CAST MODE

The CAST mode is the 'normal' operating mode of TAPS. This is the primary use for which TAPS was designed. There are three variants on CAST mode available.

In basic CAST mode, TAPS always takes acoustical samples from a small, finite volume at a fixed range from the transducers. A fixed-duration ping is generated (on each channel sequentially) and the returning echo amplitudes are sampled at 5 intervals centered on a range of 1.4 m. Each sample is spaced one-half pulse length (12.5 cm) from the next so that each echo sample arises from a nearly separate set of scatterers.

Thus, the number of separate pings required to obtain a statistically-useful number of independent echo samples can be rather small, speeding up data collection. A more complete description of the statistics of acoustical sampling may be found in **Appendix 2: Basic Acoustics**.

Basic CAST mode relies on the depth sensor to control power to the acoustic transceivers, turning them on and off as TAPS is lowered and raised in the water. Thus, installing the shorting plug will not automatically begin data collection.

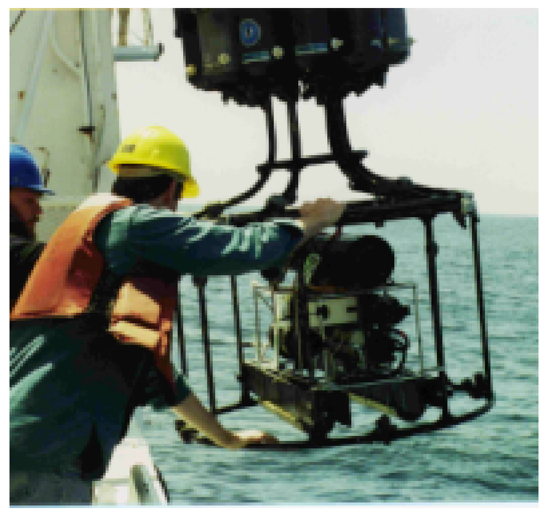
RAW CAST mode is precisely like basic CAST mode except that the echo amplitude samples, which are normally squared and summed to form the mean echo intensity, are saved instead. The data from this mode can be converted to mean echo intensities (and to volume scattering strengths) in post-processing but the raw data permits examination of echo statistics as well.

INSTRUMENT mode is like basic CAST mode except that TAPS begins pinging shortly after power is applied and data are output as ASCII-HEX strings of fixed format for recording elsewhere. This mode was created to permit integrating TAPS with datalogging systems in multi-sensor profiling arrays.

A TYPICAL CAST

A typical cast might go as follows: The TAPS is physically secured to a CTD cage or to the hydrowire with the transducer end free of any obstruction and pointing horizontally. When the cast is ready to commence, the 2-pin shorting plug is installed and the locking sleeve secured over it. All connectors are checked to ensure a dummy plug or interconnect cable is attached to each jack and the locking sleeves are installed.

Installing the shorting plug applies power to the TAPS CPU board. The first function performed by the CPU is to initialize the TAPS system. This includes



reading stored operating parameters from an EEPROM inside the CPU chip. Since CAST MODE has been selected, the CPU also measures the output of the depth sensor and saves this value as a zero-depth offset. This offset is used to correct depth values once TAPS is put into the water.

After this initialization, the CPU begins sampling the depth sensor continuously. As TAPS is lowered into the water, the depth reading begins to change until it reaches the pre-programmed TURN-ON DEPTH. When this depth is reached, the CPU switches on the acoustic circuits and starts an approximately 3-second delay to let the circuits stabilize. If external sensors are connected to TAPS, they are also powered at this time. During the delay, TAPS writes a data header to non-volatile data RAM containing certain information about the TAPS setup.

When the delay is complete, TAPS begins taking data. TAPS reads and stores the value of the internal real-time-clock (RTC). If external sensors are enabled, these are sampled and the results stored. Then TAPS begins a loop: Each acoustic channel is pulsed once in sequence and the echoes sampled and accumulated into memory. The depth and temperature sensors are sampled and the results added to accumulators. Then the cycle begins again with acoustic channel #1. When the pre-programmed number of pings have been completed, the various accumulators are moved from working memory to the non-volatile RAM used for data storage. Then sampling begins again with another read of the RTC.

Why sample depth and temperature on each ping cycle? This way, the data sets (acoustic and physical) have the same depth resolution. They are averages over the same vertical extent.

As TAPS approaches the surface, it will pass above the TURN-OFF DEPTH (which must be less than the TURN-ON DEPTH). Power to the transceivers is removed and an end-of-file mark is written into data memory to mark the end of a cast.

During the downcast, it may happen that the depth exceeds a user-specified threshold called the MAX DEPTH. If this occurs, sampling ceases and power to the transceivers is switched off. TAPS continues to monitor depth but no data are stored. This will mark the end of the first 'cast'.

On the way back up, when TAPS rises above the MAX DEPTH, power is restored to the transceivers and sampling starts again. This will constitute a new cast, with a new cast header being stored in data RAM along with the pertinent setup information.

On deck, the TAPS operator can elect to dump the data just collected (with any internally-recording instrument, it is advisable to dump the data whenever the opportunity presents itself). The dummy plug covering the 8-pin IO connector is removed and either the data cable or the charging cable attached.

The operator must then start a terminal program running on the data-logging computer. Note that any sort of computer may be connected to TAPS so long as the serial port is RS-232C compatible. The serial port should be set for 19200 baud, no parity, 8 data bits, and 1 stop bit (19200-N-8-1).

Typing an "S" or an "s" will produce a STATUS screen like that shown in Fig. 1. This screen describes the current TAPS setup and shows the current date, time, depth, temperature and battery voltage. It reports on the number of casts stored in memory. The acoustic frequencies and the associated calibration constants are displayed. Finally, any external sensors connected to TAPS are listed.

The data may be dumped to the data logging computer by typing a "D" or a "d". In CAST mode, the data are transferred as ASCII text lines. The operator is first reminded to open a data capture file; after pressing the RETURN or ENTER key, a formatted data dump commences. A typical data dump is shown in Fig. 2.

Each cast begins with a data header containing information about the TAPS setup. These data are sometimes quite important in interpreting the results or in deciding what further processing should be done to certain data. For example, there is a user-entered scale factor for the depth sensor. If it were found from comparison with a CTD that the TAPS depth sensor read 5% high, an appropriate scale factor could be entered into TAPS for use on subsequent casts. Knowing which casts were obtained with which scale factor, however, allows post-cast correction of depth values so that all cast data are scaled similarly.

The actual data consists of lines of numbers, beginning with the date (yymmdd), the time (hhmmss), the depth (m) and the temperature (C). Two values for the external sensors follow. The last six numbers are volume scattering strengths at the six TAPS frequencies from lowest to highest. Each line ends with a <CR> <LF>.

```
  TAPS-6 ACOUSTIC PROFILING SYSTEM
              S/N 16
          S/W VERSION 8.00

CAST MODE : INTERNAL RECORDING
NUMBER OF CASTS STORED     = 2
CF SECTOR #                = 10AD
TURN-ON DEPTH              = 2.50  M
TURN-OFF DEPTH             = 1.50  M
MAXIMUM OPERATING DEPTH    = 190.00  M
MAXIMUM SAFE DEPTH         = 194.10 M
MEAN SAMPLE RANGE          = 125  CM
CURRENT BATTERY VOLTAGE    = 22.76  VDC
CURRENT TIME & DATE        = 07:52:30  03/12/07
CURRENT DEPTH              = 0.00  M
CURRENT TEMPERATURE        = 22.89  C
PINGS PER DATA SET         = 6
PERCENTAGE OF MEMORY USED  = 0.0 %
FREQUENCIES:  265   420   700   1100   1850   3000  KHZ
CALS = -68.3    -62.9    -60.0    -52.3    -37.1    -20.3  dB
SENSOR #1:    SBE-4
SENSOR #2:    -
```

Figure 1. Example of a STATUS screen from TAPS.

If several casts are stored in memory, each new cast will begin with a new cast header. This is usually redundant but does allow for the possibility that TAPS was reprogrammed between casts without data being dumped and erased.

When all cast data have been transferred to the logging computer, the data capture file should be closed. At this point, the data in TAPS memory can be erased to make room for new data if desired. Typing an “E” or an “e” starts the erase procedure. An “are you sure” dialog lets you change your mind and provides an escape from errant typing. Erasure occurs essentially instantaneously since only a single byte value is changed. You can follow an “E” with an “S” to display the STATUS screen again and verify that data RAM has been erased.

TAPS is now ready for another cast or set of casts. The data cable should be removed and the dummy plug installed along with it’s locking sleeve. If the next cast is to begin fairly soon, the shorting plug may be left in place. If the next cast is some time away (say, more than 30 minutes), some battery capacity will be saved by removing the shorting plug until

```
TAPS-6:  S/N 16   S/W V. 8.00
CAST # 1
PULSELEN = 336 ,  NPINGS = 6 ,  NSAMPS = 5 <R> = 1.25 M
BATTERY = 22.62,  DEPTH SF = 1.000 ,  TEMP OFFSET = 0.00
FREQUENCIES:  265   420   700   1100   1850   3000  KHZ
CALS = 0.0    0.0    0.0    0.0    0.0    0.0  dB
SENSOR #1:  SBE-4
SENSOR #2:    -

010331 074317 39.53 19.57  0.0  0.0  -43.0  -40.2  -40.0  -37.6  -40.0  -38.1
010331 074320 38.35 19.56  0.0  0.0  -41.2  -41.3  -38.6  -38.8  -38.8  -39.1
010331 074324 37.16 19.57  0.0  0.0  -45.6  -44.8  -43.4  -42.8  -42.9  -42.4
010331 074327 36.02 19.57  0.0  0.0  -44.9  -44.6  -43.3  -42.9  -42.9  -42.8
010331 074330 4.74 19.56  0.0  0.0  -45.1  -44.8  -44.0  -42.5  -43.5  -42.0
010331 074333 2.42 19.56  0.0  0.0  -45.5  -44.6  -43.2  -43.5  -42.5  -42.4
```

Figure 2. Example of a data dump from TAPS. In this case, no internal cals were stored in TAPS and must be applied to the data in subsequent processing. Don't you do this.

just before the next cast. Not a lot, however (see the next section).

Speaking of the battery, it will eventually run down and you will have to stop to recharge it. This is the reason the battery voltage is displayed on the status screen. In addition, you can always get the current battery voltage by typing a "V". This will result in the battery voltage being displayed (no text, just a number).

One (and perhaps the main) advantage of NiCad batteries is that the battery voltage is a useful indicator of remaining capacity. The battery is approximately at half capacity when the voltage is 21.6 V. Total discharge occurs at a battery voltage of approximately 19.8 V. You should never operate TAPS if the battery voltage is below 21 V, which represents approximately 20% capacity remaining.

Golden rule: Charge TAPS whenever the battery voltage drops to about 21 V.

Finally, you will want to process and display the data. Information on data formats, editing tips, and plotting and inversion programs are provided in **Appendix 3: Data Analysis**.

CHARGING THE BATTERY

Charging the battery begins with connecting TAPS to the Charger/IO box. The cable provided for this purpose is approximately 4.5m long. It has an 8-pin underwater connector on one end that plugs into a mating jack on TAPS and a round, military-style Amphenol connector on the other end that plugs into a mating jack on the Charger/IO box.

The Charger/IO box connects to the AC mains with a standard AC cord plugged into the rear of the charger unit. (Chargers and cords are available for most common AC power sources.)

Two small jacks on the front panel are connected to the internal power supply. You may measure the Charger/IO power supply voltage directly with a voltmeter from these jacks. The actual TAPS battery voltage is not accessible from outside the TAPS; it is shown on the STATUS screen or can be displayed when you type a 'V' whenever TAPS is on.

CAST MODE

With TAPS connected to the charger and the charger connected to AC mains power, turn the POWER switch to ON. The power light will illuminate immediately. If TAPS is not turned on (the shorting plug installed), the charge indicator will come on in a few seconds and burn steadily. This indicates high rate charging in progress.

When the battery approaches full charge, the charge indicator will begin to blink. The blink rate is slow initially but increases as full charge is reached. A rapidly blinking light indicates a fully-charged battery. A slowly blinking light indicates a nearly fully-charged battery. Sometimes this is good enough.

While no battery manufacturer would recommend it, we occasionally charge the battery briefly between stations just to extend the useful operational life. On 24+ hour stations, this practice may be mandatory to enable TAPS to continue operating. Just don't make it a habit, please.

There is a DB-9 serial jack on the front face of the Charger/IO box. This jack provides serial communications with the TAPS, should you wish to dump data, reprogram, or otherwise communicate with TAPS while it is connected to the charger. Operations and battery charging are basically separate activities; only one may be done at a time. Battery charging merely requires the cable be connected between the Charger/IO box and TAPS. Operations require that the shorting plug be installed on TAPS to power-up the internal computer and enable communications. Doing so causes charging to stop.

The shorting plug must be removed to charge the battery.

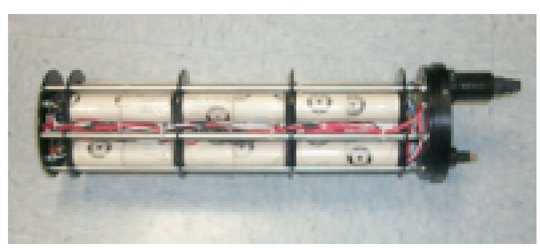
When the shorting plug is installed but TAPS is not operating (pinging), the current draw is about 60 mA. The battery capacity (when new) is nominally 5.7 A-hrs. Thus, TAPS can 'idle' for about 95 hours before the battery is dead. Operating, the current drain is about 350 mA. Thus, TAPS can operate for about 16 hours before the battery is dead. The actual usable time between charges will depend upon the relative amount of time spent waiting and the time spent operating and on the health of the battery.

It is not recommended that you run the battery completely down on a regular basis. This is deleterious to battery life. And the battery does have a finite lifetime which depends heavily on how it has been treated. In addition, NiCad batteries self-discharge over time. For maximum service life from your TAPS battery, you should recharge the battery about every 2-3 months when not in use.

EXTERNAL POWER

TAPS can be provided with external power to increase it's operational life. Several options exist: we have used a long cable with the CHARGER/IO box to power TAPS remotely for months on end. Underwater batteries (24V stack) can be used to power TAPS for periods of weeks (see SOUNDER MODE chapter for examples).

We offer an external battery as an option for TAPS that can be useful in extending the operational life of TAPS in CAST MODE. The external battery pack consists of three TAPS batteries wired in parallel in a pressure case (shown below without the pressure case). This external battery is



connected to TAPS with a short cable to the Data/IO connector on TAPS. Since this effectively covers up the serial I/O pins, an additional jack has been provided on the external battery pack to connect the TAPS/BATTERY combo to a computer.

The photo above shows the external battery unit with the interconnect cables attached.

TAPS operational lifetime is roughly quadrupled with the external battery pack. The case is rated to the same depths as TAPS itself and is of similar design for mounting. Additional information on the battery pack is supplied with the units.

DATA ANALYSIS

An entire section on this topic is included in this manual. Matlab programs are provided to read, bin, and plot the acoustic data (these may be modified to include data from your external sensors as well) and then to invert the acoustic data to estimate size-abundance spectra of the zooplankton scatterers.

PHYSICAL MOUNTING

It seems rather silly to emphasize this, but in cast mode you are attempting to measure the vertical structure of acoustical scattering – in particular, how acoustical backscattering changes with depth. So, for CAST mode TAPS really ought to be oriented HORIZONTALLY! Take another look at the first photo in this chapter.

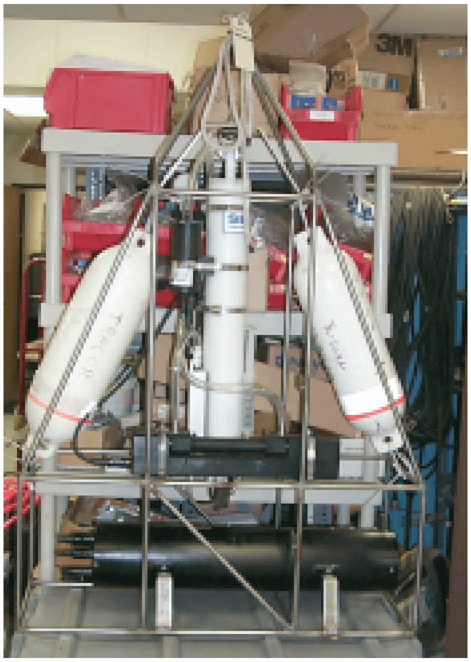
The acoustic beams of the transducers are aligned parallel to the long axis of the pressure case and the sample volume is located about 1.4 m away from the transducer faces. If you orient TAPS with the transducers pointing at some angle to the horizontal, the acoustic data will not correspond to the temperature data, nor to the depth sensor value, since they are not measured at the same depths.

Also, keep in mind that an echo is an echo. TAPS has no way of knowing if the echoes it measures come from zooplankters or a loop of cable dangling from the rosette cage. It is up to ***you*** to ensure that TAPS has a clear field of view for the transducers. This is sometimes a bit tricky for the following reason: The directivity patterns of the transducers direct <u>most</u> of the sound energy along the geometric axis of the TAPS but there is <u>some</u> sound energy at all angles. Zooplankton are very weak scatterers, so the source levels and the receiver gains of each transducer are as high as is practical to maximize the on-axis echo levels. Metal struts, cables, and similar objects are very strong scatterers, however. Such an object located at an angle to the TAPS axis might easily produce an echo as strong or stronger than that from the zooplankton on axis, even though the effective source level and receiving sensitivity off-axis is very small.

So the rule is, keep potential scatterers away from the transducer end of TAPS. Whenever possible, orient TAPS so that any potential reflectors are behind the plane of the transducers.

TAPS is provided with tabs to simplify the task of mounting it on platforms like CTD cages and net spreaders. It is strongly suggested that you do <u>not</u> use the tabs as a primary means of support, although the CTD frame below is an example of mounting TAPS by the ears.

CAST MODE



It is almost always preferable to mount TAPS to the platform with clamps (hoseclamps are suitable) around the pressure case and to use the tabs to limit fore-and-aft motion and as mounts for safety lines.

If you use hoseclamps to mount TAPS, two precautions are in order. First, a layer of neoprene rubber gasket material or heavy tape around TAPS under the hoseclamps will protect the anodizing and prevent the onset of corrosion. Second, use only enough clamping force to lightly compress the neoprene/tape layer. Excess force could (possibly) distort the case enough to affect the o-ring seals, especially for casts close to the depth limit.

PROGRAMMING

First of all, of course, to use CAST mode you must be *in* CAST mode. When power is first applied to TAPS, the first program to run is a driver program located in the CPU flash-eprom memory. This program does some setup and then outputs the line:

PRESS ANY KEY TO CHANGE MODES, K TO EXIT PROGRAM

Pressing any key (except K) then produces the program selection menu:

```
CURRENT MODE IS 1  - EXTERNAL SOUNDER
DO YOU WANT TO CHANGE MODES (Y/N)? Y
       MODES
0    CAST
1    EXTERNAL SOUNDER
2    INSTRUMENT
3    RAW CAST
4    TEST
ENTER NEW MODE CODE: 0
```

In this example, the mode is EXTERNAL SOUNDER so you should answer 'Y'. Then the MODES menu is displayed. You should enter '0' to select CAST mode.

Doing so will cause the driver program to load the CAST program from the CF-RAM card. After the code is loaded, the program will be executed. After some initialization, the CAST program will display the programming screen to have you verify the operating parameters. (This screen can also be obtained by pressing CTRL-P.)

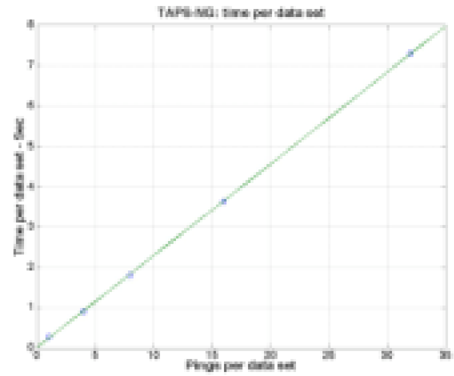
Your first parameter selection is the number of pings per average. The larger this number is, the more statistical degrees of freedom attach to each value of volume scattering strength. Up to a point, this is good. On the other hand, it takes time to accomplish each ping cycle and TAPS is moving down the water column while this goes on. So the smaller this number is, the better vertical resolution you obtain. Drat, choices!

A reasonable number of pings for general use is around 6. This gives a new data set every 2 seconds and, since each ping averages 5 independent samples, 30 degrees of freedom per average. Doubling the number of pings to 12 doubles the number of degrees of freedom (but does not halve the statistical uncertainty) of each average and doubles the time between data sets.

For higher vertical resolution, we often use 4 pings per average. Together with the binning that occurs in the analysis program, **plot6**, this usually results in sufficient degrees of freedom to obtain useful acoustic averages. The time interval between data samples is about one second.

The plot shown to the right displays measured times per data set versus the number of pings selected in CAST mode.

Next, you are asked to enter the turn-on depth for TAPS. As described above, this is the depth at which TAPS energizes



the transceivers and begins taking data. Any value greater than 0.5m will be accepted.

The turn-off depth is the depth at which TAPS stops collecting data on the way back up. Clearly, this depth must be less than the turn-on depth. It could be just a bit less than the turn-on depth—but

```
REPROGRAM OPERATING PARAMETERS:
ENTER NEW DATA OR <CR> TO ACCEPT CURRENT VALUE

# PINGS/AVERAGE =  16   6
TURN-ON DEPTH = 2.00 2.5
TURN-OFF DEPTH = 1.00

MAX SAFE DEPTH = 196.61 M
MAX OPERATING DEPTH = 150.00

SELECT EXTERNAL SENSOR TYPE:
    0 = NO SENSOR INSTALLED
    1 = FREQUENCY OUTPUT SENSOR
    2 = VOLTAGE OUTPUT SENSOR

EXTERNAL SENSOR # 1 TYPE = 2
EXTERNAL SENSOR # 2 TYPE = 1

MAKE THESE CHANGES PERMANENT (Y/N)? Y
```

Figure 3. Example of REPROGRAM screen. This is an interactive screen, thus only portions are visible when first entered.

this is not usually a good choice. The depth is measured with a pressure sensor. The diaphragm for this sensor is a strain gauge mounted on a thin stainless steel sheet which bends in response to the ambient pressure. The force that deflects this diaphragm is the ambient pressure; the restoring force to 'un-deflect' the diaphragm is the tangential stress in the diaphragm. Large deflections cause a large restoring force, small deflections yield a smaller restoring force.

The diaphragm responds to small negative pressure changes rather slowly because the restoring force is quite low. Thus, if you select a turn-on depth of, say, 0.5 m and a turn-off depth of, say, 0.2 m, it might take quite a while for the diaphragm to relax enough on the upcast for the pressure sensor value to catch up to the real pressure. Possibly several minutes. And TAPS will be taking data all this time. So select these depths with some regard for this phenomenon.

Next the MAX SAFE DEPTH (MSD) is displayed. This is the maximum depth for the depth sensor installed in your TAPS. On the next line, you are shown the current value of MAXIMUM OPERATING DEPTH. The maximum operating depth can be set to any desired value (up to 1000 m). If you set this parameter to a depth greater than the MSD, TAPS will probably never shut off. Unless you have some intricate data collection scheme in mind, this parameter can be set to 1000m and forgotten. Since this depth is used to stop data collection while TAPS is below this depth, it can be used to collect data from some shallow depth interval while the package TAPS is riding goes deeper (but not below the maximum depth for TAPS please).

You should not exceed the maximum working depth of the depth sensor in your TAPS. It is prudent to never take TAPS below the Maximum Safe Depth.

NOTE: the type of pressure sensor installed in your TAPS is noted on the specifications page in **Appendix 1: Calibrations**. While these sensors are rated to withstand 4 or 5 times the rated pressure without failure (bursting), they are only rated to 2 times the rated pressure <u>without damage</u>.* A likely result from overpressure is a change in the output characteristics of the pressure sensor, giving false depth readings thereafter. A maximum working depth for your TAPS is given in the specifications. This depth may differ from the maximum depth rating for the TAPS pressure case and transducers.

The purpose of entering code numbers for the external sensors is, first, to flag the TAPS code to ensure that the selected sensor channels are measured and, second, to make sure the sensor is of the correct type. Sensor #1 can be either a frequency- or voltage-output device. Sensor #2 must be a frequency-output device. Enter the appropriate number for sensor #1 and sensor #2. Remember that external sensors take a little extra time per data frame so you shouldn't leave codes here unless there actually is a sensor connected and you want that data.

The last choice is whether or not to make these changes permanent. If you think you entered everything correctly, answer "Y" or "y". If you know you made a mistake, press ENTER (and then start again by pressing CTRL-P).

If you elected to save these changes, TAPS will save these parameters to an EEPROM and then display the status screen for your inspection. TAPS is now ready to take data

* In older TAPS, as the depth exceeds the MSD the voltage output of the depth circuits continues to increase. This will cause an offset in the ADC that is reflected in the acoustic data as well as incorrect depth readings.

CAST MODE

SETTING THE CLOCK

There is a clock-calendar chip inside TAPS that is used to time-tag data. At the factory, we generally set this clock to Pacific time—standard or daylight, depending upon the season. You may wish to set the clock to your local time or possibly to Universal Coordinated Time (UTC). This is a simple process.

You can display the current date and time by pressing 'T' or 't'. The clock-calendar chip is read and the current values of time and date displayed, viz,

17:15:23 06/23/00

The order is time (HH:MM:SS) and date (MM/DD/YY).

To set the clock, press CTRL-T (or CTRL-t). TAPS will display a message,

ENTER DATE AS YY MM DD

You should enter the last two digits of the year, a space, the month (one or two digits), a space, and the day (one or two digits). Press ENTER.

TAPS will then ask for the time with the message,

ENTER TIME AS HH MM SS

You should enter the hour (one or two digits in 24-hour format), a space, the minutes, a space, and the seconds. Enter a time several seconds ahead of current time. Then press ENTER.

TAPS will now ask you to press ENTER (or RETURN or <CR>) at the exact time you want to set the clock. Hence the caution to enter a time slightly in the future. When your time reference agrees with the time you entered, press ENTER and the clock will be set.

You can check that the time and date are correct by pressing 'T' or 't' again and comparing the displayed values with the current time and date.

If you make a mistake, just repeat the setting procedure until the date and time match your reference.

CAL CONSTANTS

TAPS is designed to measure acoustical volume backscattering (Sv) in absolute units. Of course, what it actually measures are echo voltages from each transceiver channel. Converting these to actual Sv values requires calibration—which is generally a factory job—and application of these calibrations to the measured data.

The calibration sheet supplied with TAPS (or returned with TAPS after re-calibration) contains a line of numbers entitled *CAST mode cal constants*. These numbers are the values that must be added to the measured echo intensity values to convert them to Sv. (Another set of numbers is provided for SOUNDER mode data conversions; these numbers are used in the data analysis software only.)

One handy place to store these numbers is inside TAPS itself. In fact, if you do, the data will be output as Sv values directly. Isn't that clever?

The CAST mode cal constants are installed in your TAPS at the factory (originally and again whenever TAPS is re-calibrated). Normally, you should never have to worry about installing the cal constants. But, stuff happens. TAPS have been known to get struck by lightning, for example, which can do bad things to data stored in EEPROM.

The cal constants are displayed whenever the STATUS screen is displayed. From time to time, you might want to compare these values to the ones on the calibration sheet. These values are also sent as part of the header information whenever data are dumped from TAPS. Should it be necessary, a trail exists for changing the cal constants of even historical data. You are saving the data dumps as archive files, aren't you?

But, suppose your TAPS is the next one to be struck by lightning and the cal constants are lost. Can you re-install them? Sure. It is a simple procedure.

Type “CTRL-Z” or “CTRL-z”. You will see an “are you sure” line; answer Y or y to proceed. Then you will be prompted to enter (or accept) six values for the six channels. Enter the numbers carefully as there is minimal error checking in the code. A typical entry might look like

-47.8

Don’t forget the minus sign. If the value displayed is correct, you can accept this value by pressing ENTER.

The same screen that lets you re-enter the cal constants also lets you enter the depth sensor rating (in psia) and two 'scale factors.' The standard depth sensor for TAPS is a 300 psia pressure sensor. If you requested another sensor, this value will be listed in the SPECIFICATIONS section.

The first scale factor is a multiplier for the depth channel, the other is an additive constant for temperature. The depth scale factor lets you adjust the TAPS depth readings to conform to, say, a CTD on the same package. Similarly, you can add a constant offset to adjust the TAPS temperature data to match if needed.

You can also re-enter the TAPS serial number and the battery scale factor. This last is the scale factor that multiplies the ADC value to produce the displayed battery voltage. If you feel the battery voltage displayed in STATUS screens or after pressing 'V' is wrong, you can alter this scale factor to make the displayed value match the actual battery voltage as measured on the power control card.

EXTERNAL SENSORS

Provision has been made for connection of up to two external sensors to TAPS. Typical choices might include a conductivity sensor to estimate salinity and a fluorometer to estimate chlorophyll-A. We have used an SBE-4 conductivity sensor, both WetLabs and SeaTech fluorometers, a PAR sensor, a transmissometer and an optical backscatter sensor with our TAPS at various times.

If you need to change the sensor setups, refer to the EXTERNAL SENSORS section in this manual.

External sensors should be mounted with due regard to orientation and location. That is, the conductivity cell (or fluorescence chamber, etc.) should be mounted so that water will flow through as the package is lowered The sensor should also be located approximately at the same depth as the transducers and the depth and temperature sensors on TAPS so that all data comes from the same depth.

There is no particular reason that an external pump couldn’t be added as well. A special cable would be required and a low-currrent version pump should be used. You could wire the pump in parallel with the power leads of your external sensor or simply use the second sensor channel to provide power to the pump.

The use of external sensors adds potentially valuable data to the TAPS data stream but there is a slight cost associated with this. Each instrument added to TAPS costs approximately one/tenth second per data frame per instrument. Either a smaller number of pings per average must be selected or TAPS must be lowered more slowly to obtain the same vertical resolution when using external sensors. Also, the external sensors use battery power. This will reduce the operating life of TAPS.

RAW CAST MODE

There may be times when you would like to inspect the raw echo values to examine the echo statistics. The copious memory capacity of TAPS makes this possible.

RAW CAST MODE may be selected during the first few seconds after TAPS power is applied, as described above (see also the PROGRAMMING chapter).

This mode operates just like basic CAST MODE except that the five echo amplitudes that would normally be squared and summed after each ping into an accumulator are saved to a buffer in RAM and, when the buffer is full, transferred to the CF-RAM card. TAPS still turns on and off using the depth sensor values, the only difference is the type (and amount) of data stored.

The RTC is read on each ping cycle, as is depth and temperature. External sensors may be used and this data is stored as well.

INSTRUMENT MODE

A variant of the CAST mode is the INSTRUMENT MODE. This mode is identical to CAST mode except that (1) the depth sensor is not used to start/stop TAPS and (2) data are output continuously on the serial port in ASCII-hex format. This mode was created to permit the use of TAPS with an external datalogger on a vertical profiling package. External power should be provided if long-term operation is desired.

When power is applied to TAPS in this mode, data begin automatically appearing at the serial output after a delay of a few seconds. Data continue to be displayed until power is turned off.

The data format is fixed; every line is exactly 89 characters long. A special Matlab® script has been provided to read and convert these files, **rdtapsinst.m**. This subroutine requires some modification before use--you must edit the code to insert the calibration constants for your TAPS and the pressure sensor rating.

For those who wish to write their own code to decode INSTRUMENT MODE data, a table showing the character allocations and decoding is provided below. The data consist of ASCII-hex characters that must be converted first to decimal numbers and then to engineering units.

The initial step in translation is to convert the ASCII-hex characters into decimal numbers. In the case of time and date, the conversion is complete. For the remaining data, however, some computation is required.

The Depth number is a sum of the ADC raw values (less the offset measured in CAST mode on deck) over NP pings. The raw number can be converted to depth in meters by multiplying by DPB, the depth per bit, and dividing by NP. The depth per bit is found from the

Starting character number	Number of characters	Value	Conversion method	Example	Converted value
1	1	Month	HEX->DEC	B	11 or Nov
2	2	Day	HEX->DEC	7	7th
4	2	Hour	HEX->DEC	0E	14
6	2	Minute	HEX->DEC	15	15
8	2	Second	HEX->DEC	08	8
10	8	Depth	HEX->DEC + Equation 1		
18	8	Temp	HEX->DEC + Equation 2		
26	8	Freq1	HEX->DEC + Equation 3		
34	8	Freq2	HEX->DEC + Equation 4		
42	8	Sv1	HEX->DEC + Equation 5		
50	8	Sv2	HEX->DEC + Equation 5		
58	8	Sv3	HEX->DEC + Equation 5		
66	8	Sv4	HEX->DEC + Equation 5		
74	8	Sv5	HEX->DEC + Equation 5		
82	8	Sv6	HEX->DEC + Equation 5		

Table I. Format of data from TAPS in INSTRUMENT MODE and conversion methods. See text for equations.

following equation

$$dpb = (Pmax-14.7)/(14.7*16384)$$

where Pmax is the maximum pressure rating for the depth sensor in psia, 14.7 is the pressure equivalent of 1 atmosphere, and 16384 is the number of steps in the A-D converter.

Temperature is similarly a sum of raw ADC readings but in this case there is a sign bit to account for. The value is first converted to a decimal number, Nt. If Nt is greater than 65536 (signifying negative values), it is replaced by

$$Nt = -(2^{32}-Nt).$$

Then Nt is divided by NP.

Next, Nt is converted to sensor resistance using the following equations:

$$Z=N/65536$$
$$X=(0.5 + Z) / (0.5 - Z)$$
$$R=R25*X$$

where R25 = 30.0E3 ohms is the resistance of the themistor sensor at 25C and R is the measured resistance of the sensor.

Finally, the sensor resistance is converted to temperature using the Steinhart and Hart equations:

$$LR = \ln (R)$$
$$TI = a +b*LR +c*LR^3$$
$$T=1/TI - 273.115$$

where ln (R) is the natural log of R and T is the temperature in C. The constants are

$$a = 9.354E-4$$
$$b=2.211E-4$$
$$c=1.257E-7.$$

The next two values are the frequencies from external sensors 1 and 2 (if installed; zeroes otherwise). These characters must be converted to decimal frequency. Further processing depends upon the external sensor(s) and will not be discussed here. See the section on External Sensors for further information.

The last six numbers are the outputs of the echo intensity accumulators. They must be converted to decimal values and divided by 5 times the number of pings, NP. The reason for the extra 5 is that TAPS sums 5 consecutive echo intensity samples on each ping.

The intensities may be converted to volts-squared by dividing by 1E6 (this is because the ADC conversion is one bit per millivolt, or an output of 1000 for a 1 volt input). Then each value of volts-squared can be converted to Sv using

$$Sv(i) = 10*\log_{10}(V^2)+CAL(i)$$

Where V^2 is the scaled intensity, Sv(i) is the ith value of volume scattering strength and CAL(i) is the associated conversion constant from the TAPS calibration sheet (see Appendix I).

TIME SERIES DATA

It is sometimes interesting to suspend TAPS at a depth and take data for a period of time, say for comparison with some other sensor or to investigate the variability of zooplankton concentrations with time or position. This is often done with TAPS in CAST mode. Afterwards, however, the user is faced with the problem of analyzing such data.

Plot6.m assumes the data are in the form of a vertical profile and bins the data accordingly. This is not satisfactory for data collected over time at a single depth as all the variability has been averaged out.

Plottime.m is a variant of Plot6.m that processes data taken as time series. It operates much like Plot6.m but does not bin data in depth. You do have the option to bin adjacent data sets to increase the degrees of freedom (reduce the variance). Data are plotted versus time of day rather than versus depth. A slightly different set of data is saved to disk. A variant of inv6.m is thus also required; Invtime.m inverts the data from Plottime.m and plots the data versus time of day. The operation of Invtime.m is identical to inv6.m.