

SOUNDER MODE

TAPS can also be programmed to operate in what we term the **SOUNDER** mode. This mode is called **SOUNDER** because it is similar in operation to an echo sounder or fish finder. A typical fish finder produces a *map* of the water column with, normally, depth on one axis and time or horizontal extent on the other. Scatterers appear as bright or colored spots on the display. The depth or range resolution is determined by the pulse length.

Our version of the echo sounder behaves in much the same way. You must select the number of 12.5 cm wide depth bins to sample, which determines the maximum range for each depth profile. If the data are to be stored internally, you will also select the number of profiles to store, the time interval between profiles, and when to start taking data.

Instead of taking samples of the echoes at a few points around a fixed range (as in cast mode), TAPS samples the echoes at equal range (time) intervals beginning at 37.5 cm range out to a user-selected maximum range (up to 35.375 m). Each bin is defined by the length of the transmit pulse ($cT/2$, where c is sound speed, T is the pulse length, and 2 because of 2-way travel) and the width of the transmitted beam. Because the beam patterns of the transducers are essentially conical, the volumes of the bins will increase with range. A typical set of bin volumes is plotted versus range in Fig. 1.

Note that the 'range' of each bin is the distance from TAPS transducers to the center of the bin. The scattering at each range is due to echoes from all scatterers within the range bins arriving at the time of the sample, thus each sample represents an 'integral' of scattering from a finite range interval.

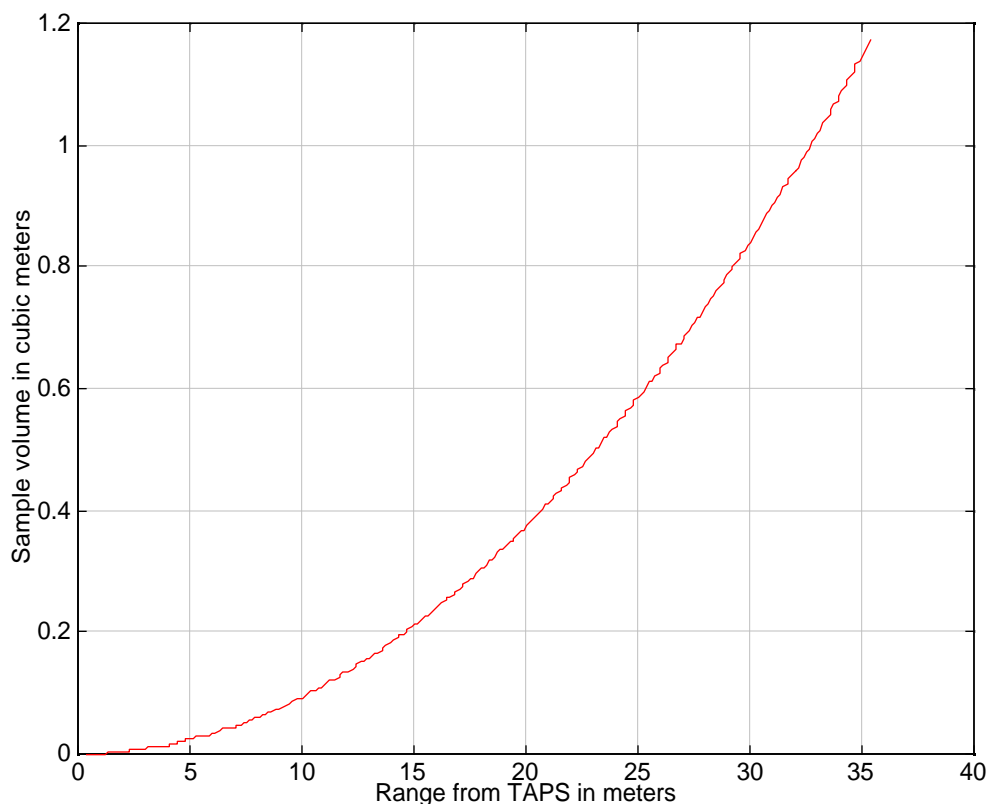


Figure 1. Typical TAPS sample volume versus range. In CAST MODE, the sample volume is approximately 0.002 m^3 .

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Echo amplitudes are sampled at each range, squared, and added into six accumulator arrays (one for each frequency). Each element of these accumulator arrays holds the sum of the echo intensities at a fixed range from TAPS. After the selected number of pings have been accumulated, each accumulator holds a range profile of sums of echo intensities—dividing by the number of pings converts this profile to an average intensity profile versus range.

If TAPS is held at the surface, pointing downwards, the profiles obtained will be identical to those from a fish finder—except that the TAPS profiles are averages over some number of pings. The user is free to orient TAPS in any direction whatsoever, however. Mounting TAPS on the bottom in shallow water can provide data on the critical region just below the surface (e.g., Barans, et al, 1997). In this case, tidal currents provide the horizontal ‘axis’ of the data set. The time interval between the profiles can be adjusted to suit the expected rate of change of biomass distributions.

Similarly, TAPS might be oriented horizontally across an inlet to observe the patterns of ingress/egress during a tidal cycle. Due regard should be given to the variable sizes of the sample volumes in this case, however, and the effects of transducer sidelobes (see Appendix 2: Basic Acoustics for details). Basically, though, the choice of orientation is up to the user.

Two sorts of SOUNDER mode are offered—external recording and internal recording. The external mode requires that TAPS be connected to an external computer, which does the data recording (hence, ‘external’). This mode is most commonly employed when TAPS is also powered externally and can run for indefinite periods of time, often unattended. The external power mode may require a simple internal modification to TAPS; this is described under the REMOTE MODE heading in this section

In external mode, data sets are initiated by the external computer sending a RUN command (“R”) to TAPS. This starts the data collection process: power is applied to the transceivers; the real-time-clock (RTC) is read and stored; if selected, the external instruments are powered and the outputs sampled; and then acoustic sampling begins. Depending upon the number of pings and number of range bins selected, this can take from several seconds to a few minutes.

Sending a DUMP command (“D”) anytime after the RUN command will cause data to be output as soon as collection is complete. Each data set consists of one line of numbers: date, time, depth, temperature, instrument 1, instrument 2, NBINS values of scattering intensity at frequency 1, NBINS values of scattering intensity at frequency 2, ..., NBINS values of scattering intensity at frequency 6, followed by a carriage return character. Note that the acoustic data are NOT volume scattering strengths. External processing is required to convert these numbers to Sv (see CONVERTING SOUNDER DATA below).

The ‘internal’ mode uses TAPS non-volatile memory to store data much like in the CAST mode. The main difference in this mode is the use of the RTC to control data collection. In internal sounder mode you must enter the date and time at which you want data collection to begin, the time interval between data sets, and the number of data sets to be collected. The number of data sets you can store is limited by available memory.

The idea behind this mode of operation is as follows. TAPS can be programmed ahead of time (days or weeks ahead, if desired) in convenient surroundings. The shorting plug is removed to conserve battery life. Then TAPS can be deployed—installed by divers, lowered to the bottom, etc.—and the shorting plug installed, shortly before the programmed start time (by someone

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else, even). TAPS will begin collecting data at the scheduled start time and, after completing the last data set, enter a low-power mode to conserve battery power. TAPS may then be retrieved and the data downloaded. These data are formatted as described above, with the exception that a data header is displayed at the beginning of the data sets.

EXTERNAL SOUNDER MODE

The SOUNDER mode is selected via the PROGRAM command. Press <CTRL>-P to select the programming mode. An opening dialog displays your choices of operating modes. Select mode 1: SOUNDER MODE, EXTERNAL RECORDING.

The next dialog asks you if it is ok to erase memory. Answer 'Y' or 'y' if this is permissible; answering anything else negates the mode change you just made.

Next, you are prompted to enter the number of pings per average. The current value is displayed and the program pauses for you to either enter a new value or press ENTER (<CR>) to keep the old value. Since each range bin is sampled once per ping, you will want to use a fairly large number of pings per average to obtain satisfactory statistics at each range. A typical number of pings might be 16-32, compared to 4-8 in cast mode. The maximum number (limited by word size) is 256 pings per average.

TAPS then displays the current maximum range and number of range (depth) bins. If you are switching from cast mode, the maximum range will be 8.875 m and the number of bins will be 68. Enter a new value for the number of depth bins if desired. The new computed value of maximum range will be displayed. Up to 280 bins may be selected, giving a maximum range of 35.375 m. The number of bins, N_b , to achieve a particular range, R, may be computed from

$$N_b = 8 * (R-.375).$$

Both ASCII and binary output modes are available. Data output in ASCII mode is generally simplest, as the data may be logged in a simple terminal program on almost any computer. Since most terminal programs do not support unformatted binary data transfer, ASCII mode is usually preferable. It is slower than binary mode, however, by a factor of about 5. If speed is critical—data intervals of 1 minute or less are desired—binary mode will have to be used. This particular circumstance calls for special effort. A program that controls data collection for TAPS in EXTERNAL SOUNDER MODE and handles binary data is provided with TAPS. (See the discussion of **EZSOUND** later in this chapter.) A Matlab[®] script to read these binary files is also provided.

The next programming selections are the usual ones for baud rate and external sensors (see CAST MODE or PROGRAMMING sections for details). At the end is the usual question, "MAKE THESE CHANGES PERMANENT (Y/N)?" Answer Y or y if the setup is satisfactory. Note that you will have to cycle TAPS power to install this new mode properly.

Removing and replacing the shorting plug will cause TAPS to start up in the new mode. You will, of course, be running a computer program (terminal or special) with a direct connection to TAPS. If you are running a terminal program, you will see ... nothing. This is the correct response in external SOUNDER mode. The usual commands will still work, however. Try an 'S' and the status screen will be displayed, showing the mode to be SOUNDER: EXTERNAL RECORDING and ASCII (or BINARY) output.

INTERNAL SOUNDER MODE

The internal SOUNDER mode is selected via the PROGRAM command. Press <CTRL>-P to select the programming mode. An opening dialog

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displays your choices of operating modes. Select mode 2: SOUNDER MODE, INTERNAL RECORDING.

Selection of the number of pings per average and the number of bins is identical to the procedure given above. The first difference occurs when the current date and time are displayed and you are asked to enter the start date and time for data collection. You must enter the month, day, hour, and minute at which you want the first profile to be collected. This epoch must be in the future. It might also be a good idea to set TAPS internal clock before setting these values.

Following this, you will be asked to enter the time interval in minutes between profiles. This value can range from a low of 1 minute to a high of 255 minutes.

Then you will be prompted to enter the number of profiles to store. The maximum number that will fit into memory will be displayed to help you select this value. This value is computed from the number of range bins selected above. Remember that the number of profiles that will fit into memory is dependent upon the length of each profile, hence the number of range bins and the number of profiles trade off.

The remainder of the programming dialog is identical to CAST mode and the external SOUNDER mode. If all of your entries are correct, answer 'Y' or 'y' to the final question to store these operating parameters for future use. Remember, you will have to cycle power to fully implement the changes you have made.

The programming step may be accomplished well in advance of deployment, if desired. When it comes time to install TAPS, the shorting plug should be installed and the normal checks made. Then TAPS can be installed and left until the data collection is complete or it is convenient to recover TAPS again.

Something to keep in mind, however—leaving TAPS running for an extended period of time will run the battery down completely. Prolonged connection of a fully discharged NiCad battery is considered abuse and the battery will repay this treatment in kind. It would be prudent to recover TAPS as soon after data collection ceases as possible to guard against damaging the battery.

MOUNTING TAPS

All of the precautions and advice given in the CAST MODE section apply to mounting TAPS for SOUNDER applications. Pay particular attention to the orientation of the transducers as the beams spread with range, making the chance for interference from structures (buoys, mooring lines, etc.) that much greater.

Probably the most important thing to consider is the fouling that is inevitable in any long-term immersion in sea water—and long-term is the whole point, generally, of using SOUNDER MODE.

There are no perfect solutions to counteract fouling. One thing we do that seems to work fairly well is to wrap the outside of the case with tape (electrical or duct). This does not stop the fouling but does let you remove it by peeling the tape off after a deployment. Of course, you cannot cover the transducers with tape without drastically affecting the acoustic calibrations. Fouling of the transducer faces oftentimes forms the limiting factor to long-term deployment. Anti-fouling paints provide some relief where permitted. You must ensure that no bubbles are trapped in the paint film over the transducers as these can cause severe degradation in the system calibration properties. We have used anti-fouling paint with good success in the past but we double-checked the calibrations just to be sure the paint did not affect the system response. You might want to do the same.

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Physical mounting of TAPS can take many forms. Two schemes we have used are depicted in Figs. 2 and 3. These photos illustrate methods for mounting TAPS to look either up (Figure 2 and 3) or down (Figure 3).

We have deployed TAPS in fjords, bays, and offshore to take data for weeks to months. Short-term deployments can utilize battery packs, longer-term studies demand shore power.

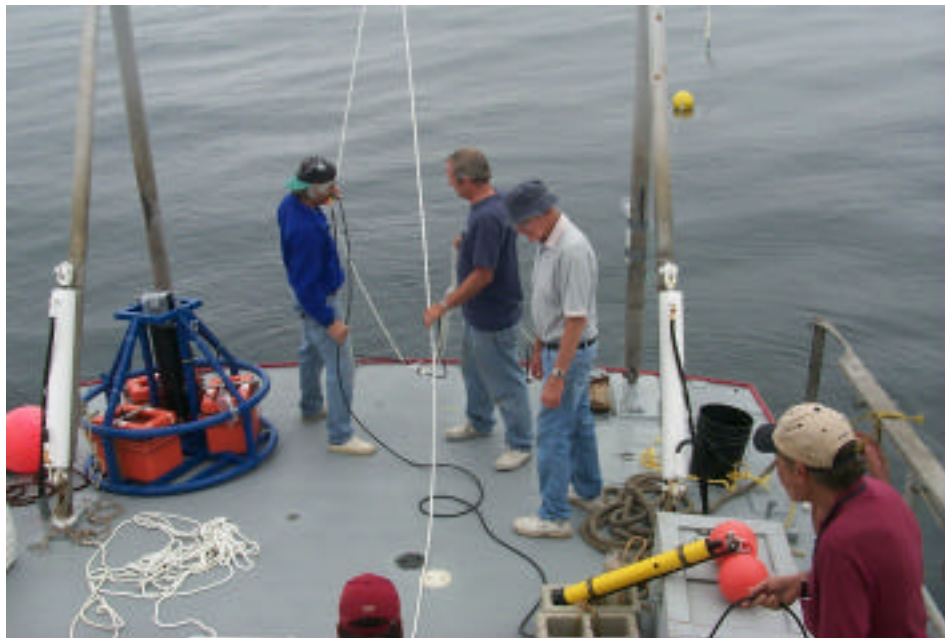
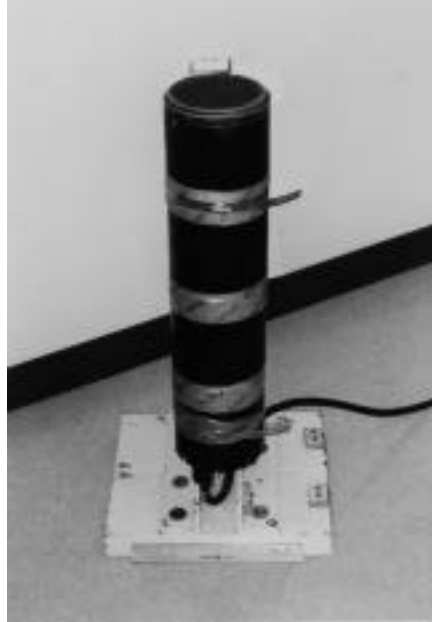


Figure 2. Examples of mounting methods for placing TAPS on the bottom looking up. The upper figure is for a TAPS cabled to shore, the lower picture shows TAPS powered by underwater batteries (in the blue frame) and telemetering data to shore via an RF modem in a spar buoy (leaning up against the A-frame on the right).

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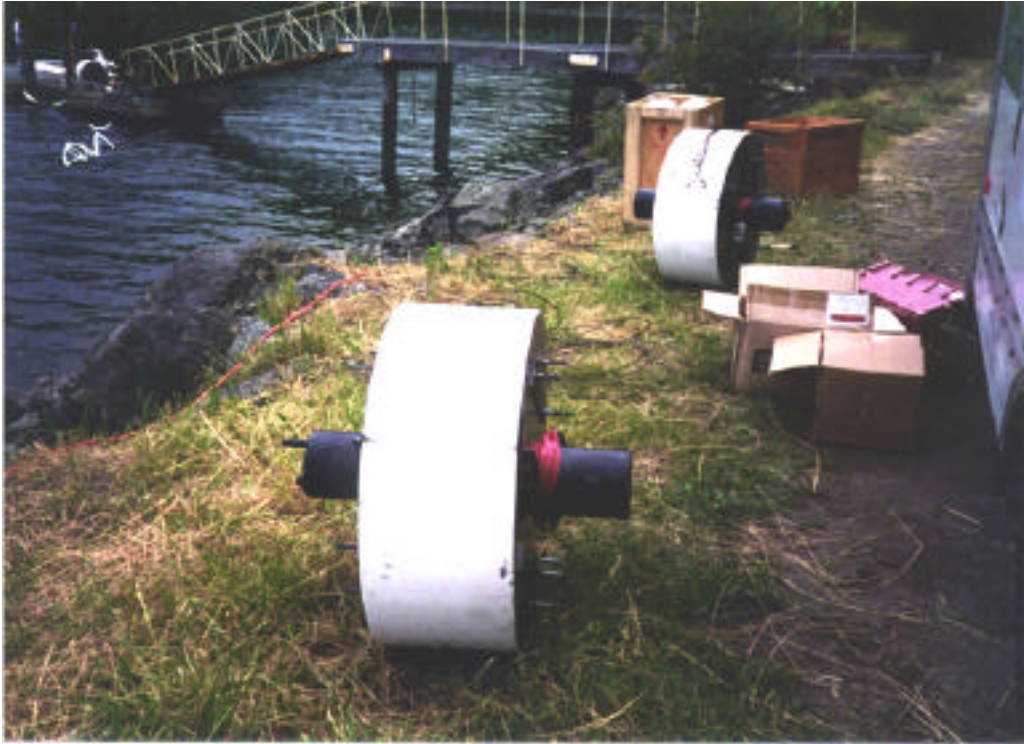


Figure 3. TAPS encased in a foam float for mooring in either up- or down-looking configuration. This photo was taken in 1998 at East Sound, WA where three TAPS were moored at about 12 m depth looking up. A single-point moor was deemed satisfactory for the up-looking application. A similar setup was used in 1999 for a down-looking configuration off Fort Walton Beach, FL where two TAPS were moored about 6 m above the bottom to observe diel migrations of benthic organisms out of the bottom. Two spread anchors were used to enable us to monitor the undisturbed bottom directly below TAPS.

CONVERTING SOUNDER DATA

SOUNDER data are stored as raw accumulator values and these are the values delivered to the user. In order to convert these values into volume scattering strengths, some work must be done. Some programs are available to help you here; see Appendix 3: DATA ANALYSIS for Matlab[®] code listings. Basically, the numbers must be converted to squared volts, corrected for spreading losses and absorption and the variable sample volumes, converted to dB, and the calibration values added.

If the binary data transfer mode was selected, the data will arrive as one long

stream of 8-bit bytes with a peculiar format. Inspect the program listing for **rdbsndr.m** to see how the bytes must be read to obtain date, time, depth, temperature, the two external sensor frequencies, and the six accumulators. Note particularly that the byte order of the data is 'big-endian' like Macintosh computers and Motorola processors in general, whereas the byte order for PC's and Intel processors in general is 'little-endian.' If you don't know what this means, by all means use the code provided to ensure the data are read correctly, especially if you intend to process the data on a PC.

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If ASCII data transfer was selected, the data will arrive as a long stream of text character numbers, separated by spaces.

The order of data is unaffected by the choice of output mode, however.

Once the data are arranged into arrays of accumulator values, they must be converted to squared volts. First, each accumulator element must be divided by the number of pings (you did write this down somewhere, didn't you?) since each value is the sum of NPINGS samples. Converting these normalized values to volts-squared is then quite easy—divide by 1,000,000. The analog-to-digital converter range in TAPS is 0-4.095 volts and the output is an integer in the range 0-4095. Dividing this number by 1000 gives the input level in volts, hence dividing a squared value by 1000^2 gives volts-squared.

Correcting for spreading loss simply involves multiplying each intensity value by the squared-range of each sample. The first sample occurs at .375 m and each succeeding sample is .125 m greater in range.

Correction for absorption is slightly more complicated in that you must compute the absorption coefficient, α , for each frequency and this coefficient varies with temperature and salinity (Urlick, 1967). It is usually sufficient to compute α for the mean temperature and salinity at a site. Algorithms for this calculation are given in **Appendix 2: Basic Acoustics** and a Matlab[®] function for calculating α is provided on the analysis programs disk.

Correction for absorption is best made after the data are converted to dB ($10 \log_{10}[\text{intensities}]$) by adding

$$10 \log(2 \alpha R)$$

to the data set. In this equation, R is the vector of ranges to the centers of the

range bins (see the code listings in Appendix 3: Data Analysis for examples).

The corrections to this point essentially perform the volume-scattering TVG (time-varied-gain) function of an analog echosounder. In essence, the scattering intensities have been adjusted to look as though they all were measured at one meter range.

The next corrections involve the system parameters of TAPS. We must correct the log intensities for the sensitivity of each channel (source level + receiving sensitivity + gain), for the beam width of each transducer, and for the pulse length employed. These can be combined into a single calibration constant. In fact, they have been. These values can be found in **Appendix 1: Calibration** in the Calibration table. When the values shown in this table under SNDR mode cal constant are subtracted from the log-intensity values, the result is volume scattering strength, Sv.

The program **makesndr** provided on the TAPS CD-ROM performs these conversion steps for you, as well as formatting the data for plotting and inversion.

Remote operations are an optional variant of external SOUNDER mode. The major difference is that power can be supplied from the Charger/IO unit via a cable. The baud rate may need to be reduced to permit reliable communications over a long cable (unless the RS-485 option is installed; see the Test & Maintenance section for details).

REMOTE SOUNDER MODE

The REMOTE SOUNDER MODE for TAPS allows you to both power TAPS from a remote source (the Charger/IO box, for example, located ashore or an external battery pack in a buoy) and to control TAPS from this same location. We routinely deploy TAPS in this way, taking vertical profiles at one minute

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intervals and dumping data at 9600 baud to a host PC. We convert TAPS to RS-485 to maintain this baud rate by removing one IC and installing another IC—you may prefer to accept a lower baud rate (required by the long cable) rather than change chips inside TAPS. In addition, you will need to provide RS-485 capability in the host PC.

If you elect to reduce the baud rate while using the long cable, it would be wise to reprogram TAPS (using, say, the data download cable) for external SOUNDER mode and a baud rate of 2400 baud before you hook TAPS up to this cable. This will ensure that you will be able to talk to TAPS when it is configured for remote operations—once configured, you will not be able to power the unit except through the 600m cable and, if you don't have communications with TAPS, you won't be able to change the baud rate.

Installation of TAPS for remote mode is otherwise straightforward. The cable comes with connectors that mate in only one way. One end of the cable has an underwater connector that plugs onto the 8-pin connector on TAPS. The end of this cable mates to only one end of the second cable, etc. The far end of the cable has a circular-mil connector that plugs into the charger connector on the TAPS Charger/IO unit.

Don't forget to install the shorting plug! This should be done just prior to installation to minimize the drawdown of the internal battery. TAPS may run without the shorting plug due to the conduction of saltwater but this is not guaranteed. It is guaranteed, however, that the pins of the shorting jack will be corroded and eventually disappear.

With TAPS deployed, the shorting plug installed, and the 600m cable connected to the Charger/IO unit, check that the front panel switch on the Charger/IO unit is set to OFF. Connect the AC power cord.

Install a serial cable between the Charger/IO unit and the host computer. Start a terminal program and set it for 2400 baud, no parity, 8 data bits, 1 stop bit. (Or, if you have installed the RS-485 driver IC, setup your RS-485 port for 9600 and N-8-1.)

Turn the power switch on the Charger/IO unit ON. You should see a blank screen if TAPS has been programmed for external SOUNDER mode. If TAPS is in some other mode, configure it for external SOUNDER mode. Verify TAPS is operating properly by typing an "S" to view the STATUS screen.

The most common way of collecting data from TAPS in remote mode is to run a program such as *EZsound.exe*. This program, which runs on PC's under DOS, is provided with TAPS on the programs CD. Operating instructions and a code listing will be found at the end of this section. This program is similar to the ones we use and is offered as a template for custom versions if the sampling scheme is not suitable for your needs. The C code is provided should you wish to compile it for use on other computers.

Custom programs may be written if desired. A control program must, at minimum, be able to generate a RUN command ("R" or "r") at desired intervals, followed by a DUMP command ("D" or "d") to retrieve the data. If binary output mode is selected, the data must be read and stored as binary; if ASCII output mode is selected, the data consist of text characters and should be stored that way.

Data analysis is identical to that described above in CONVERTING SOUNDER DATA save for the input file structure. Matlab programs for processing remote mode data are provided with TAPS and can be found on the CD-ROM provided. Discussion of the use of these programs is contained in Appendix 3: Data Analysis.

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EZSOUND PROGRAM

Ezsound is a program that will run on a personal computer (PC) under WINxx or Windows NT. It allows you to collect data from a TAPS unit in remote SOUNDER mode. The sampling period, the number of range bins, the communication mode (ASCII or binary), and the baud rate can all be set by the user to match the setup entered into TAPS.

Copy the contents of the EZSOUND folder on the CD to the hard drive of your PC. It might be useful to make a shortcut to this folder on your desktop.

Double-click on the EZSOUND.EXE file icon. You will see a screen like the one below.

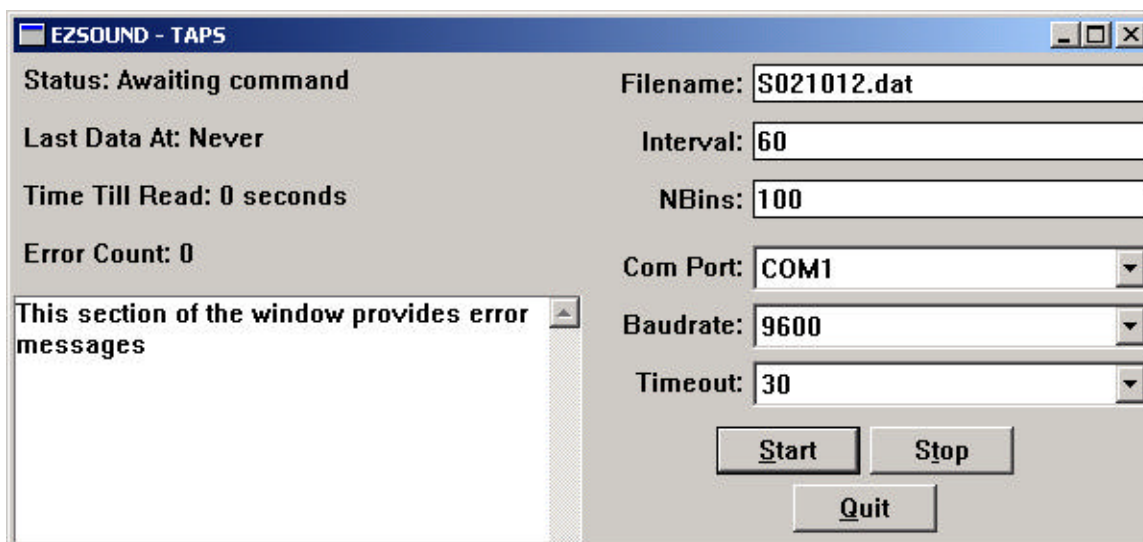


Figure 4. Startup screen for EZSOUND. This screen shows the default TAPS parameters as well as default status displays. In operation, the Status, Last Data, and Time Till Read lines will display current information on program operation.

The boxes on this screen display status (left side) and setup parameters (right side). Before starting data collection, you will need to setup certain critical parameters such as the comm port and baud rate as well as the number of range bins (NBins). These must all match your TAPS setup for the program to run properly.

The box labeled **Filename:** displays the filename under which data will be saved. The filename begins with S to signify SOUNDER data. The digits correspond to the current MONTH, DAY, and HOUR of your PC clock. In the example, the PC clock is set to 12 o'clock on February 10th.

When data collection begins, data will be stored into this file until the PC clock rolls over to the next hour. When this happens, the current file will be closed and a new file opened. The name of the new file, in this example, would be S021013.dat to signify data from the 1300 hour of February 10th. Data files created in EZSOUND contain up to one hour's worth of data each.

Data files are stored in the EZSOUND folder. Upon completion of data collection, it might be prudent to move the data files into an appropriately-named folder of their own.

The box labeled **Interval:** contains the time interval between data sets in seconds. This is a user-set parameter.

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Keep in mind that TAPS takes about 15-30 seconds to collect a set of data and transmit it to the PC. The exact time is a function of the number of pings and the number of range bins set into TAPS. Setting **Interval** to a very small number, less than the actual number of seconds it takes to collect and transmit the data, will cause data collection to be essentially continuous.

The box labeled Timeout: contains a program variable that tells the program how long after a RUN command has been issued should it expect to wait until data begin arriving. The time between a RUN command and when a response to a DUMP command begins is a function of the number of pings. The default value (30) works fine for 32 pings/data set or fewer. It may be necessary to increase this value a bit if more pings/data set are set into TAPS.

When the program variables are set to your liking, click on the START button. The Status: line will change to 'Checking for TAPS'. The program sends a T to TAPS and expects a line of characters in response (the date/time line). If this is received, the program presumes a TAPS is connected and working. If no response is received, an error message will be displayed in the message box.

Assuming a satisfactory response, the program will now delay until the PC clock time divided by the time interval is an integer value. Then data collection will begin. The status line will display what is currently happening in the program. When data have been obtained from TAPS, the time of the last RUN command will be displayed. A countdown time will display the number of seconds until the next RUN command will be issued.

The program is intended for unattended operation. Once set running, EZSOUND can run until TAPS power is consumed or the hard drive runs out of space.

Occasional checkups by a human are probably a good idea, of course. The screen display has been designed to hopefully make it easy for even a naive observer to determine if the program and TAPS are working properly or not. Three things to look for are:

1. Does the current filename match today's date and time?
2. Does the time of the last data set match the current time within the time interval?
3. Is the countdown timer running?

A yes to all three questions suggests all is well.

NOTE – EZSOUND expects binary data from TAPS. You must make sure to select binary data transfer in the TAPS programming screen when you setup TAPS for SOUNDER MODE.

Clicking the mouse in the STOP box will stop data collection but leave the program running. This might be useful while troubleshooting a connection problem or doing disk housekeeping. Keep in mind that the file is NOT closed when STOP is clicked.

Clicking the mouse in the QUIT box will exit you from the program. The current file, if open, is closed and program execution is terminated.

When the program is started, if a file with the proper name exists, data will be appended to this file.

A Matlab[®] script, **makermt.m**, is provided to read the outputs of *sounder*. This program expects to read data in hourly chunks and binary format. See **Appendix 3: Data Analysis** for details of this program and examples of long-term SOUNDER data.

REMINDER

Keep in mind one important feature of SOUNDER mode: TAPS sample volumes increase with range due to the

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geometrical spreading of the sound beam. See Figure 1.

One effect of this is that at larger ranges it is more likely that scattering can arise from the rare, larger scatterers (such as euphausiids, medusae, larval fish, etc.) that are generally not seen in the small sample volumes used in CAST MODE. This can affect your ability to obtain accurate inversions, especially when a single model is used.

Another effect is the increase in attenuation due to absorption that can cause the echo levels to decline below the

noise levels at relatively short ranges on the higher-frequency channels. Thus, you should expect to obtain different effective ranges on each channel, further complicating the chore of inverting the acoustic data.

In addition, some loss of accuracy occurs because we have no information on the temperature/salinity structure of the water column above/below TAPS and thus cannot correct for changes in absorption. This is more important at the higher frequencies, of course, but is rarely a major error source.

References:

Barans, C. B., B. W. Stender, D. V. Holliday, and C. F. Greenlaw, 1997. Variation in the Vertical Distribution of Zooplankton and Fine Particles in an Estuarine Inlet of South Carolina. *Estuaries* 20(3): 467-482.

Urick, R. J. *Principles of Underwater Sound for Engineers*. McGraw-Hill, New York. 1967.