from "Day One" to "Day Two's" daily allowance, thus "Day Two" maintains an allowance of 500).

Do you wish to be able to set the daily transmission allowance on a month-by-month basis? [n]

This option allows you to either vary the daily transmission allowance by month (month is determined by the SDR's clock), or set one daily allowance to be used throughout the deployment.

Press **y** if you wish to set a different daily allowance for each month in Command P (e.g., set an allowance of 50 for each day in January, February and March, then 500 for each day in April through December).

Press **n** if you only need to set one daily allowance in Command P (e.g., the same allowance will be used for each day of all the months).

This recorder has 2 available depth ranges:

The Shallow range measures from 0 to 235 m, with a resolution of 1 m

The Deep range measures from 0 to 490 m, with a resolution of 2 m

Currently depth is measured using the Shallow Range.

Do you wish to switch to the Deep Range?

SDRs with a software version number of 3.10 or higher have two available depth ranges. The Deep range is twice the Shallow range as a default, however, the actual ranges are specified at the time of order. The depth range prompt displays the depth ranges that are installed on the SDR, and which (Shallow or Deep) range is currently being used (this particular example shows the depth ranges and resolutions for a 250/500m instrument - 235 is the maximum depth that can be recorded on the shallow range, and 490 is the maximum depth that can be recorded on the deep range). Press `RETURN` to maintain the current range, or press `v` to change to the alternate range.

NOTE:

If you change the depth range being used, all parameters set via Command P are rescaled accordingly. For example, if the SDR has a 250m Shallow and 500m Deep range, and you use this option to change from the Shallow to Deep, all depth values set by Command P (e.g., minimum depth to be considered a "dive", depth histogram upper limits, etc.) will be multiplied by 2.

Enter number (0/6/10/14) of depth histogram bins: [c]

Enter number (0/6/10/14) of duration histogram bins: [c]

Enter number (0/6/10/14) of time-at-depth histogram bins: [c]

The above three options establish the number of histogram bins for each type of histogram (see *SDR message overview*, page 7). If a type (depth, duration or time-at-depth) of histogram has zero bins, no messages are transmitted for that type. Histogram messages vary from 4 to 16 bytes in length. Each message contains one header byte, 2, 6, 10 or 14 bytes for the bins (one byte per bin), and one checksum byte (see *How the Histogram Message Data are Encoded*, page 50). The longer the message is, the longer it takes to transmit and the greater the battery drain. The SDR does not transmit unnecessary bins, however. Messages are shortened by 4-byte segments if the counts contained in four consecutive bins, starting at the highest bin and working downwards, are all zeros. For example, if a histogram is defined to have 14 bins and all the bins contain non-zero counts, the message built would be 16 bytes long (one header byte, 14 bin bytes, and one checksum byte). If, however, the histogram has the counts 2,53,4,1,1,7,7,0,0,0,0,0,0,0 in bins 1 through 14 respectively, the histogram message built will be 12 bytes long, (one header byte, 10 bin bytes containing 2,53,4,1,1,7,7,0 respectively, and one checksum byte). The shortest histogram message possible is four bytes.

This means, for example, that if the SDR has a 500m depth range, but you do not think your study animal ever goes deeper than 300m, you may feel free to set up an extra four deep bins to cover the 300-500m range. If your animal never goes beyond 300m the SDR will not expend any extra battery power, but if the animal does, you will have the additional information.

The current number of bins for each type of histogram is displayed in brackets.

PRESS RETURN to keep the current number of bins.

Target number of bytes per transmission (4/8/12/16/20/24/28/32) = *c*
Enter new value:

The "target number of bytes per transmission" option provides further control of the transmitted message length. As mentioned earlier, longer transmissions take a longer period of time to transmit and cause a greater battery drain. If, however, your study animal does not surface frequently or is in an area of poor satellite coverage, you may want to try to get as much data through each transmission as possible. The SDR provides the option to concatenate histograms and timelines.

If, for example, the next two histograms or timelines scheduled to be transmitted have a total length that is less than or equal to the target number of bytes per transmission, the two messages will be concatenated and sent in one transmission. The messages must be decoupled at analysis time. Each of the concatenated messages, however, can stand alone. Histograms and timelines are always sent in their entirety, thus have their header and checksum bytes. If the transmission of the second concatenated message is disrupted because the animal went below the surface, the first message should still be valid.

A "partial" histogram or timeline is never transmitted. For example, if the target number of bytes is 8 and a histogram has a length of 12, the message length will be 12. Therefore, if you do not want the messages ever to be concatenated, set the target number to 4. Note that timeline messages are always 12 bytes long.

This option also controls how the "nominal battery capacity" is calculated and displayed in Command P. The number of transmissions is calculated based upon this target value.

PRESS RETURN to keep the current target value.

Version 3.14a and greater - Freshwater layer option

Instruments with software version 3.14a and greater have a new feature, the *Freshwater layer option*, in the "O" command. The freshwater/seawater layer option is designed to help out in areas where there is a layer of freshwater over the seawater (e.g., where freshwater streams enter the sea, or areas of heavy glacial melt), or areas of low salinity. Freshwater has a lower conductivity (higher resistance) than seawater. Air has the highest resistance (255).

The SDR measures resistance when it is at-depth. It then considers it has cleared the water, thus is at the surface and able to transmit, when the resistance is roughly twice the at-depth resistance. A potential problem occurs under two circumstances. One case is when there is a discrete freshwater layer over the seawater, so that the resistance suddenly jumps when the animal ascends into the freshwater layer. The SDR could get confused, and think the freshwater layer is actually air, and initiate a transmission. The second case is when the water has such a low salinity that the instrument does not recognize "wet".

Unless you know that there will be a freshwater layer or you are deploying in a low-salinity environment, disable this option.

If you want to use this option, you will need to measure the resistance of the surface water (freshwater layer or low-salinity water). Communicate with the SDR, and run command A2. Carefully dip the pack into the water so that both washers are covered, (be careful not to get the comm port wet). Look at the "S.W.resistance" value. If it is reading 70 or more, then you may want to use this option. You will find this option at the end In the "O" command submenu. Enable the option and set the value to the measured S.W.resistance value. The maximum for this value is 200, but your readings should never approach this.

Note that under normal operation, the SDR tracks changing sea water resistance at depth. If you have animals that are swimming into and out of well-mixed estuarine environments, the normal resistance tracking will continue to optimize the transmission conditions. This freshwater layer option will force the pack to delay transmissions until it has cleared a possible freshwater layer, but the resistance value of this "layer" does not change once it has been set.

Now remember to run Command P if you made any changes!

Command P - Program user-defined variables

Description: Command P is used to set the user-defined variables (parameters).

NOTE: You should keep track of the values you enter for each parameter. They are essential for the subsequent analysis of your data.

Format: Type **P** invoke this command. The current value for each parameter will be displayed, and you will be prompted for the new value. Enter the new value. If you do not wish to change the value, just press **ENTER**.

The prompts for the user-defined parameters are (where *c* is the current value of the variable):

User-definable identification = *c*
Enter new identifier (up to 15 characters):

This parameter allows you to individually identify this unit, apart from the ARGOS geolocation id. Enter up to 15 characters.

Minimum depth to be considered a "dive" = *c*
Enter new value:

"Dives" are defined as starting when the SDR depth sensor reads deeper than a threshold depth and the conductivity sensor reads "wet", and ending when the depth sensor reads shallower than the threshold or the conductivity sensor reads "dry". This parameter defines the threshold depth value (and effectively the lower limit for depth histogram bin 1). You can set the threshold to 0 meters if you wish, dives will then be defined solely by the conductivity sensor. Note that the depth and conductivity sensors are measured every 10 seconds, so a surfacing shorter than 10 seconds may be missed. Enter the minimum depth in meters.

Maximum depth for accumulating "at surface" time = *c*
Enter new value:

"At surface" time is defined as the number of seconds (in 90 second increments) during a six-hour period the SDR depth sensor reads less than (shallower) or equal to a specified depth, or the conductivity sensor reads "dry". This parameter specifies the maximum depth for which "at surface" times are accumulated. Enter the maximum surface depth in meters.

Depth above which unit will try to detect surface every second = *c*
Enter new value:

Depth above which unit will try to detect surface every ¼-second = *c*
Enter new value:

The SDR has a standard sampling ("wake-up") interval of every 10 seconds. If it is time to make a transmission and the unit is wet, however, the SDR is designed to shorten this interval to every one-second, then to every 1/4-second as the animal approaches the surface. This improves the chances that the SDR will recognize that it is dry and begin transmitting as soon as the animal surfaces (see *How your Satellite-linked Time-depth recorder works*, page 5). The above parameters define the depths at which the SDR changes sampling rate. It will change to the one-second rate if the depth is less than or equal to the "every second" value but greater (deeper) than the "1/4-second" value. It samples every 1/4-second when the depth is less than or equal to the "1/4-second" value.

You must set the "every second" parameter to a value greater than the number of meters you believe your animal can ascend in 10 seconds, and the "1/4-second" parameter to a value greater than the number of meters it can ascend in one second. Additionally, the 1/4-second parameter must be at least twice the depth resolution of the instrument. The 1/4-second depth value must always be less (smaller) than the 1-second depth value. Failure to set these parameters correctly will result in significantly reduced uplinks.

The power consumption of the sampling is very low compared to that of transmissions - if the SDR sampled continuously at a 1/4-second rate for 26 days (highly unlikely, as that would mean that the animal stayed shallower than the 1/4-second depth without ever getting the SDR dry), it would only use approximately 10% of the total battery capacity.

Local time [0-23 hours] corresponding to 00h UT (GMT): *cc*
Enter new value:

This parameter is used to determine the histogram collection periods ("night", "dawn", "day", and "dusk"). Enter the local time (where the SDR is to be deployed) that corresponds to midnight Greenwich Mean Time. You may use the *Longitude - Local Time Translation Table*, page 68, to determine the local time that corresponds to midnight GMT based upon the longitude you anticipate your study animal to spend most of its time.

Change to on-land transmission interval after *n* consecutive transmissions without sea-water induced delays. *n = c*
Enter new value:

The SDR has different "on land" and "at sea" transmission intervals; that is, the minimum number of seconds that must elapse between transmissions. The "on land" transmission rate is slower to conserve battery power. These intervals are not user-modifiable, and are displayed via Command B. The SDR will only transmit when "dry" (regardless of the transmission rate). If the conductivity sensor reads "wet" at a scheduled transmission interval, the transmission is delayed, and the unit switches to the "at sea" rate (if it is not at that rate already). This parameter determines the number of consecutive transmissions that must be made while transmitting at the "at sea" interval, without an intervening "wet" reading causing a delay, that must be accomplished before the unit switches to the "on land" transmission interval. Enter a value from 1 - 255. A value of around 10 is recommended.

After n hours of "haul-out", unit will suspend further transmissions.
 n=c
 Enter new value:

Battery life can be extended by programming the SDR to suspend transmissions after the animal has been "hauled out" for a the number of hours specified in this parameter. You may enter a value of 1 to 255; a value of 4 to 8 hours (depending upon satellite coverage) should be sufficient time to for all collected data to be received.

NOTE: The SDR ignores hours with bad satellite coverage (see below) when counting hours of haul-out. This is to ensure that you get your data transmitted even if the haulout starts during a period of bad coverage.

"Haul-out" ends when n successive at-sea transmission intervals elapse which are all "wet". n=c
 Enter new value:

This value prevents the unit from ending a "haul-out" period because of transient conditions (animal rolls over on wet sand, thus causing a few wet readings). Setting this value to "10" means that the unit must be wet for $10 \times$ at-sea transmission interval before transmissions will be resumed. The at-sea interval is usually about 50 seconds, therefore the animal would need to be continuously wet for 500 seconds before transmissions would resume. Enter a value which is less than the duration of a "typical" dive divided by the at-sea transmission interval.

Suspend transmissions at low temperatures? [y]

This prompt appears if the SDR has the low-temperature cutoff option installed (generally installed on SDRs powered by 2/3 A cells). Cold temperatures cause the 2/3 A battery cells to be drained at a faster rate. The nominal capacity of 30,000 transmissions at +10°C is reduced to 27,000 transmissions at 0°C, and to 20,000 transmissions at -20°C. Once temperatures fall below -20°C, transmissions can cause the battery voltage to drop precipitously, causing the SDR's computer to irreversibly "lock-up" (fail).

The low-temperature feature should be enabled (by typing Y). When you type Y, the following prompt appears:

Transmissions will be suspended below c°C
 Enter new value:

Set the cutoff temperature set to a value no lower than -20°C. The cutoff temperature can be set to a higher value if you wish to extend the battery life at the expense of low-temperature transmissions (e.g., the SDR will not transmit when the animal is hauled-out where the air temperature is below this minimum). Note that the actual temperature will differ from the value you enter by a very small amount because of internal scaling factors.

The low-temperature cutoff is not usually implemented on units powered by C cells, as the C cells do not exhibit the same potential for lock-up at low temperatures.

Unit will duty cycle with n [1-15] days on. n = c
 Enter new value:

Unit will duty cycle with n [1-15] days off. n = c
Enter new value:

The above two prompts give you the option to cycle transmission "days on" and "days off", in order to further conserve battery life. The "days on" value represents the number of days where transmissions are made, and the "days off" value represents the number of days where transmissions are suppressed. The SDR will cycle, transmitting for the number of "days on", then suppressing transmissions for the number of "days off" (which can be set to zero). Data collection continues during the "days off" cycle. This option is provided for subsequent studies on species whose primary deployments ended with the batteries becoming exhausted before the unit fell off the animal. Unless you are certain that you will be reliably receiving transmissions (e.g., you are tagging a species whose behavior is known to be favorable for transmissions), we recommend that you set the "days off" to zero.

Nominal battery capacity is $aaaaa \times bb$ -Byte transmissions total @10°.
Daily allowance (bb-Byte transmissions; unused xmits dddddddd) = ccc

- Or -

Nominal battery capacity is $aaaaa \times bb$ -Byte transmissions total @10°.
Daily allowance (bb-Byte transmissions; unused xmits dddddddd) =

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ccc	ccc	ccc	ccc	ccc	ccc	ccc	ccc	ccc	ccc	ccc	ccc

Enter 12 new allowances [0 to 65535 each]:

Jan:
Feb:
Mar:
Apr:
May:
Jun:
Jul:
Aug:
Sep:
Oct:
Nov:
Dec:

The nominal battery capacity is dependent upon battery size, temperature, transmitter strength and length of messages. For example, half-watt SDRs with 2/3 A cells have a nominal battery capacity of 30,000 × 8-byte transmissions at 10°C, while half-watt SDRs with 4 × C-cells have a 100,000 × 8-byte transmission battery capacity at 10°C.

The above prompt displays the appropriate capacity for the particular configuration of your unit, where *aaaaa* is the number of transmissions. *bb* is the target number of bytes per transmission, *ccc* is the current allowance in number of transmissions, and *dddddddd* says either "accumulate" or "don't accumulate". The values *bb*, *ccc*, and *dddddddd* depend upon what was set in Command O.

Enter the new allowance(s). Press RETURN to maintain the current value. Note that if you wish to zero the allowance for a month, you must enter a zero after the month name (pressing RETURN will maintain the value displayed).

STATUS will be sent every nth [0-255] message. n = c
Enter new value:

This parameter determines how often status messages are transmitted. Enter a value from 2 - 255. A value of 20 is recommended. Note that status messages have priority over all other messages. If you set this value to "1", the SDR will only transmit status messages. If you set this value to "0", no status messages will be transmitted.

Blocks of Time-Lines will be transmitted every nth [0-255] message. n = c
Enter new value:

This parameter determines how often timeline messages are transmitted. Enter a value from 0 - 255. If you want an equal probability of receiving either timelines or histograms, set this value to the number of types of histograms that will be transmitted (depth, duration and/or time-at-depth) $\times$ 16. That is, if you set the SDR to transmit all three types of histograms, use a value of $3 \times 16 = 48$. Note that timeline messages have priority over histogram messages. If you set this value to "1", the SDR will never transmit histograms. If you set this value to "0", no timeline messages will be transmitted.

Transmission hours with good satellite coverage	000000000011111111112222
(these hours (read vertically) are all in GMT)	012345678901234567890123
current setting (1=good, 0=bad)	cccccccccccccccccccccccccccc
Enter new settings.	 :

You have the option to stop transmitting during certain hours (when satellite coverage is poor) to conserve batteries. This parameter defines the probable satellite coverage for each hour from hour 00 through hour 23 (hours are designated as vertical pairs on your screen). A "1" under the hour means coverage should be good, and the SDR should perform scheduled transmissions. A "0" indicates poor coverage, and the SDR should not perform transmissions during that hour. It is best to be generous in defining good coverage hours, especially if you are uncertain of the locations through which your study animal will be travelling.

The next three prompts set the upper limits of the various histogram bins. See *SDR transmitted message overview*, page 7, for a description of the histogram bins.

Set the upper limits of the histogram maximum-depth bins in meters
Upper limits of depth bins are: c,c,c,c,c, ∞
Enter new upper limits:

This prompt displays if you specified a value greater than zero for the number of depth histogram bins in Command O. Enter the depth in meters for the upper limit of each histogram bin (from shallow to deeper). Note that you only enter values for one less than the number of bins that you specified in Command O. The SDR automatically defines the last bin to contain the number of dives greater (deeper) than the upper limit of the second-to-last bin, and indicates this bin with the " ∞ " symbol. The upper limit of the second-to-last bin should be less than the maximum depth for the depth range chosen in Command O.

Set the upper limits of the histogram dive-duration bins in minutes
Upper limits of duration bins are: c,c,c,c,c, ∞
Enter new upper limits:

This prompt displays if you specified a value greater than zero for the number of duration histogram bins in Command O. Enter the time in minutes for the upper limit of each histogram bin (from shorter to longer). Again, note that you only enter values for one less

than the number of bins that you specified in Command O. The SDR automatically defines the last bin to contain the number of dives longer than the upper limit of the second-to-last bin, and indicates this bin with the " ∞ " symbol. **NOTE:** Early SDR units set the upper limits of the duration bins in *seconds*.

Set the upper limits of the histogram time-at-depth bins in meters

Upper limits of time-at-depth bins are: c,c,c,c,c, ∞

Enter new upper limits:

This prompt displays if you specified a value greater than zero for the number of time-at-depth histogram bins in Command O. Enter the depth in meters for upper limit of each histogram bin (from shallower to deeper). The SDR will accumulate all time spent when the unit read "dry" into the first bin. If you assign a depth of "0" (zero) to that first bin, only dry readings will be accumulated in that bin, and zero depth readings would be accumulated into the second bin. Note that again you enter values for one less than the number of bins that you specified in Command O. The SDR automatically defines the last bin to contain the time spent deeper than the upper limit of the second-to-last bin, and indicates this bin with the " ∞ " symbol.

Command R - Re-Initialize SDR

Description: Command R is used to reset the SDR to its default, power-up settings:

Format: Type **R** to invoke the re-initialization, you will be asked to confirm this command selection.
This function is generally used if you get into a tangle when setting the user-defined variables and wish to start over.

Command S - Set Sampling Protocols

Description: Command S is used to set the sampling protocol for collection of data in SDRs with the TDR data-logging option installed.

The sampling protocol supported by the SDR is a simplified form of the protocols used by Wildlife Computers Time-Depth-Recorders (Mk3e and Mk5 TDRs). The SDR sampling protocol allows you to set the sampling rate for each channel defined on your instrument, and the "condition" for the sampling of the data.

Format: Type **S** to invoke this command. The currently defined sampling protocol and condition will be displayed. You will then be prompted to enter **c** to set the condition or **s** to set the sampling rate.

Setting the sampling rate:

Type **S** to set the sampling rate. You will then be prompted with:

Enter multiple of 10 seconds for sampling Depth (m) [0-255]:

The 10 seconds represents the SDR's "wakeup" period. Enter the multiple of 10 seconds that you wish to be used as your sampling interval (*e.g.*, "3" for every 30 seconds, "9" for every 90 seconds). This prompt will be repeated for each defined channel on your TDR. Note that if you enter "0" as the multiple, data will NOT be sampled on that channel (if you enter zero for the multiple for all channels, you are effectively disabling the TDR data-logging option).

Setting the conditions:

Type **C** to set the condition. Two conditions are supported:

E indicates that data will be recorded when the instrument is either wet or dry.

T indicates that data will be recorded when the instrument is wet and the time duration of dry periods will be recorded (timed haulout).

Command T - Report/set the SDR's Time

Description: Command T is used to report or set the time of the SDR's clock. The time should be set to GMT (Greenwich Mean Time) when the SDR is first switched on.

Format: Type T *hh:mm:ss* to set the time, where *hh* represents the hour, *mm* represents the minutes and *ss* represents the seconds. Hit **ENTER** when the time you just set is equal to the current time (*i.e.*, enter a time 5-10 s ahead of the current time and wait until they coincide to hit **ENTER**). Remember that the SDR uses a 24-hour clock. If no numbers follow the T command, the current time will be reported.

Command U - Set the Duty Cycle

Description: Command U is used to set the duty cycle feature if the SDR has the TDR data-logging option installed.

NOTE: This does **not** define the "days on" and "days off" transmission duty cycling (see *Command P*, page 32).

Duty cycling allows data to be sampled using the defined sampling protocols for a given period of time, the "on" cycle. The TDR then stops collecting data regardless of sampling protocols for a second period of time, the "off" cycle. The TDR continues to alternate between the "on" and "off" cycles until memory is filled. This feature can be used during long deployments of units with limited memory to gather data intensively during short, but representative, periods spread out over a long period of time.

Format: Type **U** to invoke this command. The SDR will then display the current status of the duty cycling feature and ask if you want to change it. A response of **N** (No) will return you to the SDR> prompt with the duty cycling unchanged, while a response of **Y** (Yes) will lead to the next prompt. This prompt is for the units of time that the duty cycle will use; although the "on" and "off" cycles can have different values, they must use the same units of time. The choices are:

- O** turns **O**ff the duty cycling feature and returns to the TDR> prompt
- D** sets the duty cycling unit to **D**ays
- H** sets the duty cycling unit to **H**ours
- M** sets the duty cycling unit to **M**inutes

You are next prompted with the "on" phase time (in the selected units), then the "off" phase time. Both of these times must be in the range 1 to 255.

When enabling duty cycling, the SDR usually is set to start with a duty cycle off phase, and you are prompted for the delay until the start of the first "on" phase (again, in the selected units); this can take any value in the range 0 to 255. Alternatively you can start in a duty on phase and set the delay until the start of the first "off" phase by making this number negative. Thus a delay of -3 until the start of the first "on" phase will be interpreted as a delay of 3 until the start of the first "off" phase, and the SDR will start in a sampling mode.

Command V - Check Battery Voltage

Description: This command is used to get a general assessment of the batteries. The battery voltage is measured under a low drain. SDRs with new batteries should read about:

- *SDRs using Telonics ST-6 transmitters powered by $5 \times 2/3A$ cells:* 12 Volts.
- *SDRs using Telonics ST-6 transmitters powered by $4 \times C$ cells:* 14 Volts.
- *SDRs using Telonics ST-10 transmitters powered by $2 \times 2/3A$ cells:* 6 Volts.
- *SDRs using Telonics ST-10 transmitters powered by $2 \times C$ cells:* 7 Volts.
- *SDRs using Seimac one-watt SSC# powered by $3 \times C$ cells:* 10.5 Volts

Any voltage below this indicates that the batteries are suspect and might need replacing.

A better way to assess the condition of the batteries is to measure the voltage during a transmission. See **Checking the voltage of the internal battery pack**, page 15, for details.

Format: Type **V** to invoke this command. The battery voltage is then sampled and reported.

Command X - Enter Transmission Sub-menu (*Half-watt SDRs*)

Description: This command is used enter the sub-menu which contains the commands for testing the SDR transmitter. These commands are generally used by Wildlife Computers to test the unit prior to delivery, however, they are available for use should you wish to perform test transmissions.

NOTE: The interface between the Wildlife Computers controller and the Telonics ST-5 (one-watt) or ST-6 (half-watt) transmitters are slightly different. This difference is reflected in a different Transmission Sub-menu for each.

Format: Type **X** to invoke this command. The SDR transmitter submenu commands will be displayed, and the **D** command automatically invoked. You may enter any other submenu command at the "X-SDR>" prompt.

The commands are:

D Enter data to be included in transmission

You will first be prompted for the number of bytes of sensor data to transmit. Enter "8".

You will then be prompted for values for each byte of sensor data. Enter a decimal value (0 to 256).

After entering the sensor values, the "X-SDR>" prompt will appear, and you may enter another submenu command.

H Help - display the commands

L List the PTT ID and data to be transmitted

This command will display the PTT ID and the data that have been entered for the test transmission.

T Transmit the current data on the current PTT ID number

This command initiates a test transmission. A sequence of battery voltage readings taken before, during and after the transmission will be displayed. The readings should range from:

- **5 × 2/3A cells** 10 - 12 Volts
- **4 × C cells** 12 - 14 Volts

If your unit has been in storage for a length of time, you may notice the voltage increasing with subsequent transmissions, due to the "burning off" of the oxidation that may form internally in the batteries. This is normal.

For new units, any battery voltage below:

- **5 × 2/3A cells** 11 Volts
- **4 × C cells** 13 Volts

during transmission should cause concern. Contact Wildlife Computers.

+ Turn the ST-6 on

This turns on power to the ST-6 (Telonics transmitter). The ST-6 has a relatively high power consumption, even in its quiescent state (when it is not transmitting). In order to maximize battery life, the SDR does not provide power to the ST-6 during poor satellite coverage hours or non-transmission days.

- Turn the ST-6 off

This turns off power to the ST-6.

? Check the ST-6 for response

This verifies that the ST-6 is communicating with the SDR controller.

X Exit the submenu and return to the main menu

Command X - Enter Transmission Sub-menu (*One-watt SDRs*)

Description: This command is used enter the sub-menu which contains the commands for testing the SDR transmitter. These commands are generally used by Wildlife Computers to test the unit prior to delivery, however, they are available for use should you wish to perform test transmissions (e.g., check the battery voltage).

NOTE: The interface between the Wildlife Computers controller and the Telonics ST-5 (one-watt) or ST-6 (half-watt) transmitters are slightly different. This difference is reflected in a different Transmission Sub-menu for each.

Format: Type **X** to invoke this command. The SDR transmitter submenu commands will be displayed, and the **D** command automatically invoked. You may enter any other submenu command at the "X-SDR>" prompt.

The commands are:

- C** For Wildlife Computers testing use only
- D** Enter data to be included in transmission

You will first be prompted for the number of bytes of sensor data to transmit. Enter "8".

You will then be prompted for values for each byte of sensor data. Enter a decimal value (0 to 256).

After entering the sensor values, the "X-SDR" prompt will appear, and you may enter another submenu command.
- E** Send an Erroneous transmission (too long)

This command is used to check the fail-safe mechanism of the SDR that prevents excessively long transmissions. Invoking this command initiates a long transmission. The SDR should terminate the transmission after about 1.1 seconds, and not allow another transmission to be sent for 15 minutes.
- H** Help - display the commands
- L** List the PTT ID and data to be transmitted

This command will display the PTT ID and the data that have been entered for the test transmission.
- T** Transmit the current data on the current PTT ID number

This command initiates a test transmission. A sequence of battery voltage readings taken before, during and after the transmission will be displayed. The readings should range from:

 - $3 \times C$ cells 9.5 - 10 Volts
 - *2/3A battery packs (Walrus)* 8.5 - 9 Volts

If your unit has been in storage for a length of time, you may notice the voltage increasing with subsequent transmissions, due to the "burning off" of the oxidation that may form internally in the batteries. This is normal.

For new units, any battery voltage below:

- $3 \times C$ cells 8 Volts
- *2/3A battery packs (Walrus)* 7.5 Volts

during transmission should cause concern. Contact Wildlife Computers.

CHAPTER 3

How Data Are Encoded

How the Status Message Data are Encoded

The SDR encodes the status messages into either eight (SDR pre-version 3.10) or twelve (SDR version 3.10 or above) bytes for transmission.

Following is a description of how the status message data are encoded into the eight bytes. Note that "byte 1" is the first "sensor" value reported by Service Argos, and "bit 1" is considered the low-order bit.

Byte 1 Maximum depth reading

Bit 1 Always zero

Bit 2-8 Depth reading

Multiply byte 1 by the depth resolution of the instrument to get the maximum depth measured over the last 24 hours (midnight to midnight) in meters.

NOTE: The maximum depth reading was implemented in SDRs manufactured after 15 February 1992.

Byte 2 The "at surface" time for the previous histogram period (*i.e.*, the period that began 1-6 hours prior to this transmission - see **How the SDR Collects and Transmits Histograms**, page 49). "At surface" time is defined as the number of seconds the SDR depth sensor read less than (shallower) or equal to a specified depth, or the conductivity sensor read "dry". (NOTE: "At surface" time was implemented in SDRs manufactured after 01 October 1992).

(Pre version 3.10) Multiply byte 2 by 80 to get the "at surface" time in seconds. Note that the maximum value byte 2 can hold is 256, so the "at surface" time for the six-hour period pegs-out at 20,480 seconds.

"At surface" time = byte 2 × 80 seconds

(Version 3.10 and greater) Multiply byte 2 by 90 to get the "at surface" time in seconds. The full 6-hour period can be reported (will not peg-out at 20,480 seconds).

"At surface" time = byte 2 × 90 seconds

Bytes 3-4 Binary value representing the number of messages sent so by the unit. To calculate the actual number of messages:

Total messages = (byte 3 × 256) + byte 4

Once the total number of messages exceeds 65535, this counter will reset back to zero.

Byte 5 Pressure zero offset (internal, unscaled value). The SDRs are initially calibrated so that the depth reading (unscaled) for zero meters is approximately 10 for the deep depth range, or 20 for the shallow depth range, which allows the SDR to compensate for drift. This value represents the offset at zero meters when the SDR transmitted the status

message. If this value drifts to 0, it means that the pressure transducer has pegged out, and the actual depths reported by the instrument may be greater. Dramatic changes (± 10) indicate that the pressure transducer may be failing.

Byte 6 Battery voltage. Multiply this number by 0.064 to get the voltage during the last transmission.

Byte 7 Assessment of seawater resistance at depth. This value is used by the SDR to determine when the unit is at the surface (thus can transmit) while "at sea". In seawater, this value is typically around 20 for SDRs in an anodized aluminum housing, 8 for the epoxy-cast units. The value increases with decreasing salinity. If the value exceeds 100, it is an indication that the conductivity sensor is failing.

Byte 8 *(Pre version 3.10)* Checksum, such that the sum of bytes 1 through 8 is evenly divisible by 256.

(Version 3.10 and greater)

Byte 8 The "at surface" time for the 6-hour histogram period preceding the previous period (*i.e.*, the period that began 7-12 hours prior to this transmission). This is the value that was reported in Byte 2 during the previous 6-hour histogram period.

Byte 9-11 The time on the SDR internal clock in decimal

Byte 9 = hours

Byte 10 = minutes

Byte 11 = seconds

Byte 12 Checksum, such that the sum of bytes 1 through 8 is evenly divisible by 256.

How the SDR Collects and Transmits Histograms

The SDR records up to three types of histograms: dive depth, dive duration, and time-at-depth. Each dive is evaluated for maximum depth and maximum duration, and the time the animal spends within preset depth ranges is accumulated. The appropriate histogram bin, or accumulator, is then incremented. Standard TYPE3 SDRs support up to 14 bins for each type of histogram.

Histograms contain data that were collected over a six-hour period. The start of each period is user-settable to allow the coverage of "night", "dawn", "day", and "dusk" behavior patterns. The SDR calculates which period (0 - 3) the dive belongs to by:

$$((t_{\text{SDR}} + t_{\text{local time at 0 UT}} + h_{\text{hour offset}}) / h_{\text{hours per hist}}) \bmod 4$$

where t_{SDR} = Hour on SDR clock (which should be set to UT/ GMT)

$t_{\text{local time at 0 UT}}$ = Local time when it is midnight in Universal Time (Greenwich Mean Time), as entered as a parameter to the SDR

$h_{\text{hour offset}}$ = Internal offset of hours. This value is 3 (unless specified otherwise at the time you ordered your SDR), so that collection of data for period 1 begins at 3:00 A.M. local time.

$h_{\text{hours per hist}}$ = Number of hours per histogram period. This value is 6 (unless specified otherwise at the time you ordered your SDR).

Histograms for the previous four periods are transmitted while data are collected for the current period.

For example:

Assume the SDR clock reads 4:15, and local time when it is midnight in UT (GMT) was set (entered as a parameter to the SDR) to be 8 (meaning that at 8 a.m. local time the SDR reads 00:00). The number of hours from 00UT to begin collecting period 0 is 3, and number of hours per histogram is 6. The current period (the histogram period for which data are being collected) is calculated to be "2" as follows:

$$((t_{\text{SDR}} + t_{\text{local time at 0 UT}} + h_{\text{hour offset}}) / h_{\text{hours per hist}}) \bmod 4$$

$$((4 + 8 + 3) / 6) \bmod 4 = 2$$

The time on the SDR clock at which period 0 data begin to be collected is calculated to be 13 as follows:

$$((t_{\text{SDR}} + t_{\text{local time at 0 UT}} + 3) / 6) = 4$$

$$((t_{\text{SDR}} + 8 + 3) / 6) = 4$$

$$t_{\text{SDR}} = 13$$

Therefore:

period 0 = 13:00 - 18:59:59 = "night" = 21:00 - 02:59 local time
 1 = 19:00 - 00:59:59 = "dawn" = 03:00 - 08:59 local time
 2 = 01:00 - 06:59:59 = "day" = 09:00 - 14:59 local time
 3 = 07:00 - 12:59:59 = "dusk" = 15:00 - 20:59 local time

From 01:00 through 06:59:59 UT (09:00 through 14:59 local time), the SDR would transmit the prior periods 1, 0, 3 and 2 (the previous 24 hours) depth and duration histograms while collecting data for the current period 2. When the SDR clock reads 07:00, the prior periods 2, 1, 0 and 3 histograms would be transmitted, while data are collected for the current period 3.

The date of data collection for histograms must be inferred from the reception date and time (the collection date and time are not encoded in the histogram message due to space constraints).

Histograms are transmitted while the animal is both on land and at sea; a "state" bit in the histogram message is set accordingly.

How the Histogram Message Data are Encoded

The SDR encodes the histogram messages for transmission. Following is a description of how the histogram message data are encoded. Note that "byte 1" is the first sensor value reported by Service Argos, and "bit 1" is considered the low-order bit.

SDR version 3.10 and greater - histogram length 4 - 16 bytes

Byte 1 Histogram header data (bit-encoded)

bit 1	Always 1	
bit 2	Histogram type	0 = depth or time-at-depth 1 = duration or unused
bit 4 & 3	Histogram period	00 = period 0 01 = period 1 10 = period 2 11 = period 3

bit 5	Histogram subtype	If Histogram type (bit 2) = 0 0 = Depth histogram 1 = Time-at-depth histogram If Histogram type (bit 2) = 1 0 = Duration histogram 1 = <not used>
bit 6	SDR State when Histogram was transmitted	0 = on land 1 = at sea
bit 8 & 7	Number of histogram bins/length of histogram	00 = 2 bins / 4 bytes 01 = 6 bins / 8 bytes 10 = 10 bins / 12 bytes 11 = 14 bins / 16 bytes
Byte 2-3	If bit 8 & 7 in Byte 1 = 00 Bin 1 and 2 (total length 4 bytes)	
Byte 4	Checksum, such that the sum of bytes 1 through 4 in the histogram is evenly divisible by 256.	
- or -		
Byte 2-7	If bit 8 & 7 in Byte 1 = 01 Bin 1 through 6 (total length 8 bytes)	
Byte 8	Checksum, such that the sum of bytes 1 through 8 in the histogram is evenly divisible by 256.	
- or -		
Byte 2-11	If bit 8 & 7 in Byte 1 = 10 Bin 1 through 10 (total length 12 bytes)	
Byte 12	Checksum, such that the sum of bytes 1 through 12 in the histogram is evenly divisible by 256.	
- or -		
Byte 2-15	If bit 8 & 7 in Byte 1 = 11 Bin 1 through 14 (total length 16 bytes)	
Byte 16	Checksum, such that the sum of bytes 1 through 16 in the histogram is evenly divisible by 256.	

SDR pre-version 3.10 - histogram length always 8 bytes

Byte 1	Histogram header data (bit-encoded)		
bit 1	Always 1		
bit 2	Histogram type	0 = depth 1 = duration	
bit 3 & 4	Histogram period	00 = period 0 01 = period 1 10 = period 2 11 = period 3	
bit 5	Histogram status	0 = complete 1 = partial (data were not collected over the entire histogram period; should only occur for the first histogram collected after deployment)	
bit 6	SDR State when Histogram was transmitted	0 = on land 1 = at sea	
bit 7	Always 0		
bit 8	Histogram data collection status	0 = OK- data collected 1 = Dummy histogram (all zeros, reflecting the histograms in the "transmit" buffer at deployment)	
Byte 2-7	Bin 1 through 6, respectively		
Byte 8	Checksum, such that the sum of bytes 1 through 8 is evenly divisible by 256.		

How the SDR Collects and Transmits Timelines

SDR version 3.11 and above provide the facility to report information on when the animal is hauled-out via timeline messages. Each timeline message covers a 24 hour period (midnight to midnight). The 24 hours are divided into 20-minute increments. The SDR assesses the conductivity readings for each 20-minute period and reports whether the majority of the readings during that 20-minute period were "wet" or "dry". Timelines for the previous four days (24-hour periods) are transmitted.

How the Timeline Message Data are Encoded

The timeline data are encoded for transmission. Note that "byte 1" is the first sensor value reported by Service Argos, and "bit 1" is considered the low-order bit. Timeline messages are always 12 bytes long.

Byte 1	Timeline header data (bit-encoded)	
	bit 1	Always 1
	bit 2	Always 1
	bit 4 & 3	Always zeros
	bit 5	Always 1
	bit 6	SDR State when timeline was transmitted
		0 = on land 1 = at sea
	bit 8 & 7	length of timeline
		Note: Version 3.11
		always have a length of 12 bytes
		00 = 4 bytes 01 = 8 bytes 10 = 12 bytes 11 = 16 bytes
Byte 2-10	Wet/Dry indicators	0 = majority of readings were dry during the 20-minute period
	The low-order bit of byte 2 represents the first 20-minute period after midnight. The high-order bit of byte 10 represents the last 20-minute period.	1 = majority of readings were wet
Byte 11	Encoded day of year.	
	0 =	pre-deployment data
	1-255 =	such that "1" represents 01 January through 11/12 September (depending upon whether or not it is a leap year), -OR- 12/13 September
Byte 12	Checksum, such that the sum of bytes 1 through 12 in the timeline is evenly divisible by 256.	

Hexadecimal Listings Format

NOTE: The hexadecimal listing format reflects how data are stored by the SDR when the TDR data-logging option is installed. This format is very similar to the format used by Wildlife Computers Mk3+ TDRs.

NOTE: 8-bit data are transmitted as 2 hexadecimal digits.

Hexadecimal listings always start with eight lines of system descriptors.

Line 1	the encoded number of bytes of data
Line 2	the channel parameters
Line 3	the names of channels 1 and 2
Line 4	the names of channels 3 and 4
Line 5	the sampling rate for protocols 1
Line 6	all zeros
Line 7	the condition for protocols 1
Line 8	all zeros

The first line contains 6 characters, and all successive lines contain 64 characters (+ carriage-return + line-feed). Remember that each line of 64 (hexadecimal) characters represents only 32 bytes of data.

NOTE: The TDR data-logging option only supports one sampling protocol, and a subset of the possible sampling conditions that are available on the Mk3+ TDRs.

Line 1 consists of 6 hexadecimal digits, *abcdefg*, which are a count of the number of bytes of data that will be transmitted. This byte count does not include the 8 lines of system descriptors. The number is calculated by:

$$a \times 1048571 + b \times 65536 + c \times 4096 + d \times 256 + e \times 16 + f$$

Line 2 consists of:

- 4 bytes for the zero offsets for channels 1 to 4. zO_1, zO_2, zO_3, zO_4
- 4 bytes for the signs of zO_1 to zO_4 . zS_1, zS_2, zS_3, zS_4
- 1 byte for version number
- 1 byte for number of channels
- 2 system bytes
- 1 byte for zero offset of battery voltage. zO_v
- 1 byte for zero offset sign for battery voltage. zS_v
- 2 bytes for battery voltage gain specifiers. ga_v, gb_v
- 4 bytes of gain specifier for channel 1. ga_1, gb_1, gc_1, gd_1
- 4 bytes of gain specifier for channel 2. ga_2, gb_2, gc_2, gd_2
- 4 bytes of gain specifier for channel 3. ga_3, gb_3, gc_3, gd_3
- 4 bytes of gain specifier for channel 4. ga_4, gb_4, gc_4, gd_4

If the zero signs, z_{s1} to z_{s4} and z_{sv} , are non-zero, then the corresponding zero offset, z_{o1} to z_{o4} and z_{ov} should be made negative.

The real (or actual scaled) value, r_n , of the stored data, x_n , for a given channel n can then be calculated using:

$$r_n = (x_n - z_{on}) \times ga_n \times$$

The real (or actual scaled) value, b_v , of the battery voltage, v , can be calculated using:

$$b_v = (v - z_{ov}) \times ga_v \times 10^{gb_v}$$

Line 3 consists of:

16 bytes of the name of channel 1
16 bytes of the name of channel 2

Line 4 consists of:

16 bytes of the name of channel 3
16 bytes of the name of channel 4

These names are encoded in ASCII, left justified and padded with NULL bytes. Thus a letter D, which has an ASCII code of 68, is represented by 44 hexadecimal.

Line 5 consists of:

8 bytes of sampling rates for protocol 1
24 bytes of all zeros

The encoding of the 8 byte sampling rate descriptor is:

Byte 1 always 5, which is the code for a fundamental sampling rate of 10 seconds. SDRs only support a fundamental sampling rate of 10 seconds.

Bytes 2 to 5 are the multiples of this sampling rate for channels 1 to 4, respectively.

Bytes 6 to 8 are unused.

Line 6 consists of:

32 bytes of all zeros

Line 7 consists of:

8 bytes of conditions for protocol 1
24 bytes of all zeros

The encoding of the 8 byte condition descriptors is:

Byte 1 = 1ww00000

where *ww* 10 for sample when either wet or dry

11 for sample when wet and time when dry

Byte 2 - 8 all zeros

Line 8 consists of:

32 bytes of all zeros

The following lines contain the sampled data and informational markers (e.g., hour change, protocol change, and timer marks for dry periods). Any value from 00 to FC should be interpreted as data, the data from different channels will be intermixed in the order that the data were sampled; the decoding program on the PC must sort this out.

Values of FD, FE and FF are indicators signaling TDR informational (as opposed to data) bytes follow. The definition of each of these special values are:

FEaa Dry period marker (short). This marker indicates a dry phase (conductivity probe was dry) occurred during which data samples were skipped (this is only used in conjunction with a protocol which employs the T condition code). *aa* is the count of data samples that have been skipped, and can take any value from 01 to FF (1 to 255 in decimal).

FDaabb Dry period marker (long). This marker appears when a dry phase occurred during which more than 255 data samples were skipped. *aa* and *bb* indicate how many data samples have been skipped. These bytes can take any value from 00 01 to FF FF. The total number of samples skipped can be calculated using:

$$aa + bb \times 256 \text{ (256 to 65535 in decimal).}$$

FFaa indicates an hour change, duty cycle off, protocol change or asynchronous reading(s) depending on the binary value of *aa*:

00000000 Duty cycle off marker. Followed by five bytes representing: month, day, hour, minute, second

00010001 Change of protocol marker (long). TDR changed to protocol 1. Followed by five bytes representing month, day, hour, minute, second

100nnnnn Hour marker. *nnnnn* = hour (0 to 23). Followed by one byte representing battery voltage

10011111 Sampling disabled due to low battery. Followed by one byte representing low battery voltage

The time of sampling of each data point must be determined by the decoding program (analysis programs are available from Wildlife Computers). Note that FExx and FDxxxx codes provide the counts of the number of data points not collected from all channels sampled using the current protocol.

Structure of data (and how to make the most of what memory you've got)

The preceding section on hexadecimal listing formats contains all the details of how your data fills memory. By studying this information one can figure out the best ways to conserve memory. Here are some suggestions:

- Don't sample any channel faster than you need to. Consider an experiment which measures depth and water temperature. You decide that you need to know depth every 10 seconds, however you are only interested in water temperature on a day-by-day basis. It is wasteful of memory to sample temperature as often as depth, set the temperature multiple to 60 and get one temperature reading every 10 minutes instead.
- If you still do not have enough memory to allow sampling throughout the intended deployment, you can get representative data in fixed time periods by employing the duty cycling feature. This makes the recorder sample data using the defined sampling protocols during the "on" phase, then disable all sampling during the "off" phase. The "on" and "off" phases can take values from 1 minute to 255 days.

Appendix A: Troubleshooting

Following are possible communications problems:

1) The first time you try to set up communications you get no response from the SDR.

If you cannot communicate with any of your SDRs then the problem lies with the cable or the communication program.

- a) If you plugged the cable into the RS-232 port on your PC and were able to echo characters typed at the keyboard to the screen (see **To Establish Communications**, page 11), then the cable set up is probably OK, however...
- b) Make sure that the connection to your PC is snug; and that the communications program is expecting input from that input port (some PCs have more than one RS-232 port). If you continue to have problems, isolate the problem to the SDR cable or the RS-232 port by connecting some other device to that port (a serial printer, another computer). If the other device works ok, it would appear that you have a bad cable assembly, call Wildlife Computers.
- c) If the cable checks out OK but nothing happens when any SDR is connected and the **SPACE** bar is pressed, the problem lies with the external battery pack or the communications program set up.
- d) Check the voltage of the external battery pack both before and after a SDR is connected. The voltage must be between:
 - *SDRs using Telonics ST-6 transmitters powered by $5 \times 2/3A$ cells:* 9 -16 Volts.
 - *SDRs using Telonics ST-6 transmitters powered by $4 \times C$ cells:* 14-16 Volts.
 - *SDRs using Telonics ST-10 transmitters powered by $2 \times 2/3A$ cells.* 9 - 16 Volts.
 - *SDRs using Telonics ST-10 transmitters powered by $2 \times C$ cells:* 9 Volts.
 - *SDRs using Seimac one-watt SSC# powered by $3 \times C$ cells:* 12 - 16 Volts
 before and after connection to the SDR. If less, replace the AA cells ensuring correct orientation of each cell.
- e) Check that the communications program's baud rate is one of the acceptable ones (if you are attempting to use one of the faster rates try reducing it to 9600 baud). Check that your set up is for 8 data bits, 1 stop bit, and no parity bit. If all these setting are correct and characters echo on the screen when the communications cable is not connected to the SDR then the communications software must be ok, and the cable must be at fault.

2) You know that the communications work but one or more SDRs don't seem to function.

- a) Turn "off" the communications on the communications interface box as detailed in **To Establish Communications** on page 11. The communications interface box must be "off" during connection to the SDR, .
- b) Plug the 4-pin connector into the SDR

- c) *SDRs using Telonics transmitters:* Apply the magnet the over the communications/disable switch (see figure 7 on page 10).
- d) Turn "on" the interface box.

If this doesn't solve the problem there is probably something wrong with the SDR; the best solution is to return it to Wildlife Computers for repair or replacement.

- 3) Screen fills with garbage characters when communications are first established.

This usually happens when some other character than the space character is received by the SDR during its baud rate determination routine. The solution is to send a BREAK character to the SDR, then press the space bar to re-determine the baud rate. In PROCOMM, you send a BREAK character by pressing **ALT-F7**. The alternative is to briefly turn the communications "off" then "on" again at the communications interface box, next press the space bar as before.

Appendix B: Selecting maximum baud rate

All programming of your Wildlife Computers SDR is performed via an RS-232 serial communications link. A pre-requisite of using our SDR is therefore that you have access to a personal computer with a serial interface (known as an asynchronous communications interface by IBM) and communications software (such as PROCOMM). The electrical link between the 25 (or 9) pin male connector on your personal computer's serial interface card and the Wildlife Computers time-depth recorder is made using a special cable assembly. This cable assembly contains electronic components which match voltages between the Wildlife Computers time-depth recorder and your computer, and a voltmeter to check the status of the external AA battery pack.

The SDR matches its baud rate to that of the PC when the space bar is pressed at the start of the communications session. The SDR communicates using the following setup:

- 1) 600, 900, 1200, 1800, 2400, 3600, 4800, 7200, 9600, 14400 or 28800 baud
- 2) data bits, no parity bit, one stop bit
- 3) XOFF/XON (CTRL-S/CTRL-Q, ^S/^Q, DC3/DC1) software handshaking
- 4) No hardware handshaking
- 5) No character filtering.
- 6) Full 8-bit character mode, using extended IBM character set.

Appendix C: Disabling the SDR with a Magnet

A SDR can be inhibited from transmitting data by placing a magnet on the DISABLE position of the housing (see **Figure 1**, page 10). This activates a reed switch on the computer board inside. In order to ensure that the SDR does not turn itself off if the reed switch should fail, the magnet must be applied to the DISABLE position in a particular sequence (*i.e.*, applied and removed in a timed manner). The sequence must be performed exactly as follows:

Magnet is	ON	for 10 seconds (or 1 LED flash)
	OFF	for 10 seconds (or 1 LED flash)
	ON	for 20 seconds (or 2 LED flashes)
	OFF	for 20 seconds (or 2 LED flashes)
	ON	for more than 1 minute

The SDR will resume transmitting within 90 seconds of removing the magnet from the disable location.

Half-watt epoxy-cast units:

You should be able to discern differences between the length of flashes of the LED.

- The flash is very brief when the application of the disable magnet sequence has been completed and the unit is inhibited from transmitting,
- marginally longer when the unit wakes up and samples (not inhibited from transmitting),
- noticeably longer when the unit recognizes that the disable magnet is being applied (in the midst of the magnet ON-OFF sequence), and
- longest when the SDR is transmitting a message.

Once you begin the disable sequence, you should notice the flashes stay on longer; the flashes then become very brief after the sequence has completed. There should be no long flashes (indicating a transmission) after the disable magnet sequence has been completed. An uplink receiver should be used as the ultimate verification that transmissions are inhibited.

NOTE: Do not confuse the transmissions' longer flashes with the 10-second wakeups.

Appendix D: Manually Decoding Your Data

You may access the SDRs messages from Service Argos via modem prior to receiving the data on the monthly Dispose File (refer to the Service Argos Users Manual - Section 3, Access to Results). We recommend using the `/PRV/A` command, which downloads your data in "DS" format.

The purpose of this appendix is to help you quickly interpret your results. On the following pages is an example of downloaded data, with some tips on how to manually decode the information. The full description of how the SDR encodes the data bytes appears earlier in **How the Status Message Data are Encoded** on page 47 and **How the Histogram Data are Encoded** on page 50; you should refer to those pages for the complete description of the data.

Analysis software (SATPAK) is available from Wildlife Computers to help you extract and decode the data.

Example: Data downloaded from Service Argos via modem using the /PRV/A command

(A) /PRV/A,,DS,265,11464-11465										
(B)										
237.937	0.000	401649785	00955	11465	17	32	D	3	1991-09-24	15:04:14 47.737
(C1) 1991-09-24 14:57:59 1										
				(D1)	01	(D2)	00	(D3)	00	(D4) 00
				(D5)	00	(D6)	00	(D7)	00	(D8) 255
(C2) 1991-09-24 15:00:29 1										
					98		00		24	156
					10		202		08	248
					05		00		32	00
					00		00		00	251
					07		00		00	00
					00		00		00	249
					25		00		00	00
					00		00		00	231
					27		00		00	00
					00		00		00	229
					13		49		00	00
					00		00		00	194
(Cn) 1991-09-24 15:07:59 1										
					15		48		01	00
					00		00		00	192
(E) 007 msgs 002>-120dB Best: -118 Freq: 649785.3										
Lat1: 47.737N Lon1: 122.063W Lat2: 40.919N Lon2: 86.241W										

Where:

(A) The command line you type.

PRV/A The download command.

DS Format of the downloaded data.

265 Day of year. Requests messages received since that date.

11464-11465 PTT number(s). Requests messages received from these PTT numbers.

(B) The pass header line.

00955 Your Argos program number.

11465 PTT number.

17 Number of lines in this pass result.

32 Maximum number of data bytes per message.

D Letter identifying satellite that received the message.

3 Location class (where 3 is best).

1991-09-24 Date of location (in GMT).

15:04:14 Time of location (in GMT).

47.737 Latitude (-90 to +90).

237.937 Longitude (0-360).

0.000 Height of location.

401649785 Calculated frequency.

(C1) - (Cn) The messages received during the pass. One or more messages may be received by the satellite during the pass.

1991-09-24 Date the message was received (in GMT)

14:57:59 Time the message was received (in GMT)

1 Service Argos "compression index", or the number of times Argos received the identical message.

(D1) - (D8) The bytes of data transmitted by the SDR, where (D1) is the first byte, and (D8) is the eighth.

(E) Additional location results, for those PTTs with Class 0 accuracy requested from Service Argos.

The message is decoded by:

- Verifying that the message is valid.
 - The sum of the data bytes (with a histogram or status message) should be evenly divisible by 256 (add the data bytes and divide the sum by 256; the remainder should be zero). If it is not, the message was corrupted during reception. The length of the histogram message must be determined by inspection of the first byte of the histogram message.
- If the first data byte (D1) is even, the message is a status message.
 - Byte 1 represents the maximum depth recorded by the instrument over the last 24 hours (midnight to midnight).
 - Multiply byte 1 by the depth resolution of the instrument to get this value in meters.
 - The depth resolution of the instrument is the maximum depth divided by 250 (e.g., an instrument with a maximum depth of 500m has 2m resolution).
 - Byte 2 is the "at surface" time for the previous six-hour histogram period.
 - Multiply byte 2 by 90 to get the "at surface" time in seconds.
 - Bytes 3 and 4 represent the number of messages sent so far by the unit.
 - Total messages = (byte 3 × 256) + byte 4
 - Byte 5 is the pressure zero offset (an internal, unscaled value). This value should be approximately 10.
 - Byte 6 represents the battery voltage.
 - Multiply byte 6 by 0.064 to get the voltage during the last transmission.
 - Byte 7 is the assessment of seawater resistance at depth.
 - This value is typically around 20 for SDRs in an anodized aluminum housing, and 8 for both epoxy-cast units and units in titanium housings.
 - Byte 8 is the "at surface" time for the six-hour histogram period prior to that reported in Byte 2.
 - Multiply byte 8 by 90 to get the "at surface" time in seconds.

- Bytes 9 through 11 are the time (hours, minutes, seconds) of the SDR's internal clock at the time of the transmission
- Byte 12 is the checksum.
- If the first data byte (*D1*) odd, the message is either a histogram or timeline. If it is 147 or 179, the message is a timeline; otherwise it is a histogram message.
- ***SDR version 3.10 and greater:*** The first byte contains "header" information. This byte is evaluated as follows:

Bytes in message

8	12	16	Type	Period	State
65	129	193	depth	0	on land
67	131	195	duration	0	on land
69	133	197	depth	1	on land
71	135	199	duration	1	on land
73	137	201	depth	2	on land
75	139	203	duration	2	on land
77	141	205	depth	3	on land
79	143	207	duration	3	on land
81	145	209	time-at-depth	0	on land
83	147	211	TIMELINE		on land
85	149	213	time-at-depth	1	on land
87	151	215	<unused>		on land
89	153	217	time-at-depth	2	on land
91	155	219	<unused>		on land
93	157	221	time-at-depth	3	on land
95	159	223	<unused>		on land
97	161	225	depth	0	at sea
99	163	227	duration	0	at sea
101	165	229	depth	1	at sea
103	167	231	duration	1	at sea
105	169	233	depth	2	at sea
107	171	235	duration	2	at sea
109	173	237	depth	3	at sea
111	175	239	duration	3	at sea
113	177	241	time-at-depth	0	at sea
115	179	243	TIMELINE		at sea
117	181	245	time-at-depth	1	at sea
119	183	247	<unused>		at sea
121	185	249	time-at-depth	2	at sea
123	187	251	<unused>		at sea
125	189	253	time-at-depth	3	at sea
127	191	255	<unused>		at sea

HISTOGRAMS

- Bytes 2 through 3, 7, 11 or 15 represent the counts in histogram bins 1 through 2, 6, 10, 14 respectively. The total number of bytes is defined by the 1st byte.
- Byte 4, 8, 12 or 16 is the checksum. This byte position is defined by the 1st byte.
- More histograms may follow, the encoding is identical.

• TIMELINES

- Bytes 2 through 10 contain haulout information for each 20-minute period beginning at midnight. Each byte contains eight 20-minute periods.
 - Beginning at byte two, if the value is n :
 - If n is odd, the first 20-minute period after midnight was wet. Evaluate the next 20-minute by dividing n by two and ignoring any remainder. If this value is odd, the next 20-minute period is wet. Continue to divide and evaluate until $n = 0$ or 1. This gives you the first eight 20-minute periods.
 - Next evaluate byte 3 in the same manner. This will give you the 9th through 16th 20-minute periods.
 - Continue in this fashion for bytes 4 through 10. This will give you the information for the full 24 hours.
- Byte 11 contains the day-of-year for the timeline.
 - 0 = pre-deployment data
 - 1-255 = such that "1" represents 01 January through 11/12 September (depending upon whether or not it is a leap year),
-OR-
12/13 September
- Byte 12 is the checksum.

- **SDR pre-version 3.10:** The first byte contains "header" information. If the first byte is greater than 128, the message contains test histograms (the on land/at sea at transmission time indicator is correct, however). This byte is evaluated as follows:

----Value----

Test	Valid	Type	Period	Status	State
129	01	depth	0	complete	on land
131	03	duration	0	complete	on land
133	05	depth	1	complete	on land
135	07	duration	1	complete	on land
137	09	depth	2	complete	on land
139	11	duration	2	complete	on land
141	13	depth	3	complete	on land
143	15	duration	3	complete	on land
145	17	depth	0	partial	on land
147	19	duration	0	partial	on land
149	21	depth	1	partial	on land
151	23	duration	1	partial	on land
153	25	depth	2	partial	on land
155	27	duration	2	partial	on land
157	29	depth	3	partial	on land
159	31	duration	3	partial	on land
161	33	depth	0	complete	at sea
163	35	duration	0	complete	at sea
165	37	depth	1	complete	at sea
167	39	duration	1	complete	at sea
169	41	depth	2	complete	at sea
171	43	duration	2	complete	at sea
173	45	depth	3	complete	at sea
175	47	duration	3	complete	at sea
177	49	depth	0	partial	at sea
179	51	duration	0	partial	at sea
181	53	depth	1	partial	at sea
183	55	duration	1	partial	at sea
185	57	depth	2	partial	at sea
187	59	duration	2	partial	at sea
189	61	depth	3	partial	at sea
193	63	duration	3	partial	at sea

- Bytes 2 through 7 represent the counts in histogram bins 1 through 6, respectively.
- Byte 8 is the checksum.

Appendix E: Longitude - Local Time Translation Table

The following table can be used to determine the "Local time corresponding to 00UT (GMT)" parameter that is entered via *Command P*. Use the longitude that is closest to where you think your animal is going to be most of the time.

Longitude	Local Time at 00UT (GMT)
180 W	12
165 W	13
150 W	14
135 W	15
120 W	16
105 W	17
90 W	18
75 W	19
60 W	20
45 W	21
30 W	22
15 W	23
00 Meridian	00
15 E	01
30 E	02
45 E	03
60 E	04
75 E	05
90 E	06
105 E	07
120 E	08
135 E	09
150 E	10
165 E	11
180 E	12

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