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. 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 40 cm range out to a user-selected maximum range (up to 42.6 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 1/2 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.

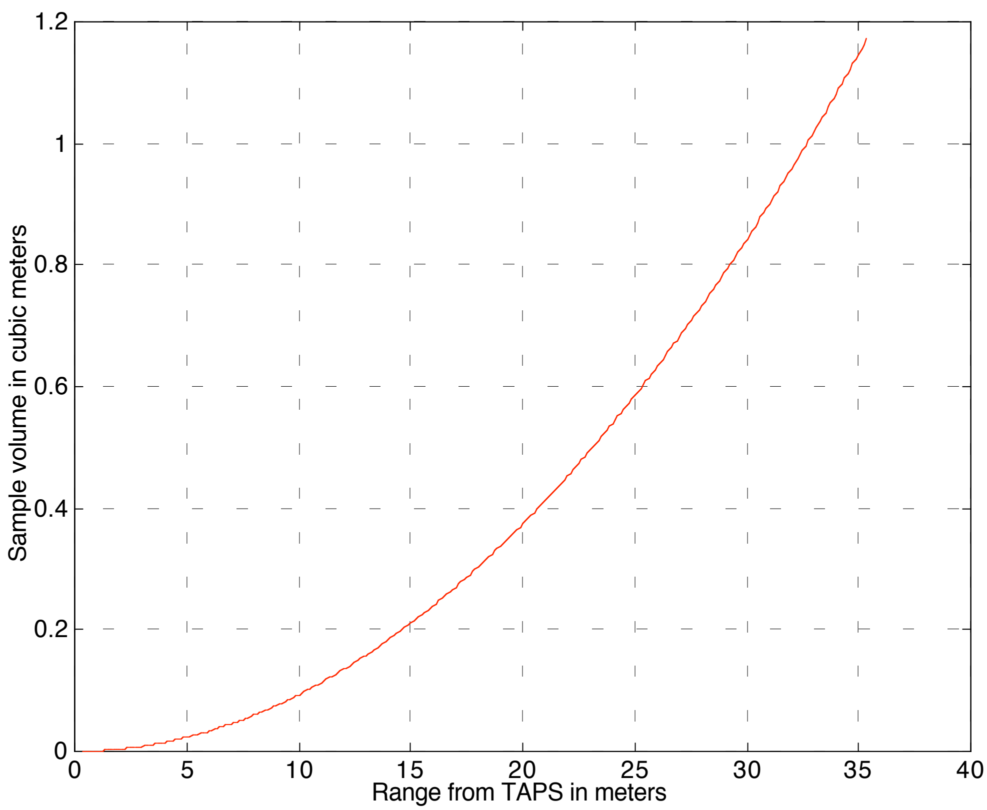

Figure 1. Typical TAPS sample volume versus range. In CAST MODE, the sample volume is approximately 0.002 m^3.

SOUNDER MODE

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.

SOUNDER mode requires that TAPS be connected to an external computer, which does the data recording. This mode is most commonly employed when TAPS is also powered externally and can run for indefinite periods of time, often unattended.

In SOUNDER 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 transcievers; 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 SOUNDER mode is selected as described in the PROGRAMMING chapter. Upon startup, press any key and then answer "Y" to the question, "`PRESS ANY KEY TO CHANGE MODES, K TO EXIT PROGRAM.`" Then select EXTERNAL SOUNDER from the list. The CPU will then load the SOUNDER code from the compact flash RAM.

You must review the pertinent SOUNDER operating parameters before this mode will operate the first time.

First 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 is 256 pings per average.

TAPS then displays the current maximum range and number of range (depth) bins. Enter a new value for the number of depth bins if desired. The new computed value of maximum range will be displayed. Up to 296 bins may be selected, giving a maximun range of 42.6 m. The number of bins, N_b, to achieve a particular range, R, may be computed from

$$N_b = (R-.40) / 0.143.$$

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.

TAPS will start up in SOUNDER mode from now on. 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.

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 oftimes 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.

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.

SOUNDER MODE

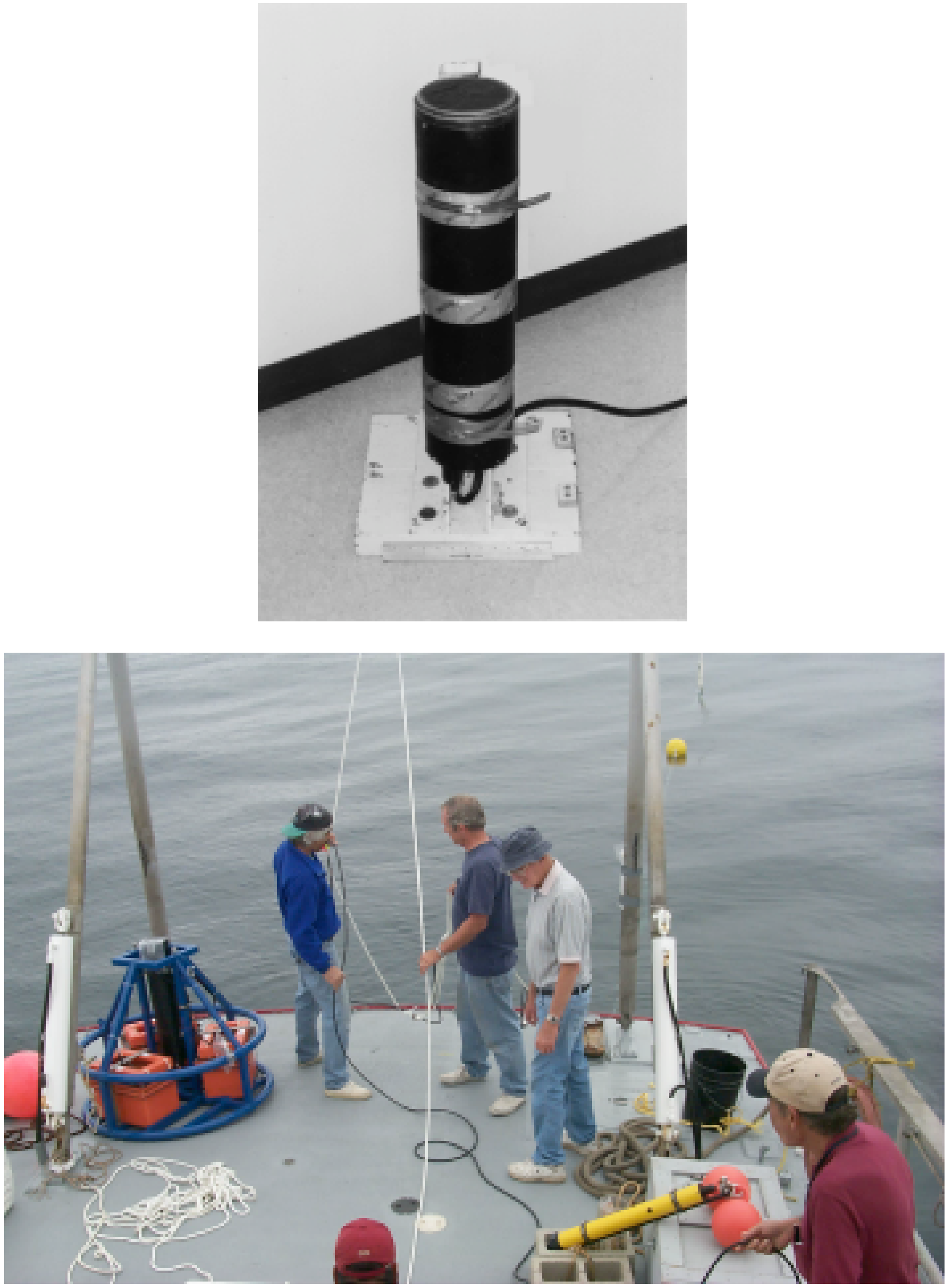

Figure 2. Examples of mounting methods for placing TAPS on the bottom looking up. The upper figure is for a TAPS cabled to shore, the lower picture shows TAPS powered by underwater batteries (in the blue frame) and telemetering data to shore via an RF modem in a spar buoy (leaning up against the A-frame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

SOUNDER MODE

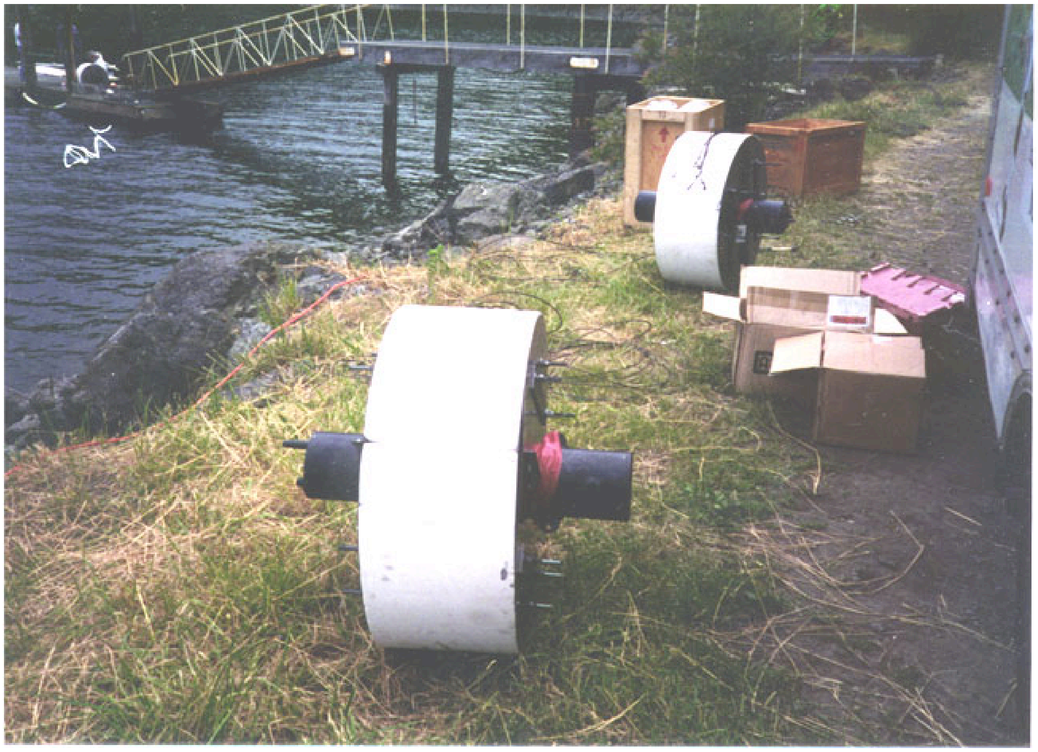

Figure 3. TAPS encased in a foam float for mooring in either up- or down-looking configuration. This photo was taken in 1998 at East Sound, WA where three TAPS were moored at about 12 m depth looking up. A single-point moor was deemed satisfactory for the up-looking application. A similar setup was used 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.

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. The accumulator values are divided by NPINGS in the TAPS code, so this step is already done. Converting these normalized values to volts-squared is then just a matter of a scale factor. The analog-to-digital converter range in TAPS is 0-4.095 volts and the output is an integer in the range 0-16383. Multiplying this number by 4.096/16384 gives the input level in volts, hence multiplying a squared value by $(4.096/16384)^2$ gives volts-squared.

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 (Urick, 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 ($10 \log_{10}$[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 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 high baud rate of TAPS may limit the usable cable lengths. In our work, we have gone almost exclusively to battery-powered moored operations using an RF-telemetry radio to communicate between TAPS and a shore computer. This arrangement allows retention of the 19.2 kbaud data rate.

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, 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.

SOUNDER MODE

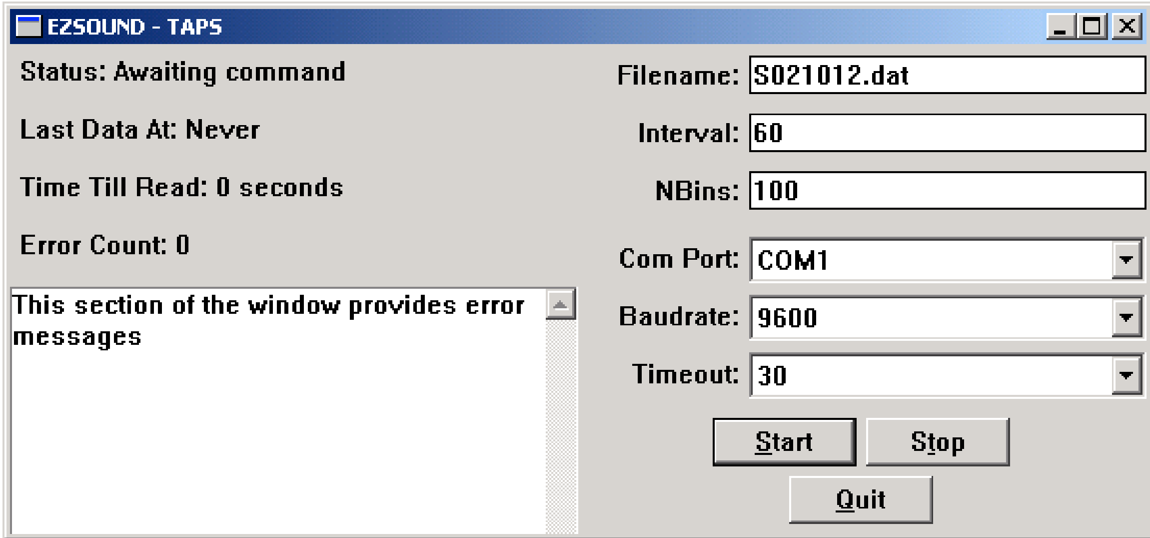

Figure 4. Startup screen for EZSOUND. This screen shows the default TAPS parameters as well as default status displays. In operation, the Status, Last Data, and Time Till Read lines will display current information on program operation. The value for NBins, Com Port, and Baudrate must be set by the user to match those set in TAPS.

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 currrent MONTH, DAY, and HOUR of your PC clock. In the example, the PC clock is set to 12 o'clock on February 10th. The file name is set automatically by the program.

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. Keep in mind that TAPS takes about 20-40 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 12 pings/data set or fewer. It may be necessary to increase this value a bit if more pings/data set are set into TAPS. We commonly use 45 seconds.

This parameter is used to determine if a communication error might have occurred. If the program waits Timeout seconds and still hasn't received an answer from TAPS, it marks an error, puts an error message in the message box, and tries to dump data again. If this second attempt results in an error again, the program logs this error also and starts the RUN/DUMP cycle again. This way, if something happens to restore communications, data flow will resume and you will start saving data again.

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 un-attended 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 todays 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 ez***sound***. 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 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.