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Xsonar/ShowImage: A Complete System for Rapid Sidescan Sonar Processing and Display

by

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Introduction

This sonar processing and display system originated from software supplied by Lamont Doherty Geological Observatory in 1989 that was originally designed for mapping and display of SeaMARC-1A data files on a MASSCOMP 5500 mini-computer system. Graphical display of the data was tied to the MASSCOMP system and therefore was not portable to other computer systems. Since that time, many new features and programs have been added to the software, and the entire set has been ported to the X Window System enabling the software to be compiled on any UNIX based system running X. This is the standard today for all UNIX systems (Silicon Graphics, DEC, Sun, HP being the most prominent) and allows users to process a variety of sonar types (Klein, Datasonics, Edgetech, SeaMARC) on these systems. The data format used by Xsonar/ShowImage is designed so that it is portable between Intel and Motorola based CPU's as well as 16/32/64 bit systems. Xsonar and showimage are two separate programs and as such can be used independantly of the other. However, functions in one program are complemented and enhanced by the other and both are neccesary for the user to carry out the processing scheme.

This document is a users manual for the software and is designed to guide a novice user who has minimal knowledge of sonar processing through the steps neccessary to unravel and display a variety of sonar file formats, ultimately mapping these same files in a rapid fashion. This system is routinely used on board ships by the USGS Marine and Coastal Program Team, Woods Hole, MA to create maps in near real-time of sonar data collected on cruises (Danforth, et. al 1991). This procedure allows making informed decisions with regards to sample sites, mooring locations, interpretation and future study directions while on board the ship.

The user is expected to be familiar with rudimentary UNIX system commands and have a login on a system that is to be used to run the processing software. Also, a starting knowledge of the X Window System and the Motif Window Manager is required (See Montgomery, 1995 and Quercia and O'Reilly, 1990).

Hardware Requirements

Xsonar and ShowImage will compile and run on any UNIX workstation that has the X Window

System, Release 4 or greater installed, as well as the libraries and include files for the Motif Graphical User Interface (GUI). A minimum of 24 megabytes of memory is suggested, and as with any graphics intensive program, the more the better. To facilitate the sonar processing procedure, especially that of high-resolution sonar where large data files are the norm, at least 1 gigabyte of disk storage is recommended. The software expects the workstation to have an 8 bit color display (PseudoColor), although development has been implemented to recognize 8 bit grayscale and 24 bit color display systems. Three mouse buttons are required to use this program and therefore a 3-button mouse is suggested for ease of use. A two button mouse can be used as long as it emulates a 3-button mouse.

Installation

In order to compile and install the Xsonar/ShowImage system, I refer the reader to the distribution archive, available via anonymous ftp at boomer.er.usgs.gov. The software distribution comes in compressed "tar" format which includes the libraries neccessary to run Xsonar and ShowImage as well as a README file that documents how to set up the distribution for compiling the source code. I have included some hints here on where to locate the Xsonar and ShowImage executable files for use by all users. Xsonar and ShowImage application defaults are also very important for correct display of the software, and thus need to be located in a directory accessible by all users of the system.

Startup Directory

Xsonar and ShowImage should be located in a directory that is accessible by everyone. Standard locations include /usr/local/bin and /usr/bin/X11, directories which are generally included in all user's paths. If you are the administrator of your own workstation, be sure to move Xsonar to one of these locations, or to a location that is included in your search path, such as $HOME/bin (csh users). If Xsonar is to run off a central file server, then contact the administrator for that system to install Xsonar and ShowImage.

Application Defaults

In the distribution for Xsonar/ShowImage, two application defaults files are provided entitled Xsonar.ad and ShowImage.ad. The system administrator should move the files to the /usr/lib/X11/app-defaults directory and name them Xsonar and ShowImage, respectively. "/usr/bin/X11/app-defaults" is the default directory for resource files associated with applications written for the X Window system, and is where each application will look for resources upon startup. Alternately, if the system administrator is not available or the user would like to keep the application local to their directory, the resource files can be put in a user's own directory, providing that the XAPPLRESDIR environment variable is set to point to that directory. For example, csh users would use this command: setenv XAPPLRESDIR $HOME/app-defaults. This assumes that the environment variable "HOME" has already been set to point to the user's home directory (on many systems this variable is set by default when logging in to the system). Setting the XAPPLRESDIR environment variable to a particular directory instructs X-based applications to look at that directory first when loading resource files. The “setenv” command should be included in your “.login” file (again, for csh users) for ease of use.

Data Formats

Input

Both Xsonar and ShowImage accept the following data formats for input: QMIPS™, Xsonar, Edgetech, SEGY and Xsonar Raster Maps. Each piece of software will recognize the parameters included in the headers and thus can correctly display and process the data files. Raw raster files containing byte data can also be brought into ShowImage, in which case the user will be prompted for the number of pixels in each row and column within the data file. Appendix B outlines the QMIPS™ format, the standard format used by the USGS Seafloor Mapping Group (Woods Hole) acquiring sidescan sonar data with the ISIS™ data logging system, and Appendix C documents the Xsonar format (see http://www.tritontech.com for details on the ISIS™ system).

Output

Xsonar uses the Xsonar format for all output files except for the final oriented image, which is written out as a raw raster file containing byte data. A processed sonar file can also be saved onto disk in the format utilized by the Woods Hole Image Processing System (WHIPS), (Paskevich, 1992a, 1992b) if the user would like to use the extended capabilities of this system. The processing procedures outlined in the Xsonar section of this manual produce new data files with extensions as follows:

Procedure:	*File suffix added:*
Slant Range	s
Destripe	d
Beam Angle Correction	b
Linear Stretch	l
Histogram Equalization	e

For example, if a demultiplexed data file named "l1f1." had the Slant Range, Destriping, Beam Angle and Linear Stretch functions applied to it (in the order stated), the resulting data file would be "l1f1.sdbl". The file from the previous processing stage is always saved in case the user needs to reuse it, for instance in the case of a linear stretch being applied to a beam corrected file where the linear stretch wasn't appropriate and new parameters need to be applied by the user. The beam corrected file is still on disk and a new stretch can be applied. **WARNING: Data files will be overwritten during any of the processing stages if a file with the same suffix already exists.** In the Xsonar processing system, data file extensions always indicate the order in which the processing functions were applied to the file. Using the previous example, if the processing order had been to apply the slant range correction, a histogram equalization, and finally a beam pattern correction, the output file would be named "l1f1.seb".

ShowImage will save selected areas of an input image, and these saved "snapshots" are named by the user in a pop up file dialog. See the ShowImage documentation for details.

User Interface Conventions

Xsonar/ShowImage conforms to the Motif graphical interface conventions as closely as possible. The reader is referred to the X Window System Users Guide (Motif edition) (Quercia and O'Reilly, 1990) if unfamiliar with the X Window System using the Motif graphical user interface. Each option in the various dialogs associated with Xsonar/ShowImage will be highlighted with a red box as the mouse moves over that particular option. Nothing will be selected until the left mouse button is pushed while over a button, slider, text or radio box.

Quick Start

To start using the Xsonar/ShowImage processing system quickly, without going through this entire manual, refer to Appendix A. The procedures necessary for loading raw data files onto disk (if on magnetic tape) are outlined, in addition to the appropriate steps to use in order to rapidly process and map demultiplexed sonar data files using Xsonar and ShowImage. The steps outlined in Appendix A are more fully discussed in the rest of this document.

Xsonar Processing System

Startup

Xsonar is started by simply typing "xsonar" at the system prompt. At this time there are no options associated with the command. After initializing the screen, the computer will display the main display panel for Xsonar as shown in Fig 1. There are twelve buttons on the display panel, and each has a separate function in the processing of the sidescan sonar data file.

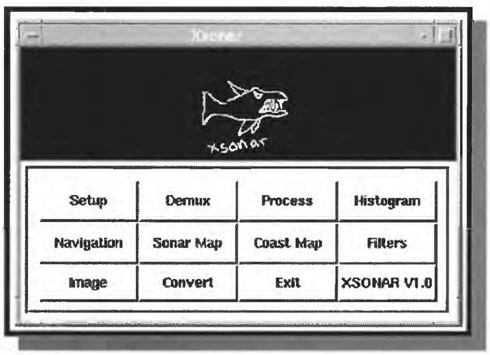

Figure 1. Xsonar initial startup window

When a button on the Xsonar panel is pushed or "activated" by pressing the left mouse button, it will turn a maroon color indicating that it is "armed". Note: If the mouse pointer is moved out of the button area before releasing the mouse button no action will be taken. If the left mouse button is released, the button pressed on the Xsonar panel will be dimmed or "greyed out" and the appropriate processing or setup routine will be called. Each of these buttons, and any routines launched by selecting these buttons, will be discussed in detail in the following sections. Warning messages are posted if a button is selected that requires more information than has been entered by the operator, such as a file name, for example.

Sidescan Sonar Image Processing Procedures

Overview

Processing of the raw sonar file to a point where a meaningful display or sonar map can be generated requires running the raw sonar file through a series of functions which are designed to reformat the data file into the Xsonar format and then geometrically correct and radiometrically enhance the sonar data. Each of these procedures are covered in this section of the manual. In addtion to outlining the basic premise behind each function, each section will indicate which setup parameters need to be entered and where in order to accomplish the function's designated task. After any of the processing tasks are completed, the resulting modification to the data file can be viewed in the ShowImage program described in the second half of this document. Briefly, the reformatting and processing procedure, from start to finished map, involves the following procedures (in the order stated):

A. Data input and reformatting

1). Select the raw sonar data file from disk or read it onto disk from tape (Appendix A).

2). Demultiplex (or "demux") the data file.

3). Check and correct altitude telemetry (critical for proper slant range to ground range correction).

4). Check and merge the ASCII navigation output from the demux stage back into the data file.

B. Geometric and Radiometric corrections

5). Perform the water column removal and slant range to ground range correction.

6). Destripe the data file.

7). Apply a beam angle (or "shading") correction to the data.

8). Contrast enhance the data via a linear stretch or histogram equalization.

C. Mapping and Printing

9). Map the data file in a Universal Transverse Mercator (UTM) projection.

10). Print the mapped data file or export it to another mosaicking program.

The next sections narrate this procedure using Xsonar, but any of the functions outlined above can be run independantly of each other if the user so desires. Setting the appropriate parameters in the setup menu and selecting the individual processing function is outlined in detail in the following sections.

Setup

Selecting initial operating parameters for processing the sidescan sonar data is the next step the operator must take. This is accomplished by clicking the Setup button on the main Xsonar display

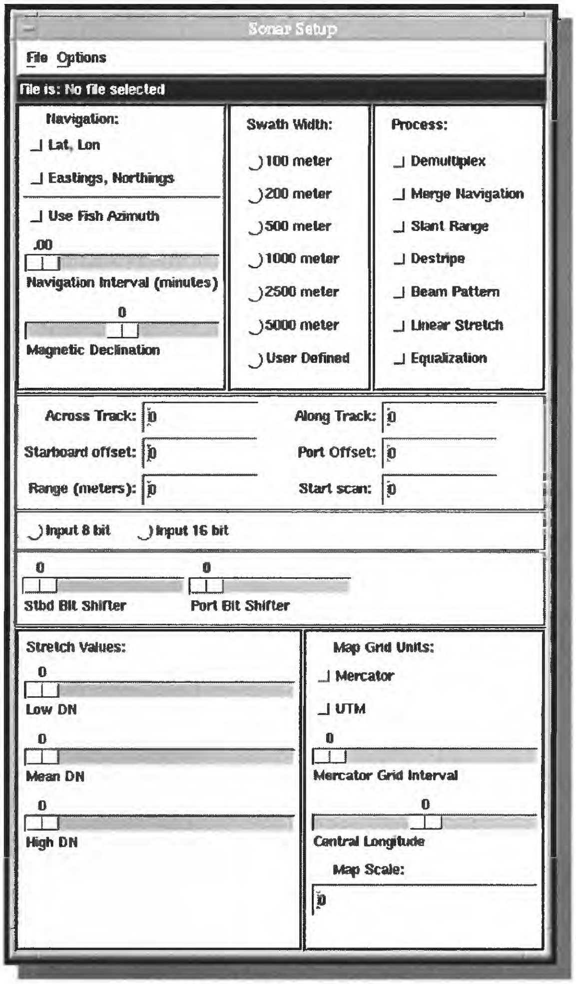

Figure 2. Setup Window

panel with the left mouse button. Notice that the Setup button will become "grayed" out on the main Xsonar window, and the Setup window (Fig 2) will appear in the upper left corner of the user's screen. The Setup display is divided into discrete areas that include options for entering the navigation parameters, sonar swath width, processing steps, demultiplexing parameters, contrast enhancement and mapping. The following sections discuss all of the steps used to process a sidescan sonar data file into a form that is ready to be mapped. Each processing procedure utilizes the Setup menu to turn on or set various options associated with that procedure, for this reason the entire Setup window will not be discussed here. The reader is referred a specific processing procedure for details on which Setup parameters need to be set for that particular procedure to run correctly.

File Selection

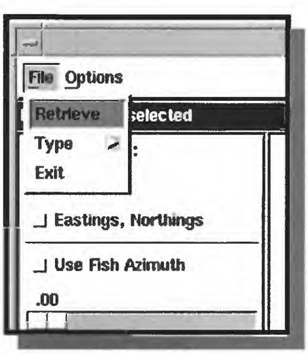

Figure 3.

File selection must be performed before any other routines can be run. This lets the program know which file will be used in the processing scheme. File selection is accomplished by selecting the File menu button located at the top of the Setup window. Pull down to and select the Retrieve option (Fig 3). This will bring up a file dialog from which the desired file can be selected. Next the file type needs to be selected by using the File menu button (Fig 3). Xsonar will accept the following raw sonar data formats: QMIPS™, Edgetech and SEG-Y. After selecting the file to use, the full path name of the file will be displayed in the Setup window right under the file selection menu. From here, other setup parameters relating to the various stages of sonar processing can be selected.

Demultiplexing

Xsonar reformats QMIPS™, Edgetech (formerly EGG) and SEG-Y data formats into an internal Xsonar format used throughout the processing procedure, a process referred to as "demultiplexing" or "demuxing" the data file. The reader is directed to **Appendix C** for details on the Xsonar format. **Appendix C** is also provided for programmers wishing to edit this format in order to accommodate new or edit existing data fields. Demultiplexing the raw data is the first processing procedure that must be applied to the data file before any further processing can be accomplished. The resulting output data file will be named according to what was typed in by the operator during data collection for QMIPS™ files with the exception that the filename suffix is removed. For example, if the operator saved the file during collection as "11f1.dat", the output demuxed data file will be named "11f1." and its associated ASCII navigation file named "11f1.nav". For Edgetech as well as SEG-Y files, the output file name will correspond with what the file was called on disk, i.e., if the data file is called sonar1.dat on disk, the output demuxed file would be "sonar1." and the nav file "sonar1.nav".

In order to demux a file, setup parameters need to be selected within several areas of the Setup window. These parameters are discussed in detail in the following sections. If a particular parameter is not selected prior to demuxing, Xsonar will pop up a warning dialog letting you know which parameter needs to be filled in. Essentially, demuxing a file accompishes several items:

- A median filter is applied to the data which eliminates noise and reduces the file to a more manageable size (if desired).
- An ASCII navigation file is written out that can be used to edit bad navigational fixes before remerging the navigation back into the data file.
- The data is reformatted into the Xsonar format. Documented below are the Setup parameters

neccessary for successfully running the demuxing process. After setting all the neccessary parameters for demuxing the data, select the Demux button in the main Setup window Processing section and depress the Demux button on the main display.

Navigation Format

The portion of the Setup window labeled "Navigation" allows the user to select the navigation recording format used during the collection of the sonar file, as well as options for instructing Xsonar how to merge navigation into the processed sonar file. There are two options for choosing the recorded navigation format by selecting the appropriate radio button: Latitude-Longitude or Eastings-Northings (Fig 4). The USGS records navigation directly into the QMIPS™ file from the navigation computers as latitude-longitude pairs, thus the radio button for latitude-longitude would be selected for demuxing USGS files recorded on a QMIPS™ system. However, some surveys may require that navigation be logged as State Plane Coordinates or Universal Transverse Mercator (UTM) values. By selecting the eastings-northings radio button, Xsonar would know to process the navigation from the selected QMIPS™ file as x-y pairs. Check the data logbook for how the navigation was stored in the collected data file as this information is not contained in the QMIPS™, Edgetech or SEG-Y header records.

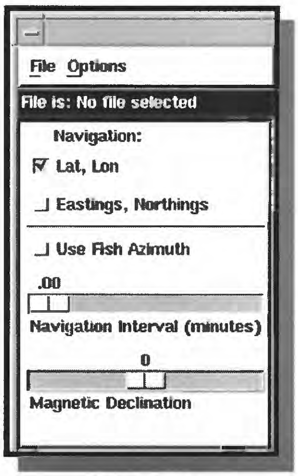

Figure 4.

Navigation Interval

The demuxing process writes out an ASCII navigation file for use in remerging the navigation back into the sonar file and requires an interval period to use when outputing the ASCII data. This is accomplished by using the slider bar labelled "Navigation Interval" (Fig 4). For example, if the slider bar was positioned at "2", each time a multiple of 2 minutes was encountered in the QMIPS™ header, that fix would be written out to the ASCII file (See Appendix D for an example of the format). ***Note:*** The interval period chosen will control how the data file is mapped. See the section entitled "Merging Navigation for furthur details on chosing the proper interval. For standard USGS processing of high resolution sidescan sonar data an interval of 2 minutes is chosen and is a good value to start with if unsure of the interval to chose. The file name for the navigation file is generated automatically during the demux process by appending the string "nav" to the end of the selected file name.

Fish Azimuth

If the sonar towfish had a compass installed, and the readings from the compass were saved by the data logging system, this information can be used during the navigation merge procedure. By selecting the "Use Fish Azimuth" radio button (Fig 4), the demux procedure will retrieve the recorded fish azimuth from the data header and store it in the Xsonar output sonar file. This parameter is important to the navigation merging procedure, discussed in the "Navigation" section of this manual. If towfish heading information is available, it is advised to select this button and retrieve the recorded towfish azimuth in order to properly orient each ping when mapping the data file. The towfish will under certain conditions will "crab" through the water depending on currents and tides. If the towfish azimuth is not used during the mapping procedure, inproper placement of each sonar ping will result in an inaccurate final map. **Important:** See the section on "Magnetic Declination" if the recorded towfish azimuth is to be used.

Magnetic Declination

Since towfish compasses record the direction of magnetic north, a correction needs to be applied to the recorded towfish azimuth reading in order to obtain a heading based on true north (unless the data logging system accounts for this). The slider labeled "Magnetic Declination" (Fig 4) allows entering the offset for a particular area which the demux process will use to adjust the recorded towfish azimuth so that the towfish heading is based on true, not magnetic north. The appropriate value can be obtained from any standard NOAA nautical chart for the area of interest.

Swath Width

Total swath coverage (the sum of the port and starboard ranges) of the vehicle (in meters) must be selected before demuxing the field data file by using the appropriate radio button in the setup menu under the heading "Swath Width". Consult the field log book for the recorded swath width that was used during data collection. Commonly used swath widths are listed next to the radio buttons, however the button at the bottom of the choices, labeled "User defined", can be selected to enter a custom swath width. When this button is selected, a pop-up window appears into which an appropriate swath width can be entered. Pressing the "OK" button after entering the correct value for the sonar swath in the text portion of the pop up dialog closes the window. **NOTE:** If the range option is used during the demux process, the resulting swath width will be less than the recorded swath. See the Range option later in this section.

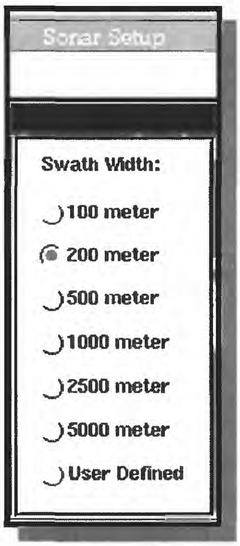

Figure 5

Across- and Along-track Filtering

Setting these two options, located in the middle of the Setup window (Fig 6), help to reduce the size of the field file, generate an approximately "square" pixel and reduce the amount of speckle and striping noise that may be present in the record. Entering a number in each of the two boxes creates a "boxcar" that is across-track by along-track elements. For example, if "4" were entered for the across track value, and "3" were entered for the along-track value, a 12 pixel boxcar would be passed over the original file and for each 12 pixels, one pixel would be output that represents the median value of that boxcar. A standard median filter such as this I find is the best method to reduce noise in a data file while at the same time being a rapid filtering algorithm. A square pixel can be generated by calculating the along track pixel resolution (based on the ship's

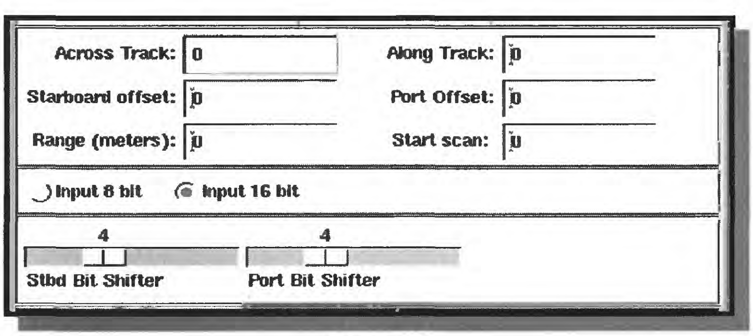

Figure 6

speed and ping rate) as well as the across track pixel resolution (# of pixels / swath width), and then setting the along- and across-track options to the appropriate values. **NOTE: If desired, all the data elements can be preserved and passed along to the output file by entering a value of "1" in the along and across track text windows.**

Port and Starboard Data Offset

This option allows an offset (in bytes) into the data record to be set and is useful if more than two channels of data are recorded in the field. For example, say a data record consisted of 4 data channels, 2 port and 2 starboard each 1024 bytes in length. You may only want port channel 2 and starboard channel 4, thus the port and starboard offset values would be set to 1024 (Fig 6), indicating that the demuxing process should begin processing data after skipping 1024 bytes for both port and starboard. Use of this option requires that the user be familiar with the location and size of data fields within each sonar record as recorded in the field. Dual frequency towfish (100/500 kHz), such as those manufactured by Klein and Edgetech, typically record 4 channels of data. This option is useful for utilizing the 500 kHz channels which contain very high resolution data records.

Sonar Range

Typing in a particular range (a value less than 1/2 the total swath width) allows selection of the number of meters of data to process as measured from the nadir for both the port and starboard channels. This option is useful if data in the far field is particulary noisy or non-existent. For example, if Klein data were collected at a swath width of 200 meters (a range of 100 meters per side), and the last 25 meters on each channel were noisy, then the range option could be set to 75 (meters) (Fig 6), in which case only 75 meters of data on each side of the nadir line would be processed. **NOTE: If this option is used, the total swath for the processed file will be the range multiplied by 2 (channels).**

Start Scan

Data demuxing begins with the first scan in a sonar data file by default, however a scan number to start the demuxing process with can be set using this option (Fig 6). This is useful if portions of the file at the beginning contain sub-standard data or if the file recorded the lowering of the towfish (usually these data are non-useable).

8/16 Bit Data Selection

Data collected by the USGS QMIPS™ system is stored as either 8 or 16 bit values, depending on what the operator selected in the field. Data processed as 8 bit numbers have values between 0 and 255, whereas 16 bit data have vaues between 0 and 4096. Some newer sonar systems have greater dynamic range and are recorded as 16 bit numbers (values from 0 to 32767) to preserve as much of the signal content as possible. If the field data is 8 bit, select the 8 bit radio button (Fig 6). If data was recorded as 16 bit numbers, select the 16 bit radio button. One of these must be selected for the demux process to proceed. Again, consult the survey logbook for how the data was recorded. Data recorded using the QMIPS™ system can be either 8 or 16 bit, while data recorded using the Edgetech systems is always 16 bit. **NOTE:** If the data is 16 bit, utilize the 16 bit shift sliders located below the 8/16 bit radio buttons to select an optimal 8 bit range to use within the 16 bit data field. After demuxing, the data record is always 8 bit.

16 Bit Data Sliders

The port and starboard sliders in this portion of the Setup window (Fig 6) enable selection of an 8 bit window within each 16 bit sonar data value to use as an output pixel value. In this way only the 8 bit range within the 16 bit data range (for each pixel) is selected that contains the best sonar signal, as Xsonar only processes 8 bit data. Analog to digital (A/D) converters installed in most systems today are 12 bit converters indicating that data values range between 0 and 4095 (unsigned, a unipolar signal). These values are saved as 16 bit numbers. However, 8 bit numbers in sonar processing are represented by unsigned numbers that range from 0 to 255, so the 16 bit value must be converted to 8 bits before further processing is accomplished. Conversion can either be accomplished by normalization, in which case the entire 16 bit range is normalized to 8 bits (including noise), by using various statistical down-sample schemes, or by sliding an 8 bit data window over the sixteen bit value. Xsonar uses the sliding 8 bit range since (from the author's experience) noise in the low or high ranges of the data can be effectively eliminated in this fashion. This method is also very rapid. To illustrate this, say one pixel of recorded data has a value of 2047 and has been stored as a 16 bit number. Graphically it would be represented in memory like this:

```
                 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1  (binary) = 2047 (decimal)
bit number:      15            7             0
```

By default, when a sixteen bit number is converted to an 8 bit value by Xsonar, the computer uses bits 0 through 7 to come up with a new number (Xsonar typecasts the 16 bit data value to an unsigned char). So, converting the above example directly (using a slider value of 0, the default) would result in an 8 bit data value of 255. These are the "lower order" bits in the 16 bit number, and will likely contain noise. To avoid this, you may want to set the sliders to "3" or "4". If the bit slider was set to "4", all the bits would shift right 4 positions, resulting in a 16 bit value of:

0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 (binay) = 128 (decimal)

As you can see, the rightmost 4 bits were eliminated, and the resulting lower eight bits are used to form an 8 bit number. The sliders have a maximum value of 12 as most analog to digital converter boards available today have a 12 bit output data range, as described earlier. The raw data files can be viewed using the ShowImage display system which has the sixteen bit sliders as well. This is useful to interactively experiment with the data sliders before deciding on an appropriate value to use. A value of 4 is usually a good value to start with and then adjusted from there. A good rule of thumb is to preserve as much of the true sonar signal as possible while at the same time reducing the noise in the saved signal by experimenting with the bit shift sliders. **NOTE: Once an appropriate bit shift has been decided upon, these values for port and starboard should be recorded and used for all subsequent demuxing of data files collected during a particular survey.** Different values may need to be determined for different surveys run over the same area as different environmental and system variables, even if using the same sonar system, can affect the recorded sonar data range.

Starting the demux process

After all of the demultiplexing parameters discussed earlier have been selected, the procedure is started by first clicking on the checkbox next to the "Demultiplex" button within the Process portion of the Setup window (Fig 7) and then pressing the "Demux" button located on the main Xsonar display window. After doing so, a dialog window will pop up show the progress of Xsonar as it demultiplexes the raw data file. Once completed, a file dialog window will pop up showing the final output resolution for each pixel in the across track dimension.

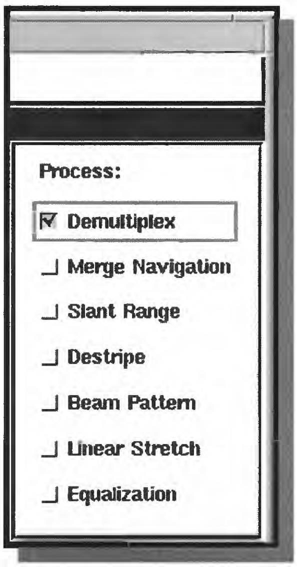

Figure 7

Merging Navigation

After the demux process is completed, or if you have a file that is already in the Xsonar format, you need to merge the navigation fixes back into the data file in order for each ping to have a unique geographic position. For example, 7.5 pings per second are collected using a Klein sonar towfish at a swath width of 200 meters. Unless navigation information is sent to the data collection system at that rate, a number of scans in the recorded data file will have the same geographic point and the mapping routines in Xsonar will not be able to place each pixel in the sonar file in its proper geographic position. To properly merge navigation into the sonar data file, select the proper parameters for the navigation merge, view and edit the ASCII associated ASCII navigation file, decide if a towfish layback correction is required, then proceed to merge the navigation. Each of these steps are discussed in detail below.

Parameters

Merging navigation requires setting the proper navigation format in the Setup window, and if using the fish azimuth option from the Setup window, setting the proper magnetic declination for the map area where the data was recorded. Parameter setup for the above two variables were covered earlier. See the appropriate section under the Demultiplexing heading on pages 10-11. The proper central longitude for the area being mapped needs to be selected as well. To do so, bring up the Setup window if it is not already popped up, and go to the lower right corner of the window where a slider bar entitled Central Longitude (Fig 8) can be found. Slide the bar to the appropriate value for the area. If unsure of the central longitude for the UTM zone being mapped, set the slider to a value of zero and then merge the navigation, in which case a window will pop up informing the user as to the central longitude being used based on the navigation being merged. **NOTE: Selection of the correct central longitude is critical for mapping the data file as the UTM coordinates assigned to the data file WILL vary according to which zone (i.e., central longitude) your working in. ALSO NOTE: This procedure uses the WGS-84 ellipsoid by default. If another ellipsoid is desired, see the section on ellipsoid selection under the Sonar Mapping Procedures.** Next the ASCII navigation file produced by the demultiplexing process has to be viewed and edited to determine if any bad navigation fixes are present which could adversely affect the navigation merging procedure.

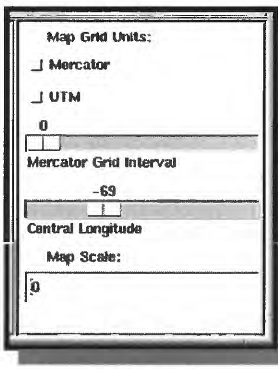

Figure 8

ASCII Nav File Viewing and Editing

To view the ASCII navigation file associated with a Xsonar file, first select a data file in the Setup window (See File Selection on page 8 if unsure of how to do this). If a file is already selected, the name will appear in the label window under the Menu Bar at the top of the Setup window. Next depress the Navigation button on the main Xsonar display panel (Fig 1). This will pop up a large window containing a menu bar and a black drawing area. Select the File menu item and go down to the ASCII File button and release (Fig 9). The ASCII nav file will be displayed as a line of data points corresponding to each entry in the ASCII file on an X-Y grid (latitude-longitude or easting northing depending on the saved navigation format). Spurious points will be apparent and can edited

Figure 9

using any text editor you choose (the most common editor is VI, available on any UNIX system); either delete the entire line which contains a bad fix or adjust the latitude-longitude or easting-northing pairs to the appropriate values. Once the bad points are edited and the ASCII file saved, review the file by repeating the procedure outlined above. The line of points should correspond to the expected navigation track. Additionally, if any latitude or longitude points in one line are duplicated in the next line, a text window (Fig 10) will pop up with the duplicate points marked for deletion. To erase these lines, depress the OK button in the text window, otherwise Cancel. Sometimes duplicate points should be saved, for instance when running straight north-south or east-west lines.

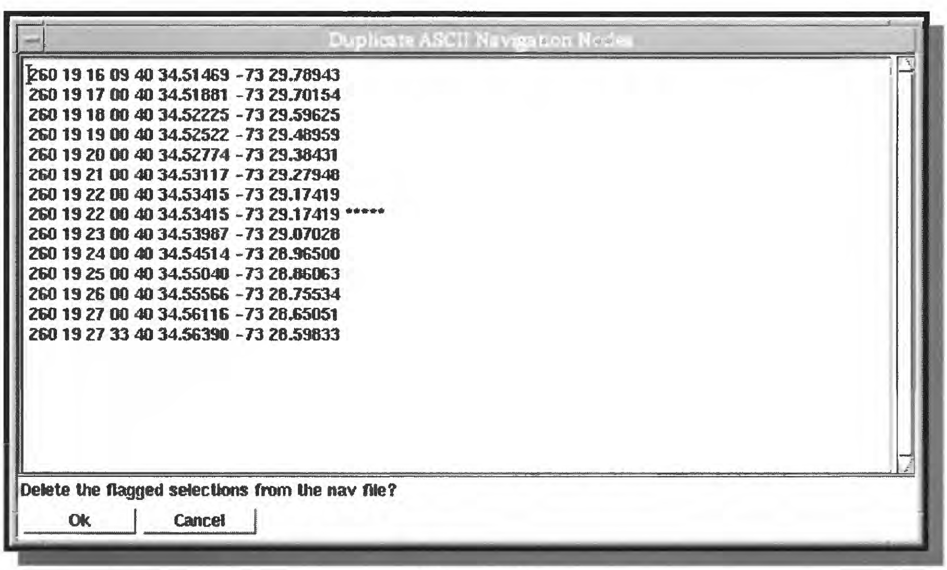

Figure 10

NOTE: Sometimes spurious nav points are produced by bad time fixes in the file or by a west longitude value not being preceded by a minus ("-"). In this case the viewed navigation file will contain a cluster of points in one spot and a lone point offset away from the data cluster. Carefully peruse the ASCII file and eliminate the offending fixes. For example, check to see that the latitude and longitude values are increasing or decreasing as expected. Sometimes a GPS time reset or navigation error will produce this effect. Once the ASCII file has been edited and viewed satisfactorily, make sure the navigation file is saved and determine if towfish layback corrections are needed, as discussed below.

Towfish Layback

If the range to the fish from the GPS antenna is known or was recorded with the data file, this can be used when merging the navigation to get a "fish position" rather than using the position of the ship. This is important if the survey was conducted in deeper water and the towfish was some distance behind the ship, since backscatter features representing geological structures will be offset from line to line. If the layback or offset to the towfish is known, this distortion can be corrected by using this option. Pop up the Navigation window from the main Xsonar display panel if it is not already up. Select the Options button from the main Navigation window menu bar (Fig 9) and go down to and select the Layback button. A window will pop up containing text windows into which the fish depth and layback can be entered (Fig 11). Both values are needed as the program uses the Pythagorean Theorem to calculate the horizontal distance to the towfish. If the two data parameters were recorded during data collection, depress the radio button entitled Read from Header. Otherwise, enter starting values for the depth and layback in the two text windows, press the Enter Values radio button and then press Apply to start the procedure. These values should have been recorded during data collection, but if not, these values can be experimentally adjusted so that geologic features from line to line match up properly. Next, select the OK button and an editable text window will be popped up (similar to Fig. 10) containing the data from the ASCII navigation file with two new fields added at the end of every line: depth and layback. Edit these values if needed and then depress the Apply button at the bottom of the text window. This will create a new file with the suffix "nav.orig", a copy of the original ASCII navigation file, and re-calculate the towfish position based on the entered depth and layback values to create a new ".nav" file. For example, if the data file was named "11f1.sdbl" and its associated nav file "11f1.nav", the original navigation will be saved in a file called "11f1.nav.orig" and the new navigation will be saved

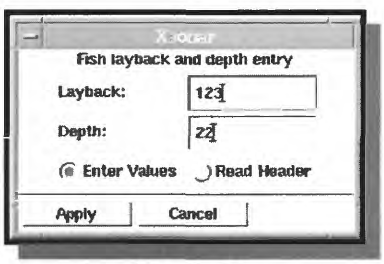

Figure 11

in a file entitled "11f1.nav". The navigation file is now ready to be merged into the sonar data file. If the calculated positions prove to be inadequate or incorrect, simply rename the "11f1.nav.orig" ASCII file back to "11f1.nav" and restart the layback procedure. **NOTE: Failure to rename the original ASCII file if restarting the layback procedure will result in the original ASCII navigation being lost. The only way to recreate this file is to "re-demux" the raw sonar data file.**

Sonar Map Coverage Viewing

Viewing the map coverage of a data file also helps to catch any bad fixes missed when editing the ASCII navigation file. To view the map coverage, select the File menu bar item and go down to the Sonar Data (Fig 9) button. After a few seconds a UTM grid overlain by Mercator tick marks will be displayed and the sonar swath mapped line by line on screen (Fig 12). Bad navigation fixes will become apparent in one of two ways:

- Xsonar will pop up a warning message that a data range is out of bounds (for instance a zero value in one of the ASCII navigation file data fields)
- "Loops" or circles in the data coverage as the data is being displayed. If either of the above is the case, the ASCII navigation file needs to be re-edited and the bad fix deleted.

Final Merging and Checking

To merge the ASCII navigation file after performing the procedures outlined above, select the Merge Navigation button on the main Setup window and depress the Process button on the main Xsonar display window. A critical step in producing a final map image is to make sure the merged ASCII navigation file has produced the expected results. This can be done by either viewing the ASCII navigation file associated with a data file or by displaying the map coverage of the data file which is based on swath width and the merged navigation. As discussed, the ASCII file is viewed first, then edited and merged, after which the result can be viewed by looking at the map coverage of the data file. Viewing of the ASCII navigation file or the map coverage can be done at any stage of the processing provided that the selected Xsonar format data file has had the ASCII navigation

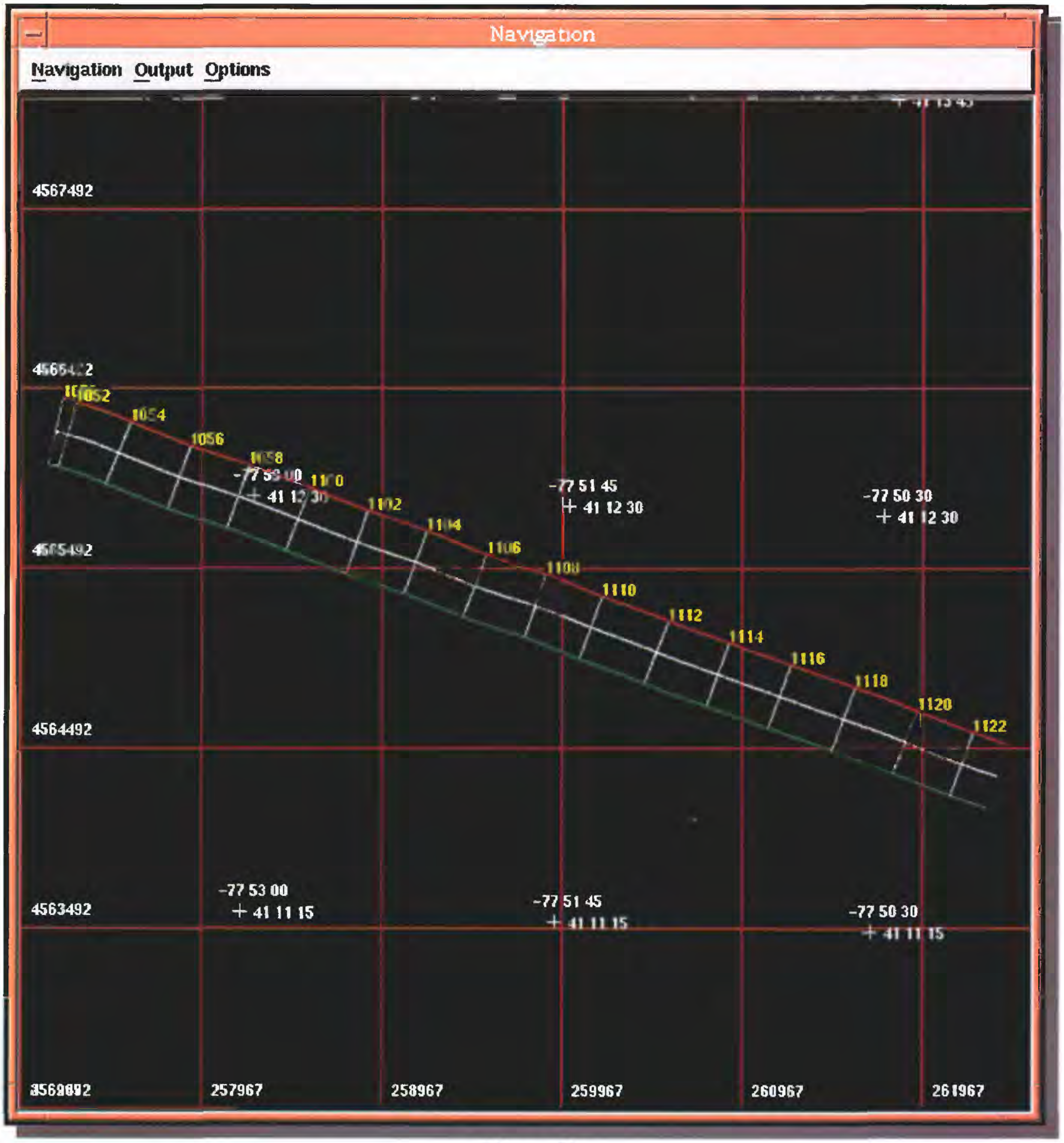

Figure 12

merged into it. If you are merging navigation with a sonar data file that is in the Xsonar format but lacking an ASCII navigation file, a new navigation file can be created by using your favorite editor and saving the result as a text file following the file format described in **Appendix D**.

Geometric Corrections and Radiometric Enhancements

The next few sections outline the corrections and enhancements necessary to produce a fully processed sonar data file. Each the functions (slant range, destriping, beam pattern, linear stretch and histogram equalization) covered in this portion of the manual can be applied in any order and independently of each other. These procedures are listed in the Processing portion of the Setup Window (Fig 13) and have a checkbox next to each. One or more of these procedures can be selected by pressing the checkbox next to the desired procedure, in which case the checkbox will be highlighted showing that the procedure will be applied. Select a highlighted checkbox to subsequently turn off the indicated procedure. All marked procedures in the processing area of the Setup Window will be applied in a top down manner after pressing the Process button in the main Xsonar window.

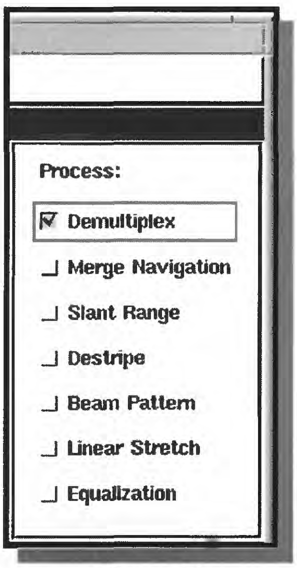

Figure 13

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Slant Range Correction

Correction for slant range distortion is the first geometric correction that is applied to a sonar data file once the file has been demultiplexed. This correction puts each pixel from a sonar ping in its proper across track position as measured from the nadir, and must be performed before any radiometric processing is applied to the sonar file. Xsonar uses the "flat bottom" assumption whereby the true horizontal ground distance of a pixel is calculated using the Pythagorean Theorem. The slant range to a pixel, the hypoteneuse of the triangle, is measured directly from the raw data file. Altitude comprises one side of the triangle, thus from the two measurements, the third side of the triangle, horizontal offset of that pixel, can be calculated. **NOTE: It is essential that the altitude telemetry data is correct for this correction to work properly. Altitude values can be manualy edited using the ShowImage display system described later. See the section entitled Altitude Corrections in the Table of Contents for ShowImage.** Future additions to Xsonar will include using co-registered swath bathymetry (if available) to correctly calculate horizontal offset, however in relatively flat areas, such as inter-canyon shelf regions, the "flat bottom" assumption works acceptably. To perform the slant range to ground range correction, make sure the proper swath width is selected for the current data file (outlined below), press the Slant Range checkbox in the main Setup window (Fig 13) and then press the Process button in the main Xsonar display window.

Selecting the appropriate button for the swath width is the only required option for this portion of the processing procedure. Simply push the appropriate radio button in the Setup up window (Fig 5) that corresponds to the recorded swath width of your data. If this step is performed immediately after demuxing a data file, the swath width entered during the demux stage will be retained and used. If the swath width is unknown for a particular data file, depress the User Selectable swath button in the main Setup window and the swath width will be read from the selected Xsonar format data file.

Destriping

This procedure will take care of any minor striping noise or dropouts (scan lines filled with zeros) present in the data file. Destriping is accomplished by comparing the present scan line with adjacent scan lines in the data file for both port and starboard. The average of the current scan is divided by the average of the next scan and saved as a "delta" value. The average of the previous scan is also divided into the average of the current scan and saved as well. These two "delta" values are averaged together and if the value exceeds 15%, the current scan is considered to be a "bad" scan line; this would be the case if the current scan was a dropout or contained a lot of noise. If the current scan is labeled "bad", then it is replaced by the average of the next and previous scans. This scheme is designed to detect and replace minor striping noise or dropouts, and works *independently on both the port and starboard sides*. If the file has large data gaps or has extreme striping (indicated by noise spanning multiple pings), then more extensive filtering would have to be applied to the data to radiometrically correct the noise.

No options are required for this processing module. Simply press the Destripe checkbox in the main Setup window (Fig 13) and then press the Process button in the main Xsonar window (Fig 1) to use this procedure.

Beam Angle Correction

Data records collected from any sonar system generally have artifacts that are related to the non-linear response of the transducers for that system. This results in areas that may be darker or lighter in the data record as you look in the along track direction. Time varied gains applied by the system attempt to compensate for this, however many times this is inadequate depending on the system and bottom type. For example, Klein files usually have very high backscatter values at nadir unless the operator finely tunes the system prior to launching the towfish. If the data file were to be mapped without correcting for this effect, the result would be a "stripy" data file that would detract from the overall backscatter variations as seen in the mapped image and hinder interpretation.

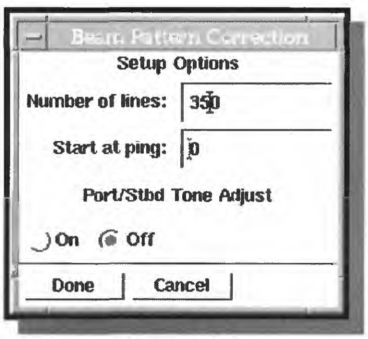

Figure 14

To correct for this effect, first select the Options button in the Setup window and go down to and select the Beam Pattern button. A dialog will pop up that asks for the number of lines to process as well as buttons that allow you to balance the tone of the port and starboard channels, if necessary (Fig 14). The number of lines to process depends on the nature of the data file. As a start, 350 lines is generally a good number to begin with, although this number will vary depending on swath width and data type. For Klein and Edgetech data (high resolution sonar), 350 lines usually gets rid of beam angle effects and produces a data file that is evenly shaded from nadir to the far range. If the port and starboard channels had different gains applied during recording and thus are unbalanced in tone, select the On button from this dialog. This will balance the two channels for a more even record. Choose the Done button after selecting the appropriate parameters, depress the Beam Pattern button in the main Setup window and then press the Process button in the main Xsonar window to apply this radiometric enhancement to the data file.

Histogram Display

Once the data file has been processed through the Beam Angle Correction stage, a histogram display of the data file can be viewed. This will give the user an idea of the parameters to use when

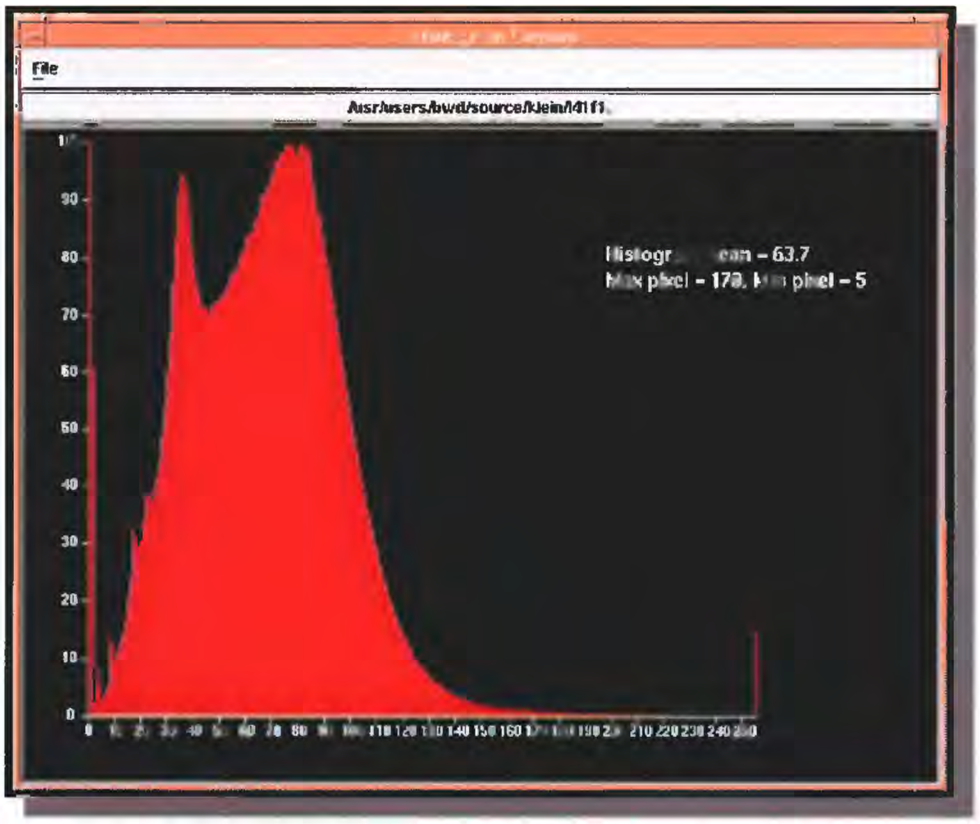

Figure 15

applying a contrast enhancement or "Linear Stretch" as described in the next section. If the user wishes to apply a histogram equalization to the selected file to enhance the data, this step is unneccessary. Depress the Histogram button on the main Xsonar display panel and a new window will pop up containing a black drawing area and a menu bar. The file name will appear in the window just below the menu bar in the this window. To display the histogram for the selected file, press the File button and go down to and select the Show Hist button. A histogram of the file will appear (Fig 15). To pop down this window, select the Close button under the File menu in the Histogram window. See the next section, Linear Stretch, on how to utilize the histogram to radiometrically enhance the data.

Linear Stretch

Depending on the bottom type that the towfish flies over or the gain and TVG settings of the data collection system, the resulting recorded data values may not span the entire 8 bit data range. To enhance variations in the backscatter values (which helps in the interpretation of the data), three slider bars (Low, Mean and High) are available in the main Setup window (Fig 16) which will expand the data values over an 8 bit range (0-255). Data values between the Low and Mean values as set on the corresponding slider bars will be mapped from 0-127, and values between the ones set on the Mean and High slider bars will be mapped from 128-255. The Histogram

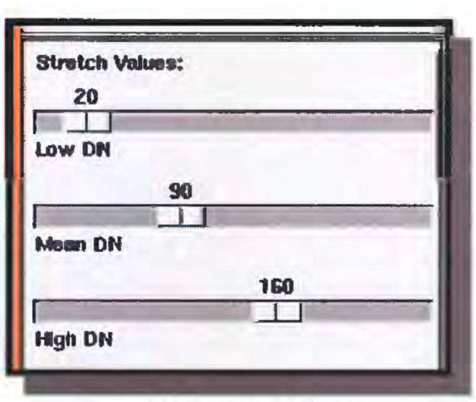

Figure 16

display (Fig 15), as described in the previous topic, gives the user an idea of what values to the slider bars should be set to for optimal enhancement of the data. For example, if the histogram tails off at the low end at a value of 20 (on the X axis of the histogram display) and the mean of the data file is 90, set the Low slider bar to 20 and the Mean slider bar to 90. If the displayed histogram tails off at the high end with a value of 160, set the High slider bar to 160. The above settings will map all values in the data file between 20 and 90 to values between 0 and 127. In addition, all values between 90 and 160 (again, in the selected data file) will be mapped to values between 128 and 255. This will bring out variations in the backscatter data that may not be apparent in the "unstretched" data file. To utilize this radiometric enhancement, select the appropriate values on the slider bars, depress the Linear Stretch checkbox in the Process portion of the Setup window and then press the Process button on the main Xsonar Window. **NOTE: The same stretch parameters should be applied to all data files from a single survey, otherwise the final mosaic will have a patch work quilt appearance. Thus it is worth viewing histograms of several files before selecting the optimum linear stretch parameters for the entire study area.**

Histogram Equalization

An alternate radiometric enhancement can be applied to the selected data file in the form of a histogram equalization. This standard method essentially "flattens" the histogram of the data where each value between 0 and 255 have an equal probability distribution. In doing so, the low and high ends of the histogram become more prominent which is where subtle low and high backscatter variations are seen. To utilize this method of enhancement, press the Equalization checkbox on the Setup window and then press Process on the main Xsonar window. No options are need for this procedure.

Image Enhancement Tools

Rudimentary image processing procedures are included in the Xsonar program. Due to the CPU intensive nature of these tasks, they are not routinely used when data processing and mapping needs to be accomplished in a rapid manner. However, if time permits, the procedures can help to enhance the data files to bring out features of interest. A full discussion of image filtering techniques is beyond the scope of this document and the reader is referred to The Image Processing Handbook (Russ, 1995) for details on the various procedures and how to use them.

Filters

To pop up the filtering dialog, press the Filter button on the main Xsonar display panel. Several radio buttons are available for selecting the desired filter function including: Low pass, Median, High Pass (two types), Edge Detect and Custom (Fig 17). These filters operate on the currently selected file, the name of which appears in the Setup window just below the menu bar. Press the appropriate radio button for the filter to be used. Below the filter selections are two text windows for selecting the size of the filter kernal to be used. Keep in mind that higher kernal values will take much longer to complete and may produce the same results as a smaller filter kernal. Once the filter and kernal sizes have been selected, press the Apply button at the bottom of the dialog to begin the procedure. A progress bar will pop up indicating how far along the filtering procedure is. To cancel at any time, press the Cancel button at the bottom of the Filter dialog. Once the filtering process completes, a new filter can be selected and the process repeated. Otherwise, pop down the filter dialog by pressing the Done button at the bottom of the Filter dialog. The results of the filter can be viewed by using the capabilities of the ShowImage program, dicussed later. All output files are written in the Xsonar file format and have appropriate extensions added indicating what the file contains:

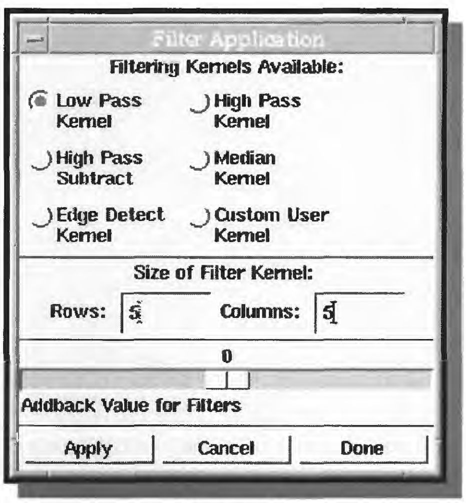

Figure 17

Filter:	*Suffix Added:*
High Pass	.hpf
Low Pass	.lpf
Median	.med

For example, if the selected file name is "11f1.sdb" and a low pass filter is applied to the data file, the resulting output file would be named "11f1.lpf". In this manner a number of filtering procedures can be applied to a single data file. **NOTE: The original data file is always left unchanged.**

Combining Files

Another popular image processing task is combining data files to produce a new file that has the features of both files intertwined. For example, it may be desirable to combine a data file that has had both a low and high pass filter applied to it. This will highlight the high backscatter features present in the data file while subduing some of the random or "speckle" background noise. To pop up this dialog, select the Images button on the main Xsonar display panel (Fig 18). The outlay of this dialog is similiar to the Filter dialog. Several radio buttons are available for the type of combination desired including: And, Or, Not and Average. Each will produce a different result and again, the reader is referred to The Image Processing Handbook (Russ, 1995) for details on the various procedures and how to use them. Below the radio button choices are two slider bars that indicate the amount of each image to use in the combination procedure (0-100%). Move the sliders to the position desired keeping in mind that the two values must add up to 100%. Press the apply button begins the procedure, at which time a file dialog will pop up asking for the name of the file to combine with the currently selected file (as indicated in the Setup dialog). Select a file and click OK, after which a progress monitor will pop up indicating how far along the combination has progressed.

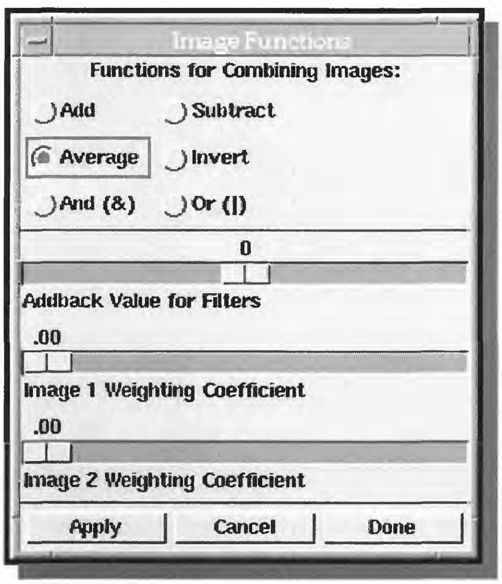

Figure 18

File Conversion

Xsonar will convert files of varying formats to and from the Xsonar format. These formats include: WHIPS (Paskevich, 1992), MIPS (Chaves, 1986) and Xsonar. To convert the currently selected file, press the Convert button on the main Xsonar display panel. This will pop up a dialog containing the input and output choices (Fig 19). Select the appropriate radio buttons and then press the Apply button. As the conversion progresses, a monitor dialog will pop up informing how far the procedure has gotten.

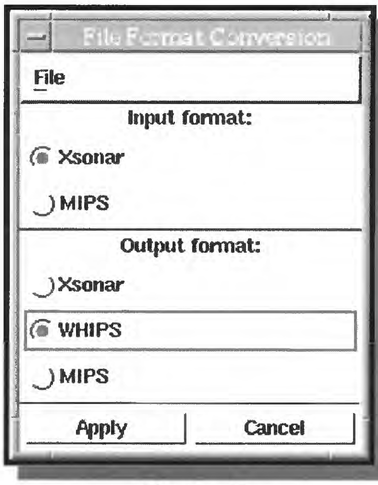

Figure 20

Output files will have different file names depending on the format selected. When creating a WHIPS file, two files are created: 1) A file containing the raster imagery and named with the suffix ".whps" as well as a file containing telemetry information for each ping having the suffix ".hdr". These two files are imported into the WHIPS system by running the mipssonar program (Paskevich, 1992a, 1992b). **NOTE: After the conversion is completed, a window pops up indicating the number of rows and samples, as well as the output pixel size of the converted data file (Fig 20). Write this information down as it is required when importing the data files using the mipssonar program.** For more information on the WHIPS system, connect to the address: http://kai.er.usgs.gov. Converting an Xsonar file to a MIPS file creates one output file with a ".mips" file extension. This file can be imported into the MIPS system on any computer running this software. Converting to and from Xsonar file formats enables exporting and importing Xsonar files to and from computers based on the Motorola and Intel CPU's. If unsure of the computer that originally processed any Xsonar format file, select the file and try to process it. If the format doesn't agree with the byte ordering on the current computer, simply convert it by selecting Xsonar for both the input and output formats. This will create a new Xsonar format file with the extension ".cnv". This file should be renamed with the original file extension so that the ASCII navigation file associated with the data file can be

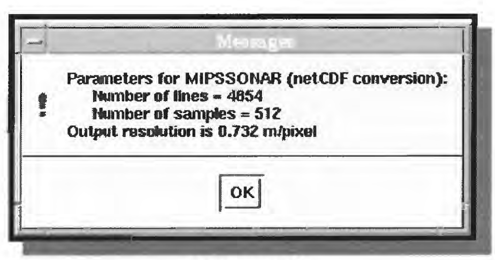

Figure 19

recognized by Xsonar.

Sidescan Sonar Mapping Procedure

After applying the appropriate radiometric and geometric enhancements to the sonar data file, the user is ready to map the data into a UTM grid for final display and printing. Several options are available at this stage depending on what the final map product is designed to be utilized for. Individual sections of the data file can be mapped and printed on either a Raytheon Thermal Display Unit (TDU-850) or an Alden 9315 Thermal Printer if the user wishes to construct a hard copy mosaic using a "cut and paste" procedure. This is handy when a large map needs to be quickly constructed and range offsets to the fish are not known (this will affect the offset of backscatter features from line to line), allowing the mosaicker to "slide" or offset each image to match up with backscatter features in adjacent lines. Alternately, a rough digital mosaic can be constructed using a selectable pixel size where each line is laid down in an existing raster mosaic file. If data already exists in the file where a new line is to be placed, an average value is calculated for each pixel location. Otherwise, the data is placed unaltered in the data file according to its calculated map position. This method is useful when range offsets or "layback" to the towfish have been recorded and utilized so that backscatter features from line to line match up directly and a mosaic can be easily constructed. Otherwise, the mapped sonar files can be saved into individual raster map files and imported into more sophisticated map generation programs such as the EASI/PACE system from PCI. The steps involved in mapping a sonar data file are as follows:

1) Select the appropriate ellipsoid to use when mapping the data.
2) Select the central longitude to use when mapping the data.
3) Display the sonar map coverage.
4) Outline the areas to be mapped:

   TDU-850 or Alden output formats require that the printer format and line spacing be setup and the areas to be mapped outlined before mapping begins. In addition, an output scale and grid marking preferences (UTM and/or Mercator) must be selected. Raster map creation requires that the boundaries of the map area be input and the mapped pixel size be selected.

5) Map the sonar data.

6) Print the final mapped image.

Each of these steps are outlined below.

Ellipsoid Selection

To select the ellipsoid to use when mapping the data file, make sure the navigation window is popped up by depressing the Navigation button on the main Xsonar display window. Under the heading Options, go down to and select the Ellipsoid button. This will pop up a dialog containing two choices for the ellipsoid to use: WGS-84 and Clarke-1866 (Fig 21). Depress the radio button for the ellipsoid you would like to use and pop the dialog down by selecting the Close button. Future releases of the Xsonar/ShowImage system will contain more ellipsoid choices for use in creating the final map product.

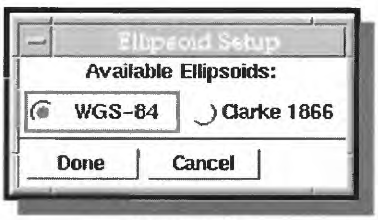

Figure 21

Central Longitude

A central longitude is required in the mapping procedure. If navigation has been merged with the data, the central longitude will have already been selected in the Setup window. If starting with a data file which has been previously processed, select the appropriate central longitude using the Central Longitude slider bar in the Setup window as outlined previously in the section entitled Merging Navigation. If unsure of the central longitude, two methods can be used to select one:

- Re-merge the navigation as outlined in the section entitled Merging Navigation (page 19).
- View the telemetry in the data file using the ShowImage program bringing up the Telemetry window which will show latitude-longitude pairs for various positions in the data file. From this the proper central longitude can be selected for the zone the data points fall in.

Sonar Map Coverage

The first step in the mapping procedure is to display the sonar map coverage of the processed data file. This is done using the steps outlined in the section entitled "Sonar Map Coverage Viewing" under the heading "Merging Navigation" in the table of contents. This step is neccessary for the creation of map files if using the Alden or TDU-850 output options. **NOTE: It is not neccesary to do this for the creation of a raster map.** Map boundaries for the raster map area are entered by the user. This method is outlined later in this section under the heading entitled Raster Map Output.

Map Area Selection

Selecting the map area is the next step in the mapping procedure and involves several steps depending on the desired output format. See the appropriate section below for each output type.

TDU-850 and Alden Output Format

If the user wishes to map individual sections of the data file and output the mapped image to either a TDU-850 or an Alden printer, the output type and printer line spacing all need to be set. To select the output type, make sure the Navigation window is popped up by pressing the Navigation button on the main Xsonar display panel. Select the Output button on the menu bar and go down to and select the Type button. This will cascade several choices to use: TDU-850, Alden or Raster Map. Select either the TDU-850 or Alden buttons.

Printer Setup

Select the Options button from the Navigation Window menu bar and go down to Printer Setup. This will pop up a dialog containing a text window for entering the number of lines per inch the printer is to display as well as two radio buttons for the preference on how to display "hard" or high backscatter values on the output image: Black or white. Select the appropriate button for the hard return (white by default) and enter the number of lines per inch the printer will output. This selection is variable depending on the

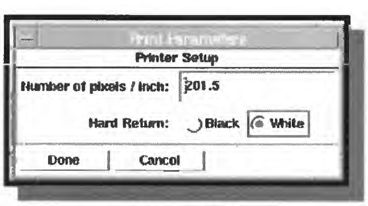

Figure 22

printer drum speed. For the Raytheon printer, it is close to the usual 200 pixels per inch resolution most printers have. The default in the text window is set to 201.5 and works well for most TDU-850 printers. The Alden is a bit slower and a good starting point to enter into the text window is 187 (pixels per inch). The key here is that the output UTM grid be square. Each UTM grid cell is 1 inch by 1 inch so a quick check can be made by measuring the cell after printing the mapped image. Adjust the printer line spacing as neccessary to obtain the 1 inch by 1 inch dimensions. **NOTE: Setting the printer spacing so that 1 inch square grids are printed is essential to make sure the output image has the proper scale as entered in the main Setup window. If this is not done, no guarantees are made as to the final scale of the output image.**

Map Scale

A map scale must be selected to create an image using the Alden or TDU-850 output formats. To do so, pop up the Setup window by pressing the Setup button on the main Xsonar display panel. In the lower right corner of the window is a text window for entering the desired scale (Fig 23). This scale is based upon the usual RF factor of 1:X where X is the scale to be entered. For example, to map the images a scale of 1:20000, enter 20000 in the Map Scale text window.

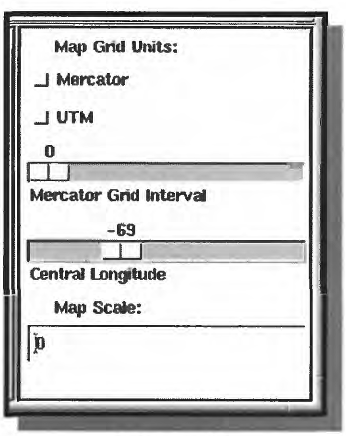

Figure 23

Grid Lines

To annotate the printed TDU-850 or Alden images with UTM and/or Mercator grid marks, depress the appropriate button in the lower right corner of the Setup window under the heading Map Grid Units (Fig 23). Depending on the selection made, a UTM grid will be overlain on the output image as well as Mercator tick marks, if desired. Both types of annotation can be placed on the output image simultaneously. The spacing of the Mercator grid marks depends on the scale of the output image in addition to the Mercator interval selected. Selection of the Mercator tick spacing is accomplished by using the slider bar in the lower right hand portion of the Setup window (Fig 23) entitled Mercator Grid Spacing. The number selected and therefore the tick spacing depends on the output scale, as mentioned. For example, if a scale of 1:5000 was selected, and a Mercator interval of 6 was set on the slider bar, each Mercator tick mark would be spaced at an interval of 6 seconds. Conversely, if a scale of 1:50000 (a larger map area) were selected then each Mercator tick mark would be placed at an interval of 6 minutes. The UTM grid interval is based on 1 inch square markings which correspond to grid squares printed on mylar used to map the final output images. Spacing between grid lines is determined by the output scale and is printed in meters according to the UTM standard.

Map Area Outling and Construction

After viewing the sonar map coverage and selecting the appropriate map parameters, the areas to be mapped need to be selected in the Navigation window. To do so, go to the Options button on the Navigation window menu bar and pull down to the Outline Image button. After releasing this button, the cursor will change shape and be "trapped" in the Navigation window. As both the TDU-850 and the Alden printer can only print a limited number of pixels across the print head, several map images will need to be created for an individual data file. Click and hold the left mouse button and a "map window" will be outlined on the screen (Fig 24). Depending on the output type selected (the TDU will print images that are 1728 pixels wide, the Alden 2048) and the map scale, different size boxes will be drawn. Drag the outlined map window to the desired area of the displayed data file and release the left mouse button. **NOTE: If the outlined area is mistakenly placed in the wrong area, click the right mouse button, go back to the Options button on the menu bar and select the Outline Image button again. This will start the selection process over and erase any highlighted areas on the screen.** After releasing the left mouse button, a new area of the data file can be selected for mapping. In this way, multiple map areas can be outlined and printed at a later time (Fig 24). Once all the desired map areas have been outlined, click the right mouse button. This will "release" the cursor from the map mode. Close the navigation window and proceed with the mapping procedure as outlined below in the section entitled Map Creation.

After mapping the outlined areas, several output files will be created with the suffix "img"

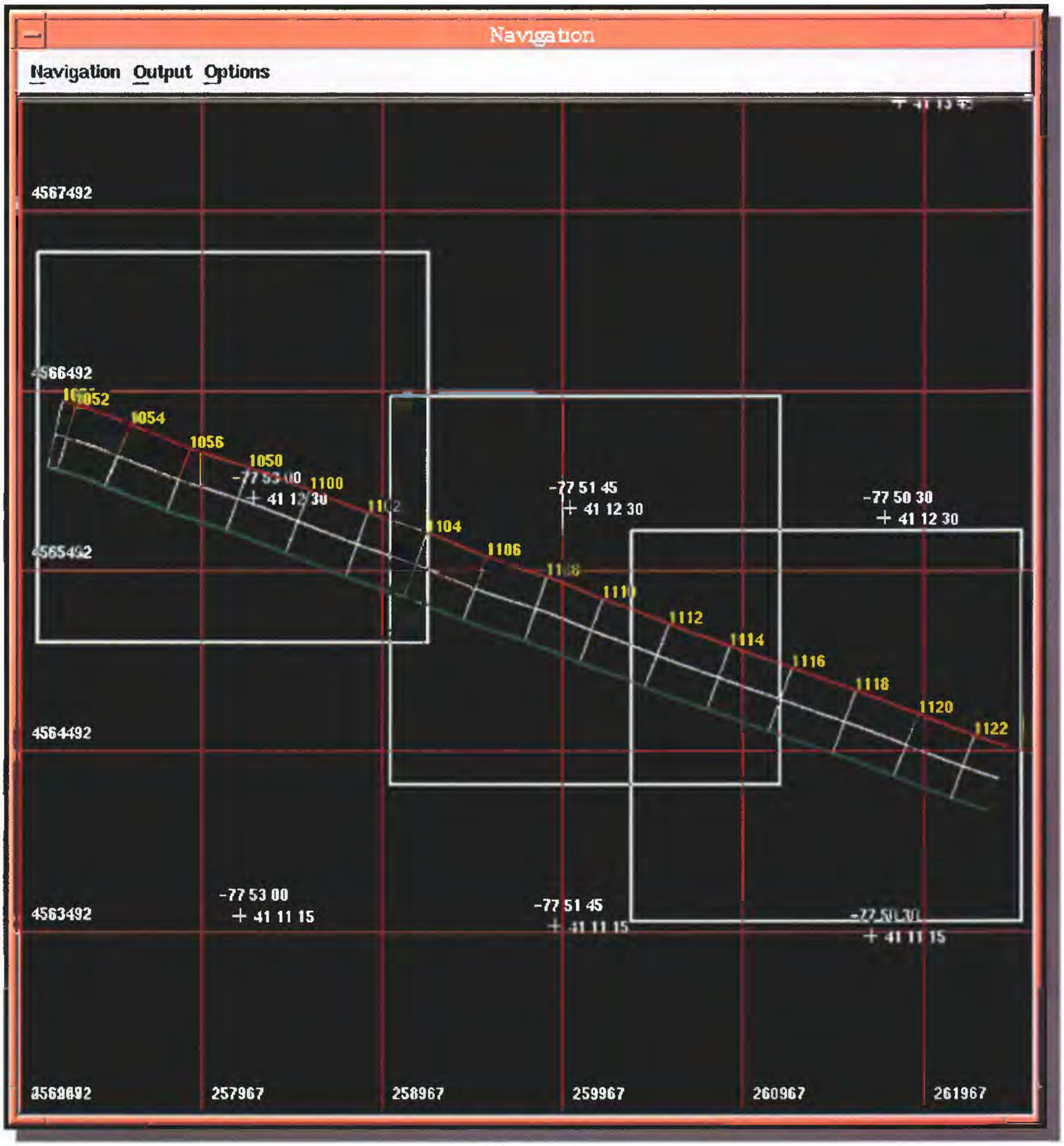

Figure 24

appended to the file name. For example, if the mapped filename is "l1f1.sdbl" and three map areas were outlined, then the following files will be created: l1f1.a.img, l1f1.b.img and l1f1.c.img. The ".a.img" file corressponds to the first map area outlined and so on. These files can be either viewed with the ShowImage program, exported to other programs or printed on the appropriate device using the lp or lpr systems. See your system administrator for details on how to print to the Alden or TDU-850 printers.

Each UTM interval is marked on both the X and Y axes of the printed images (if the UTM Grid button was selected in the Mapping area of the Setup window) and can be used to align the output images onto a final "cut and paste" map. In addition, if the Alden output type was selected, each output image will have the filename printed at the top for convenience. As mentioned, mylar overlays are brought out on cruises with pre-printed 1 inch squares which need to be marked with the UTM numbers as they appear on the printed map images. These images are then aligned to these markings on the mylar and a final map constructed. An alternate method involves creating a mylar sheet with printed Mercator tick marks based on a UTM map grid at a specified central longitude. Mercator tick marks on the output image (lacking the UTM grid lines) are aligned with the printed mylar map sheet and a final mosaic is constructed. The USGS Woods Hole Field Center routinely uses the "cut and paste" method for two reasons:

- Quick processing and map generation is accomplished aboard ship.
- This method allows the user to align similar backscatter features quickly from line to line when towfish layback and depth information is not available.

Construction of a quick mosaic is essential when decisions need to be made aboard ship regarding the location of sample sites or continuing survey coverage as well as the placement of other remotely sensed vehicles or platforms during the same cruise.

Raster Map Output

Creating a raster map allows the user to either create a composite mosaic and save it on disk, or create raster map files of individual lines which can then be imported into other mosaicking programs such as PCI which allow for more sophisticated stenciling and registration of the mapped images if realignment of the map files is necessary. Creation of the raster map requires several steps (the first two of which were covered earlier in this document):

- Pick the proper ellipsoid for the map area.

- Select a central longitude.
- Select the map boundaries.

After these parameters are set, the raster map is ready for creation.

Map Boundary Selection

To select the map boundaries, pop up the Navigation window from the main Xsonar display panel if it is not already in view. Select the Output button on the menu bar and go down to and select the Type button. This will cascade several choices to use: TDU-850, Alden or Raster Map. Select the Raster button. After setting the type, again select the Output button and go down to and select Boundaries. This will pop up a dialog containing choices for the east, north, south and west boundaries as well as the desired output pixel size (Fig 25). Select the text window(s) for each boundary and type in the desired UTM number (in meters). If unsure of these boundaries, consult Snyder (1987) for a discussion on the UTM standard. To convert latitude-longitude map boundaries for an area to UTM numbers in meters, several options are available. The reader is referred to the proj program (Evenden, 1990) for a discussion of map conversion parameters. This software is in the public domain and is available from the USGS Seafloor Mapping Web Server: http://kai.er.usgs.gov. Full documentation for proj and the program itself can be found at this site (see OF90-284.ps.gz and PROJ.4.3.ps.gz). Future releases of Xsonar will contain a conversion program for easier map boundary creation. The desired output pixel size is in meters/pixel. Type this in and press the Done button, at which time a dialog will pop up containing the number of lines and pixels the output file will contain. **NOTE: Write down the parameters displayed in the final dialog as it is neccessary to know them if importing the raster map into other programs for conversion.** This procedure will create a file titled "mosaic.ras" in the directory where the current file selected resides. If this file already exists, the selected file will be added to the current mosaic. **NOTE: If updating a mosaic or adding new**

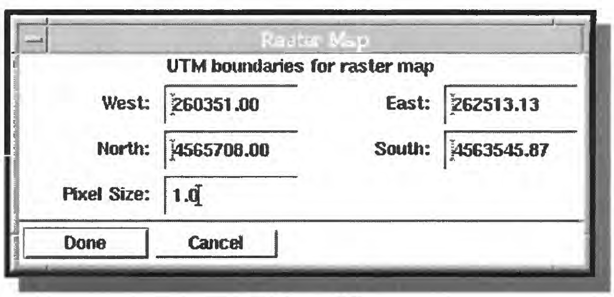

Figure 25

files to the mosaic, the file called "mosaic.ras" needs to be moved into the directory where the file being mapped exists. Failure to do this will result in a new raster map file being created. If the user wishes to create separate map files in each directory in which the various data files reside, all the files will be titled "mosaic.ras" and can be imported into other mapping programs.

Map Creation

Once all the parameters necessary for creating a map file have been entered, select the Sonar Map button on the main Xsonar display panel. This will pop up a dialog containing three buttons: Run, Stop and Close (Fig 26). Depress the Run button and the mapping process will commence. As it reads through the data file, the label on the sonar map dialog will be updated with the Julian day and time as the program maps each ping into the proper geographic coordinates. In addition, the Run and Close buttons will be unavailable. Mapping can be aborted at any time by hitting the Stop button. If a new file needs to be mapped or the user wishes to quit the mapping process altogether, depress the Close button which will pop down the Sonar Map dialog. If the Stop button is pushed by mistake, simply depress the Run button and the same data file(s) will be mapped again. After the entire file is mapped, all the buttons in the Sonar Map dialog will be made available. To map a new file, close the Sonar Map dialog and select a new file using file dialog from the Setup window.

Figure 26

If utilizing the Alden and/or TDU-850 output options, all areas selected will be mapped and files created with the appropriate suffixes as described earlier. Once all outlined areas have been mapped, the sonar map dialog will have the Close and Run buttons highlighted. Close the map dialog, select a new file and repeat the procedure for outlining the areas to be mapped and proceed with the map creation. If using the raster map option, simply select a new file and pop up the sonar map dialog. No new options need be entered at this time. Hit the Run button and the selected file will be added to the existing raster map file. Remember, the file called "mosaic.ras" must exist in the current directory that contains the data file to be mapped. Otherwise a new file will be created which contains the mapped data file.

Viewing Map Mosaicks

Mosaic files can be viewed for quality control or to save individual areas of the mapped data file at full resolution, if so desired, by utilizing the capabilities of the ShowImage program. See the details on viewing these data files in the section entitled "Image Display" under the ShowImage portion of this document.

Exiting Xsonar

To exit the Xsonar program, select the Exit button on the main Xsonar display panel. This will close all windows associated with the Xsonar program and close all open data files.

ShowImage Display System

Startup

ShowImage is started up by typing "showimage" at the UNIX system prompt. This will bring up a viewing window consisting of a main menu bar and a black image display area that is 512 x 512 pixels in dimension. It is suggested that the user put the program in the background by adding an ampersand after the command (showimage &) so that the system prompt comes back and other tasks can be accomplished in the same window. Upon startup, showimage will output various attributes of the computer display system; these are informational only and can be ignored. ShowImage will always warn the user about any parameters or attributes that may be missing or not typed in by popping up informational dialogs when a selection is made that requires more information. If a data file is viewed which does not support certain of the menu items in ShowImage, those same menu items will be "grayed out" and unselectable. For example, an Xsonar mapped raster file would not have any telemetry or altitude values associated with it and so these menu items would not be available.

Viewing Raster Data Files

File retrieval

After bringing up the main showimage window, the first task is to pick a data file to be displayed. Select the File button on the main menu bar and go down to and select Retrieve from the cascaded menu items (Fig 27). This will pop up the standard Motif file dialog from which a data file can be selected either from the current directory where showimage was started from, or from another directory if desired. If unfamiliar with the Motif file dialog, consult the X Window System Users Manual (Motif edition) (Quercia and O'Reilly, 1990) for details.

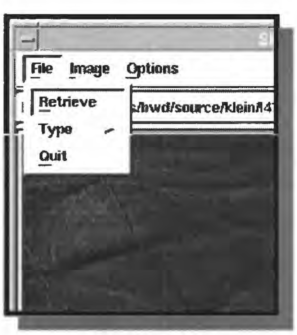

Figure 27

Data Types

Once a data file has been selected, ShowImage needs to be aware of the type of data file being displayed. Several choices are available by selecting the File button on the main menu bar and then going down to and selecting the Type button. This will cascade a number of choices: QMIPS™, EGG (Edgetech), Xsonar, Raster Map and Other. Pick the appropriate input data type for the file being displayed: The QMIPS™ and EGG choices allow viewing of the raw field data file, Xsonar selects the format that all Xsonar processed files are stored in and Raster Map allows viewing of a mapped data file (if the user selected the Raster Map option in Xsonar). The Other button allows viewing of any raster image file so long as the number of pixels for both image directions (lines and samples) is known as well as the size of any file and/or scan headers.

Image Display

To view the retrieved data file, select the Image button from the main ShowImage menu bar. A number of choices will be cascaded down. Go down to and select the Display button which will cascade a secondary menu to the right, from which the Sonar button should be selected (Fig 28). This will pop down the menu choices and begin reading data from the disk file. As the program does so, an informational dialog will be popped up showing the progress of the task as it proceeds. Once a sufficient number of scans have been read off disk to fill up the display window with data, the image will appear on screen. ShowImage displays the data in a top down manner (i.e. the towfish runs from the top to the bottom of the display; the port data is displayed on the right side of the screen and the starboard on the left) (Fig 29). However if the file being viewed is a Raster Map file or a file of type Other, the notion of port and starboard does not apply to the displayed data. The number of scans displayed depends on the input data file scan width. For example, if each scan or "ping" in the data file consisted of 1024 pixels, ShowImage will read in 1024 pings from the file and display the result in the 512x512 pixel window by down-sampling each ping to 512 pixels. In

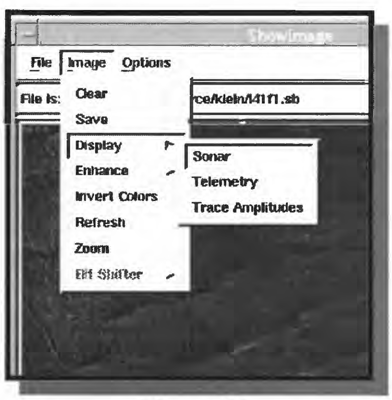

Figure 28

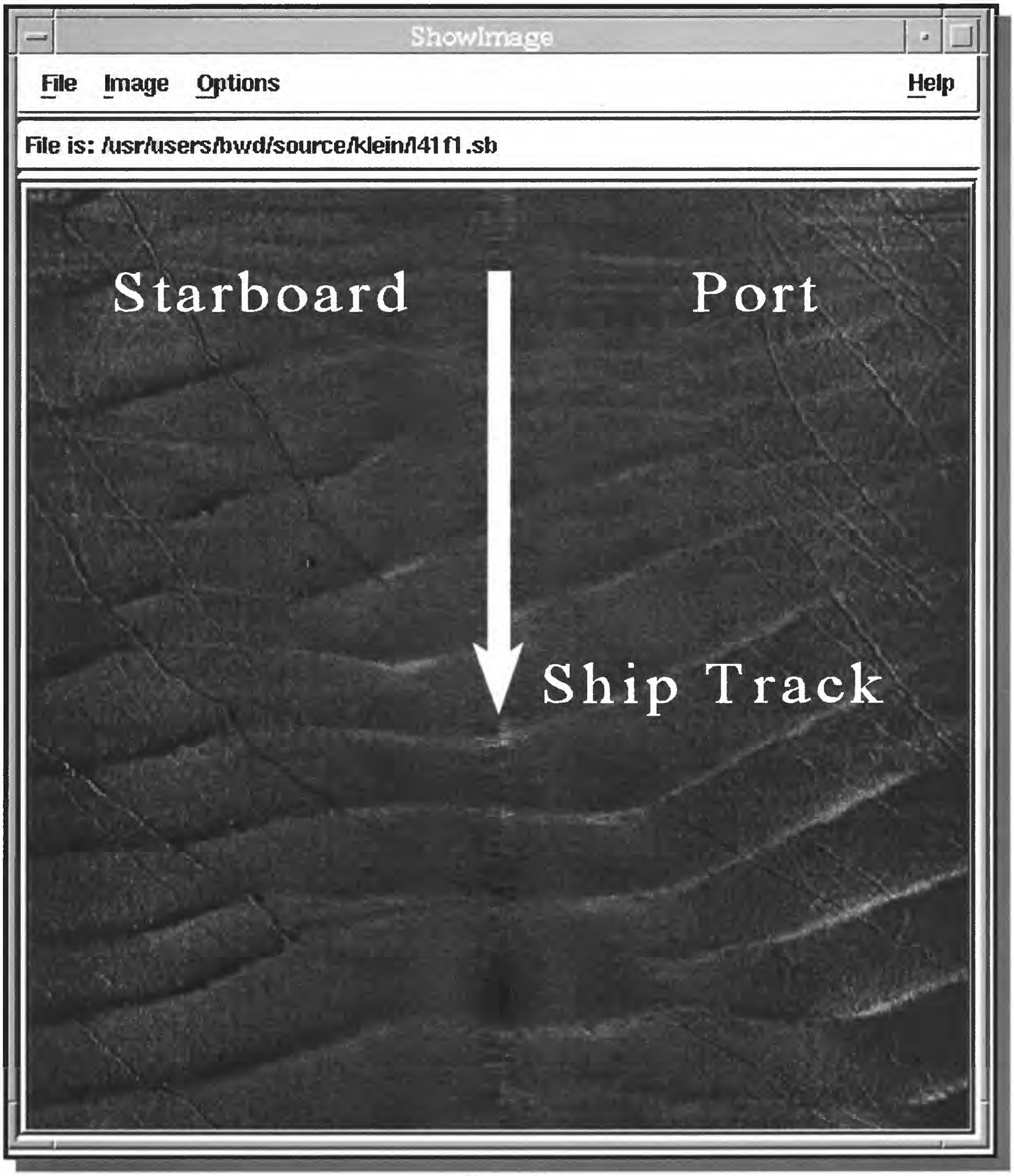

Figure 29

this way the aspect ratio of the data file is preserved. This is important as the program is designed to present the data in either the raw or processed from without distortion. A "page" of data is display one at a time in this manner. To continue viewing the data file, select the Image-Display-Sonar button sequence as described above once again and the next "page" of data, or 1024 pixels using the example just described, will be displayed. This is repeated until the end of the data file is reached, at which time an information dialog will pop up indicating that the last ping has been read off disk.

If the data file being viewed is of type 'Other', a dialog window will pop up containing text windows that the user can use to specify the various file dimensions provided they are known. These choices include the scan width (number of samples in each ping), file header size and ping header size. Select OK from the choices at the bottom of the dialog when finished entering the dimensions, otherwise the Cancel button will pop down the dialog with no choices being made. These dimensions only need to be filled in when first viewing the file; continued paging through the file will not pop up this dialog since ShowImage will remember the dimensions.

Moving Around within the Data File

To go to a certain ping in the data file, select the Options button from the main ShowImage menu bar. Go down to and select the Goto Ping button from the cascaded menu choices. This will pop up a text window in which the ping number to advanced to can be entered. Depress the OK button to close the dialog. At this point the program will point to the desired position in the data file and the image then redisplayed by selecting the button sequence Image->Display->Sonar (as described above). The ping at the top of the displayed image will be the ping number selected in the text window. Continue viewing the data file until the end of data is reached or select another ping to go to and re-display the data. If you wish to go to the start of the data file, select the Options button again from the main menu bar and select the Goto Start button and re-display the data.

Viewing Altitude Values

Correct altitude telemetry is an essential to the data processing procedure. This value is used in the slant range to ground range correction as well as the beam angle correction, as described in the processing procedures, and must be correct for proper geometric and radiometric rectification of the data file. To view the altitude telemetry for each ping in the main ShowImage display window, select the Options button from the main menu bar and then go down to and select either the Port Altitude or Stbd Altitude buttons. Each button will cascade a menu to the right containing On and

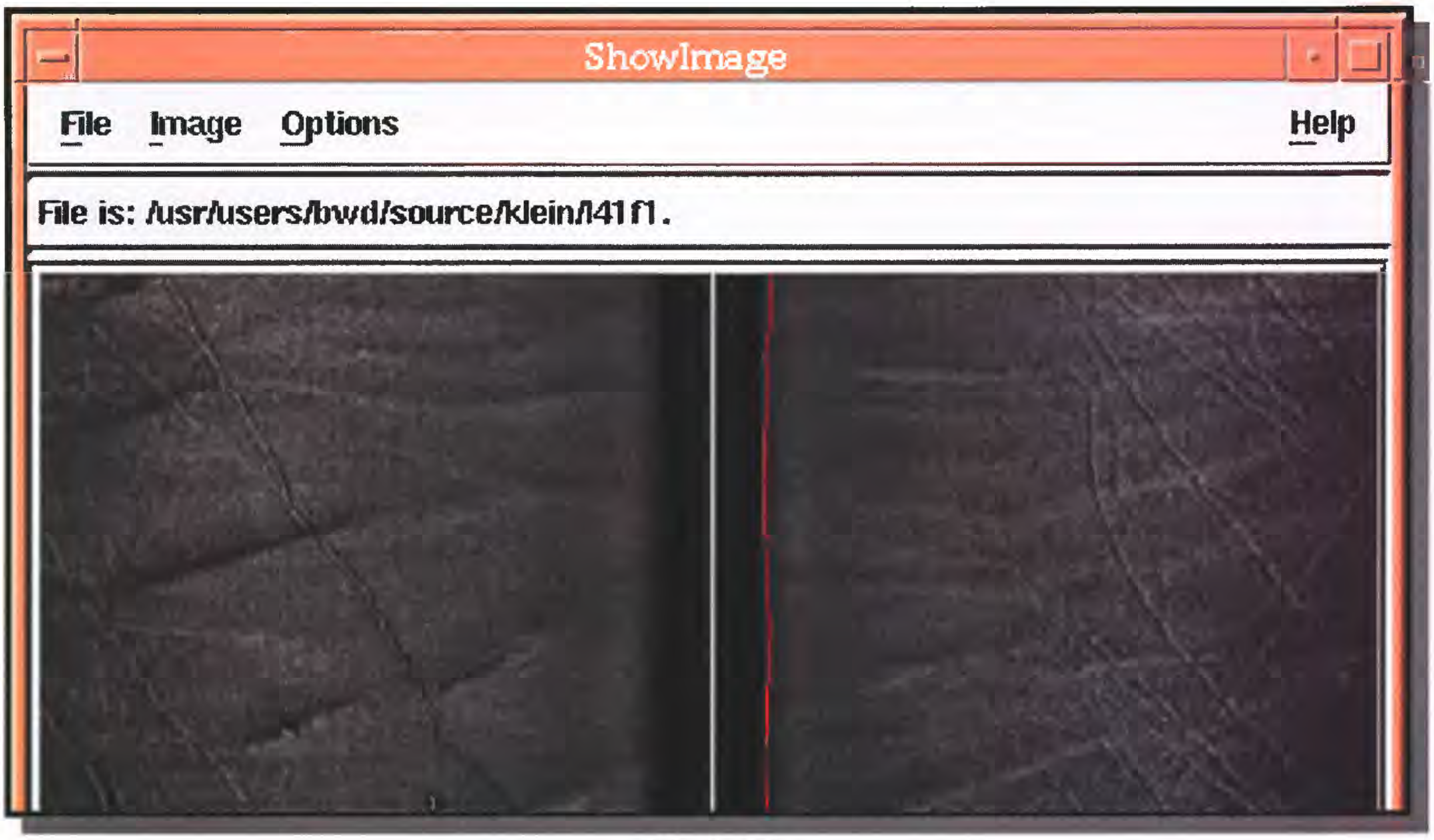

Figure 30

Off buttons. Altitude display is turned off when first starting up the program and therefore only the On buttons will be highlighted. Select the On button to view the altitude values for either the port or starboard side of the image. A red line will be drawn down the screen indicating the towfish height for each ping as displayed on the screen (Fig 30). The line should follow the "first return" of the sonar data for each ping if the data values are correct. If not, the altitude data needs to be manually corrected as described below in the section entitled "Correcting Altitude Values". This option remains on and in effect until explicitly turned off by selecting the Off button, which can be handy when "paging" through a data file looking for "bad" or incorrect altitude telemetry.

On-Screen Coordinates and Pixel DN

X-Y positions of each displayed pixel can be viewed by pressing and holding the left mouse button in the main ShowImage display window. As the left mouse button is depressed, a text window will appear at the bottom left corner of the main ShowImage display window indicating the X and Y position of the data pixel directly under the cursor as well as the pixel DN or Digital Number and the distance offset from nadir (in meters) the data pixel lies. This is useful for quickly perusing the data range of the displayed image or for noting the offset in meters a target may lie from the center line of data. To get an actual geographic position for a particular data pixel or to display more information about a certain ping, select the Telemetry window option described below.

Data Enhancement

If the displayed image is dark indicating that the dynamic range of the collected data was narrow, it is useful to enhance the displayed data for easier viewing. To do so, select the Image button from the main menu bar and go down to the Enhance button. This will cascade two choices for image enhancement: Histogram equalization or linear contrast stretch. Both will increase the on screen dynamic range of the data and can bring out subtle features that may not be visible in the un-enhanced image. Each method will produce different results and the user is urged to experiment with both methods.

Telemetry Window

Information contained in each ping header such as the geographic position of a certain data pixel (if the navigation has been merged), time and date the ping was recorded and other ancillary telemetry information including pitch, roll, depth, DN, altitude, temperature and swath width can be viewed in a separate window. If telemetry information was not recorded for a particular variable, pitch for example, the displayed data field will contain a zero for that element. To pop up the telemetry window, select the Image button on the main menu bar and pull down to the Display button. From the cascaded menu to the right select Telemetry and the telemetry window will pop up on the screen (Fig 31). Each of the telemetry values will appear in a text field that is preceded with a label indicating the type for each text window. To view telemetry for various pings, position the cursor over the area of interest and click the right mouse button. The geographic position under

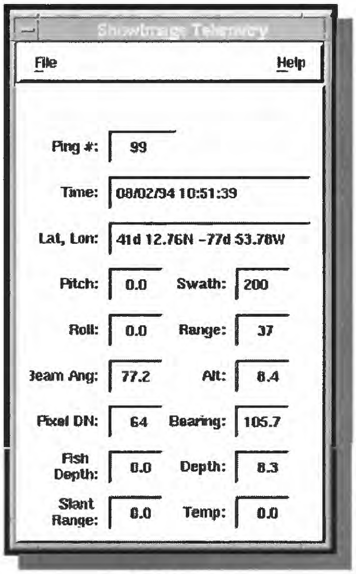

Figure 31

the cursor will appear in the telemetry window along with all the other information that was recorded for that ping. Move the cursor to another position and again, click the right mouse button for information pertinent to that area of the main ShowImage display window. If the central longitude is not known for this data file, a pop up window will appear in which the central longitude can be entered for the data file (see the next topic on how to change the central longitude if desired).

Central Longitude

ShowImage needs to know the central longitude for the zone where the data was recorded in order to display the telemetry information properly. To do so, select the Options button from the main menu bar and go down to and select the Central Lon button. This will pop up a text window in which the central longitude can be entered or edited to a new value (remember West longitude is always negative). The current central longitude will appear in the text window when the dialog is popped up. If this value is satisfactory, simply depress the OK or Cancel button to retain the current value. New values can be entered at any time using this option.

Closing the Telemetry Window

To pop down the telemetry window, select the File button on the Telemetry window menu bar. Go down to and select the Close button.

Zoom Window

As previously mentioned, ShowImage down-samples the data for display in the main image window. To view the data at full resolution, the zoom window can be popped up and each pixel as stored in the data file will be displayed in the new window. To pop up the zoom window, select the Image button on the main menu bar and go down to and select the Zoom button. This will pop up a separate window in which the full resolution data can be viewed and manipulated. There are many features associated with the zoom window, therefore each feature is discussed in appropriate sections below.

Displaying Data At Full Resolution

To display the data at maximum resolution, the data file must first be viewed in the main ShowImage window. If this has not been done, ShowImage will warn about it and the user is directed to the section on data display discussed previously on how to initially display the sonar data file. Once a data file is displayed in the main ShowImage window, an area of interest can be outlined by pressing and holding the middle mouse button. This will activate a "rubber rectangle" which can then be dragged out to the desired size. A white rectangle will be drawn as the cursor is moved around highlighting the area that will be displayed at full resolution in the zoom window (Fig 32). Once the desired area has been outlined, release the middle mouse button and ShowImage will load the data into the zoom window for viewing. A new area of interest can be picked at any time by drawing a new rectangle anywhere in the main ShowImage display window. The zoom window will be sized according to the dimensions of the data area selected and the full resolution pixel dimensions within the data file. If the full resolution of the data file is large, for instance a mapped file that is 4096 by 4096 pixels, the zoomed area may exceed the dimensions of the screen. If this happens, highlight a smaller area in the main ShowImage window.

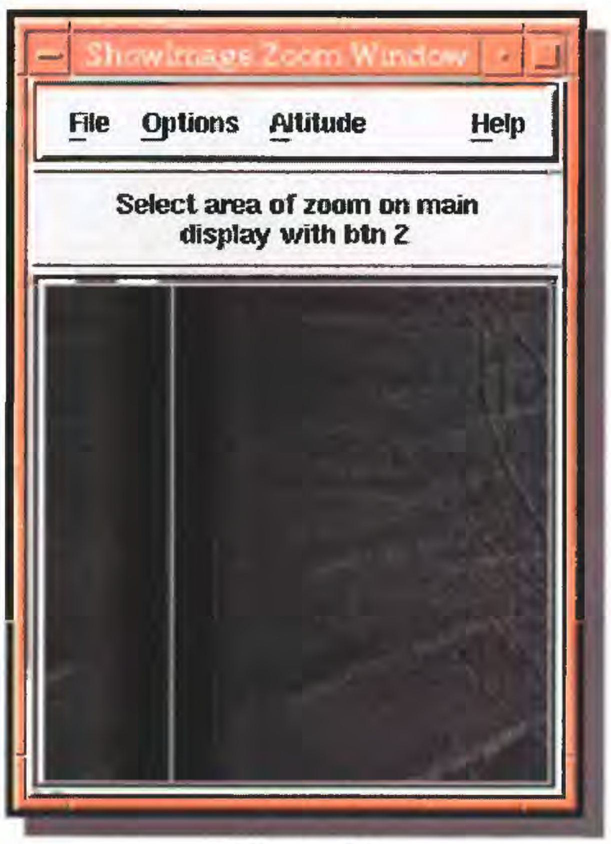

Figure 32

Data Enhancement

Imagery displayed in the zoom window can be enhanced for better viewing by either equalizing the histogram or applying a linear contrast stretch to the data. To do so, select the Options button from the Zoom window menu bar and go down to and select the Enhance button. This will cascade two choices to the right: Equalize Histogram and Contrast Stretch. Select the enhancement function desired and the data in the zoom window will be "brightened". Generally a histogram equalization provides a better look at the data as opposed to a simple contrast stretch, but these features should be experimented with as each has their advantages depending on the data quality and dynamic range.

Magnification

If desired, the imagery displayed in the Zoom window can be enlarged. Each time this is done, a 2X magnification is applied to the data by replicating pixels. To magnify the zoom window, select the Image button from the Zoom window menu bar and go down to and select the Magnify button. The Zoom window will expand automatically and the data image enlarged. To reset the magnification to the original full resolution window, select the Image button and pull down to the button labeled Reset.

Altitude

Altitude telemetry can be displayed in the Zoom window in the same manner as was discussed for altitude display in the main ShowImage window. A red line showing the current altitude values for data displayed in the Zoom window will be drawn on the screen. As mentioned, correct altitude telemetry is essential for the image processing procedures outlined earlier in this document and can be corrected manually if needed as discussed below.

Viewing Altitude Values

In order to view the altitude data in the zoom window, the portion of the image containing the "first return" or seafloor/water interface, needs to be outlined in the main ShowImage window. For example, if a portion of the altitude telemetry is to be viewed on the port side of the data file, highlight an area in the main window that extends out from nadir and overlaps the first return on the port side. After doing so, select the Options button from the Zoom window menu bar and go down to and select the Port Altitude button. This will cascade a menu to the right with two choices: On and Off. Altitude viewing is turned off by default. Select the On button and a red line will be drawn on the image in the Zoom window indicating what the fish height values are for each ping. This option remains on until explicitly turned off by selecting the Off button. If the starboard side (including the first return) is displayed in the zoom window, use the same procedure to draw the altitude values on screen by selecting the Stbd Altitude button under the Options menu item.

Correcting Altitude Values

To correct altitude values, first display the appropriate portion of the data file (port or starboard) as described in the previous section. Then select the Altitude button on the Zoom window menu bar and pull down to the Correct button which will cascade two choices to the right of the button: Port and Stbd. Select the side which applies to the data displayed in the zoom window. After doing so, the cursor will change shape to a pencil and be trapped in the zoom window. Begin redrawing the altitude by positioning the pencil cursor over and slightly before (towards the top of the page) the first sonar return that needs to be corrected. Pressing and holding the left mouse button will activate the drawing mode. Drag the cursor (while holding down the left mouse button) down the image (towards the bottom of the window) tracing the first return for as many pings as desired and then release the left mouse button. This mode only works when drawing a line from top to bottom (unexpected results occur if drawing the opposite direction). As the first return is traced, a white line will be drawn as the cursor moves down the screen showing the location of the edited altitude values (Fig 33). If the line drawn is not satisfactory, redraw the line using the method above until the correct trace of the first sonar return is achieved. As mentioned, this can be done for individual sections in the Zoom window or the entire window if so desired. If it proves difficult to trace the

Figure 33

first return in the zoom window, magnify the data. Magnification makes it much easier to trace the first return (especially if the drawing is being done on a moving ship!) and will be more forgiving of mistakes as the values representing the drawn line will be averaged for each ping (since pings are replicated when the image is magnified) when the data is written to the ping headers. Once finished, the new values are stored in memory and can be displayed either in the zoom or main windows for quality checking. If the new values are satisfactory, the data is written out to each ping in the data file by selecting the Altitude button on the Zoom window menu bar. Go down to and select Write on the cascaded menu. This will write out the updated values for each ping as drawn in the Zoom window. **CAUTION: This modifies the original data file. Any drawing done in the Zoom window will have no effect on the data file until the Write button is selected. Therefore it is safe to experiment with the drawing routine without modifying the original data as long as the Write button is not selected. However, be sure to select the Write button after satisfactorily editing the altitude values, otherwise all edits will be lost!**

Linear Feature Removal

Linear artifacts present in the data, such as scale lines or high intensity nadir returns, can be averaged and removed by using this option. To activate, select the Options button from the Zoom window menu bar. This will pop up a dialog containing text windows for entering in the number of pixels across scan to average, the number of lines to average and the number of data points to replace in the data file. The averaging is actually a median filter value that effectively subdues linear artifacts present in the data. As an example, to average out high intensity nadir values which may extend 2 or 3 pixels out from nadir, select a value of 15 for the across scan pixels and 1 for the number of lines. This will use "good" data away from nadir in the median filtering process for each scan and help to bring down the high pixel values near nadir. A value of 1 for the number of lines will average the values on a line to line basis and make for a smoother replacement. Once the values are decided upon, press the OK button and the cursor will be "trapped" in the Zoom window. To view pixel values and decide upon a location to filter, press and hold the right mouse button. A white line will be drawn down the Zoom window as well as in the main ShowImage display window.

Move the cursor from left to right while still depressing the right mouse button and pixel DN values under the cursor will appear in the lower left corner of the Zoom window representing the value of pixels under the cursor. If the right mouse button is released, no changes will take effect, thus making this an effective way of perusing the data in the Zoom window without making changes. To activate the filtering processing, press and hold the left mouse button and the same white line will appear in the Zoom window that follows the movement of the cursor. Position the cursor over the linear feature to be removed and release the button. A dialog will now appear that indicates the position of the cursor and values to be changed. If satisfied, click the OK button and a progress dialog will pop up indicating how far along the filter process has gone. If not satisfied with the selection, press the Cancel button to abort the procedure. When the filtering process is done, view the results by redisplaying the image in the main ShowImage window (Image-Display-Sonar button sequence).

Closing the Zoom Window

To close the zoom window, select the File button on the Zoom window menu bar. Go down to and select the Close button. This will pop down the Zoom window. Full resolution data can not be viewed at this point until the Zoom window is activated again from the main ShowImage menu bar.

Saving Selected Portions of the Data File

ShowImage has the facility for saving data directly to disk as a raster file. This is useful if features or targets displayed in either the main or zoom ShowImage windows need to be included in reports or for exporting these features to other programs such as Adobe Illustrator or CorelDraw (if outlining a poster presentation, for example). **NOTE: The saved raster files from either the Main or Zoom windows contain no headers at all**. The saved data can therefore be reformatted into other data types using any one of the popular data translators available today for Macintosh, IBM compatible or UNIX computer systems. Write down the number of lines and samples from the information dialog that pops up so that this task can be accomplished at a later time.

Main Window

If the currently displayed data in the main ShowImage window is to be saved onto disk, select the Image button from the menu bar and go down to and select the Save button. A file dialog will pop up asking for the name of the raster file to be created (any name can be used) and the directory in which to put it. Type this information in and click the OK button, at which time an information dialog will pop up indicating the number of lines and samples contained in the saved image. In the case of the main window, this value will always be 512x512 pixels. The process can be aborted by selecting the Cancel button in the File dialog if desired.

Zoom Window

Data displayed in the full resolution zoomed with can be saved in a similar manner. This feature is useful if data displayed in the main window does not have sufficient resolution or the object of interest needs to be magnified for greater detail. Select the area of interest as described earlier in this document under the heading: Displaying Data at Full Resolution. Once the feature or target is displayed in the Zoom window, either magnify the image or save it as is. To do so, select the Image button on the Zoom window menu bar and go down to and select Save. This will pop up a file dialog asking for the name of the data file to be saved and the directory to save it in, as was the case for the Main window file save dialog. Click the OK button at the bottom of the dialog to save the image or hit the Cancel button to abort the procedure. If the OK button is selected, an information dialog will pop up indicating the number of lines and samples the data file contains. Select a new area of interest from the Main window if desired, or pop down the ShowImage Zoom window.

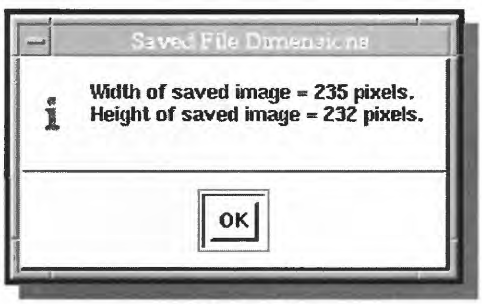

Figure 34

Exiting ShowImage

To exit the ShowImage program, choose the File button on the main ShowImage menu bar and go down to and select the Exit button. This will pop down the main display and any other open windows associated with ShowImage in addition to closing all open data files.

Appendix A: XSONAR and SHOWIMAGE "How To" Guide

Many thanks and kudos to Jane Denny (USGS, Woods Hole Field Center) for writing this how-to guide!

This lists only the necessary parameters for each stage of sidescan sonar processing. This guide is to be used in conjunction with the Xsonar/ShowImage User's Manual. The Xsonar/ShowImage User's Manual will give a full description of each processing stage.

Starting **XSONAR**:

> xsonar & ('&' will run Xsonar in the background, returning a command prompt and allowing the user to work in the active terminal)

The Xsonar command window will appear. Each button in the command window represents a different processing and/or mapping stage. To setup the parameters for processing raw sonar data click on **SETUP** on the main Xsonar window. This will bring up a **Sonar Setup** window.

DEMULTIPLEXING RAW DATA FILES

The first step in processing raw sonar data is to demultiplex the data. The demultiplex process reduces the data by applying a median filter, which creates manageable file sizes, eliminates noise, and creates 2 new files - *. (sonar data in Xsonar format) and *.nav (navigation file - ASCII file).

- To bring a raw data file into Xsonar, in the **Sonar Setup** window select:

    File:

        Retrieve:

    A popup window will appear listing the files in the current workingdirectory. Choose a file from the existing directory, or change to a new directory using filter. Select a *.dat file (e.g. L1f1.dat). The file type now needs to be set (again, in the **Sonar Setup** window):

    File:

Type:

There are four options for data type: Xsonar, raster, EGG, QMIPS, and SEGY. Raw data files will generally be either EGG (EdgeTech) or QMIPS (Isis acquisition). Choose the appropriate file type.

- The parameters needed in order to demultiplex the data are as follows:

Navigation:

Either the **Lat,Lon** or **Eastings, Northings** radio button needs to active, depending on whether the navigation was collected as lat,lon or eastings, northings. A navigation interval in minutes also needs to be specified. Click and hold the first mouse button on the sliding bar above '**navigation interval**' to set the desired value. This will specify the navigation interval (in minutes) to be written to the ASCII navigation file.

Swath Width:

A radio button by the appropriate swath width needs to be activated. If the swath width is not represented (**100m, 200m, 500m, 1000m**, **2500m**, or **5000m**), use the **User Defined** radio button to define the appropriate swath width. Once this radio button is active, a new window will appear allowing the user to define any given swath width. After entering the appropriate value, press Done.

Process:

The **demultiplex** radio button must be activated.

Across Track/Along Track:

Along and Across track values must be specified. The values represent the median boxcar filter used to reduce the raw data file (*.dat). Suggested values to start with are along track = 3, across track = 4. (A 4x3 filter will reduce the raw data by a factor of 12. The median value of every 12 pixels will be output to the '.' file).

8 vs 16 Bit Data:

Either the Input 8 bit or the Input 16 bit radio button must be activated.

Stdb/Port Bit Shifter:

The stdb/port bit shifter needs to be specified when processing 16 bit data. This option enables the user to select an 8 bit window from within the 16 bit data. This may aid in reducing noise within the sonar file. See Xsonar/ShowImage User's Manual for a full description of bit shifting.

EDIT NAVIGATION:

The first step after completing the demultiplex, is to edit the navigation file (*.nav). Xsonar offers a quick check of the navigation file. Depress **SETUP** in the Xsonar command window to bring up **Sonar Setup** window

- Retrieve the *. file (e.g. L1f1.).

  File:

  Retrieve:

- Select File Type:

  File:

  Type: xsonar

In the Xsonar command window, depress **NAVIGATION**. A navigation window will appear.

Navigation:

ASCII File

This will display the navigation fixes stored in the *.nav file (e.g. l1f1.nav) with a track line connecting fixes. If duplicate navigation fixes are found within the navigation file, a text window will appear displaying the navigation fixes. The duplicate fixes (duplicate times or lat/lon) will be flagged. Click OK to delete the duplicate fixes. View the ASCII navigation again to make sure modifications have been made (*Navigation* - **ASCII File**). It may be necessary to manually edit the navigation file with a text editor, such as vi. Key problems to look for are:

- 0 values listed for latitude/longitude,
- incorrect time or julian day,
- incorrect latitude or longitude value,
- inconsistency in trackline course (this will be visible when ascii file is displayed, the trackline will make a circle on the screen) Using a text editor, delete any of the "problem"

fixes and save changes.

View the ascii file again to ensure that course problems are corrected. If problems still exist repeat the procedure (text editor, view ASCII file).

MERGE NAVIGATION:

After the raw sonar file has been demultiplexed, navigation edited, and the altitudes corrected (see Correcting Altitudes section), the ASCII navigation file (*.nav) must be merged with the sonar file (*.)

- Parameters needed:

  Navigation:

  Choose appropriate radio button - **lat/lon** or **eastings/northings**. A navigation interval must be specified.

  Process:

  Activate the radio button for Merge Navigation.

  Map Grid Units:

  Specify a Central Longitude. (If the user does not know the Central Longitude, Xsonar will calculate a value)

In the Xsonar command window, click **PROCESS**.

SLANT RANGE:

It is very important that the altitudes are corrected BEFORE running the sonar data through the slant range routine. See the **Correcting Altitudes** section either below or in the manual for instructions on how to do altitude corrections. The slant range routine places each pixel in the correct geometric position by converting slant range to seafloor distances to true horizontal distance from nadir to seafloor. Additionally, the water column (travel-time from source to seafloor) is removed, and port and starboard channels are "seamed" together.

- Parameters that need to be set within the **Sonar Setup** window:

  File:

  Retrieve:*. (e.g. L1f1.)

File:

Type:**Xsonar**

Process:

Slant Range

Swath Width:

Choose appropriate value from the predefined list of swath widths or specify a value with the **User Defined** option

In the Xsonar command window - press **PROCESS.**

A new file is created during the slant range routine. A '.s' file. (s = slant range).There are no changes made to the '.' file.

DESTRIPE

The destripe routine corrects for striping noise within the sonar record. This routine is run AFTER the slant range routine. If the '.s' file is not selected, go to *File - Retrieve* (in **Sonar Setup**) and select the *.s file. (See Xsonar/ShowImage User's Manual for full description of the destripe routine).

- Parameters that need to be set within the **Sonar Setup** window:

Process:

Destripe

In the Xsonar command window - press **PROCESS.**

A new file is created during the destripe routine - a '*.d' file. Because the destripe routine is applied to the slant range corrected file (*.s), the new file will have the suffix '*.sd' (e.g. 11f1.sd), indicating that both the slant range and destripe procedures have been applied to the file.

Occasionally, a file will contain an area with "missed pings" - some sort of system failure or fish movement produced an area of no data. The destripe routine will not run successfully on such a file - the gap (usually of 50 pings or greater) will result in the destripe routine running a continual loop - comparing pings of no data to adjacent pings of no data. In this situation, cancel the destripe routine and continue on the beam pattern routine. (The user will know when this is occurring - the destripe routine will not complete - it will keep running and running. Cancel the job and continue on with the processing).

BEAM PATTERN

The beam pattern routine corrects for tonal variations in the sonar record from near to far-range. These are artifacts that have not properly been corrected for by the time varied gain applied to the system. The beam pattern routine should be run on either the slant range corrected (*.s) or the slant range and destripe corrected file (*.sd). See Xsonar/ShowImage User's Manual for a detailed description of the beam pattern routine.

- Parameters that need to be set within the **Sonar Setup** window:

  Options:

  Beam Pattern:

  A popup window will appear asking for the number of lines, start ping, and port/stbd adjust to be specified.

  Number of Lines:

  The number of lines specifies how many pings will be used in the beam pattern routine. 350 is the suggested starting point for high-resolution sonar data. The beam pattern routine will look at 350 pings at a time when balancing the sonar record (See Xsonar/ShowImage User's Manual for a more detailed description).

  Start at ping:0

  (default - start at beginning of record)

  Port/Stbd Tone Adjust:

  If the port and starboard channels have different tones due to gain changes, select the **ON** option. This will balance the two channels. If the two channels appear uniform, select the **OFF** option.

  In the Xsonar command window - press **PROCESS.**

A new file is created during the beam pattern routine - a '*.b' file. If the beam pattern routine was preformed on the '*.sd' (slant range and destriped) file, the new file will have the suffix '*.sdb'.

If the beam pattern routine was preformed on the '*.s' (slant range corrected file), the new file will have the suffix '*.sb'.

HISTOGRAM:

The histogram of the processed sonar record can be displayed. The histogram values should be used in defining a stretch for the sonar record.

- Parameters that need to be set within the **Sonar Setup** window:

    Xsonar command window:

    Histogram

    Brings up the Histogram window.

    File:

    Show Histogram:

    Displays histogram for the selected file.

Record the low, mean, and high values of the histogram. These will be used in defining an initial stretch for the sonar record.

LINEAR STRETCH:

If the sonar files are to be printed, it will probably be necessary to apply a contrast stretch to the files. A linear stretch will take the specified low, mean, and high values and adjust the image to the full spectrum of 0 - 255 DN values. For example, if the low, mean, and high displayed in the histogram window were 15, 45, 85, and these values were used as the stretch values, the linear stretch would take values from 15 - 45 and map them to 0 - 127. Values from 45 - 85 would be mapped from 128 - 255. The stretch may have to be adjusted. The easiest way to alter the stretch is to adjust the mean value. Print a few files with various stretches to find a stretch that yields the greatest dynamic range.

The linear stretch should be applied to the fully processed file, either *.sdb or *.sb (slant range, destripe, and beam pattern or slant range, beam pattern corrected, respectively). If one of these files is not selected, go to *File - Retrieve* to select the appropriate file.

- Parameters that need to be set within the **Sonar Setup** window:

Stretch Values:

Low, Mean, High

Click and hold the first mouse button to select the appropriate value for each.

In the Xsonar command window - press **PROCESS**.

A new file will be created with an 'l' added to the suffix - either a '*.sdbl' or a '*.sbl', depending on which file the stretch was performed.

MAPPING AND PRINTING:

The processed file (*.sdb, *.sdbl, *.sb, or *.sbl) can be mapped and printed. To map a sonar file:

- Parameters that need to be set within the **Sonar Setup** window:

Map Grid Units:

Either the **Mercator** or **UTM** radio button must be activated. UTM will annotate the map file with UTM grids and eastings/northings. Mercator will annotate the map file with latitude and longitude ticks (for the TDU or ALDEN options- see below).

Mercator Grid Interval:

Click and hold on the first mouse button to specify a grid interval in minutes (6 - ticks 6 minutes apart).

Central Longitude:

The central longitude for given survey area.

Map Scale:

specify a map scale (e.g. 10000 = 1:10,000).

Then, in the Xsonar command window - press **NAVIGATION**.

Output:

Type:

There are 3 types of output, **TDU**, **ALDEN**, or **RASTER**. The TDU and ALDEN are thermal printers that are usually used to print individual sonar files.

If **TDU** or **ALDEN** are chosen:

Options:

Printer Setup:

A popup window will appear asking for the number of pixels/inch. This value may have to be adjusted. Print files with the default value, and if the UTM grids do not appear square, adjust the number of pixels/inch to force a square UTM grid. Hard returns can either be black or white. Digital images generally use a hard return = white.

If the chosen output type is **RASTER** select:

Output:

Boundaries:

A popup window will appear asking for the UTM boundaries and pixel size. These values are determined by the proposed map area. See the section on mapping and printing in the manual for a more detailed discussion if unsure of how to set these parameters.

- Now the Ellipsoid needs to be specified:

Options:

Ellipsoid:

Choose either WGS84 or Clarke 1866 (default = WGS84)

If the output type is either **TDU** or **ALDEN**, the image must be outlined before mapping and printing (no outlining is needed for the **Raster** output type).

- To outline a sonar file:

Pop up the **NAVIGATION** window, map the selected sonar file and then outline:

Navigation:

Sonar File

Options:

Outline Image:

The cursor will change to show that Xsonar is now in outline mode. Click and hold on the first mouse button to display and position a white outline box. The size of the box is dependent on the map scale. Start at one end of the image and place an outline box. Continue placing outline boxes until the image is fully outlined. Allow overlap between adjacent boxes to ensure that there are no gaps in coverage. The procedure can be restarted by renavigating the sonar file - *Navigation - Sonar File.*

Exit the **NAVIGATION** window:

Navigation:

Exit:

Now the selected file is ready to by mapped. In the Xsonar command window - select **SONAR MAP**:

The Sonar Map window will appear. Click **RUN** to begin mapping.

- If the output type was either TDU or Alden, a number of image files (*.img) will be created. The number of image files corresponds to the number of outline boxes used. The image files can then be sent to a **TDU** or **ALDEN** printer.
- If the **RASTER** option was chosen, the output file will be a **mosaic.ras** file. If numerous files are to be mapped individually (1 sonar file to 1 mosaic.ras file), rename the mosaic.ras file. If it is not renamed, any further mapping will overwrite the original **mosaic.ras** file.

- Mapping more than one sonar file to create a digital mosaic:

Assuming there is no problem with fish layback, a digital mosaic can be created within Xsonar. In **Sonar Setup**, bring in the first file in the survey area -(*File - Retrieve).* Go to the **NAVIGATION** window. Specify the **RASTER** option, and fill in the *Boundary* information with the bounds of the survey area (in eastings and northings). Select a pixel size that will create a manageable file size. Exit the **NAVIGATION** window, and press **Sonar Map** in the main **Xsonar** window and select **RUN**. Repeat this procedure for each sonar line from the survey area. Make sure that the boundary information is correct with every file that is loaded into Xsonar. Each file will be added to the **mosaic.ras** output file, building a digital mosaic. Keep track of the number of lines and samples - they will be needed if the raster file is to be converted to any other format.

CORRECTING ALTITUDES AND VIEWING FILES IN SHOWIMAGE.

Fish altitudes must be checked and corrected BEFORE the slant range routine is performed within Xsonar. To check and correct fish altitudes run ShowImage:

> showimage & ('&' will run ShowImage in the background, allowing the user access to the active terminal)

Retrieve the '.' file and set the file type:

File:

Retrieve:

File:

Type:

There are 4 options: **QMIPS**, **Xsonar**, **Raster Map** and **OTHER.** The '.' file is **Xsonar**.

Display the sonar file:

Image:

Display:

Sonar

The first 512 pings of the sonar file will be displayed on the ShowImage screen. The fish course is towards the base of the screen, making port on the right side of the display, and starboard on the left side of the display.

Display Altitude:

Options:

Port Altitude:

ON

A red line will appear on the port channel representing the bottom tracking. The read line SHOULD run along the first bottom return (first appearance of sidescan sonar data). If the red line appears in the water column (area of no data between nadir line and first bottom return) or further within the sonar record, it must be corrected.

If the altitude needs correction, display the Zoom Window:

Image:

Zoom

A zoom window will appear.

To Zoom in on an area within the main ShowImage display window:

Click and hold on the 2nd mouse button and drag a box around an area of the sonar file. The user should zoom in on an area around the first return running about half the length of the ShowImage display screen. The zoomed in region will automatically appear in the zoom window.

In the Zoom window:

Altitude:

Port: **ON**

A red line will appear representing the bottom tracking.

To correct the altitudes:

Altitude:

Correct:

The cursor will change to a drawing tool. Click and hold the 1st mouse button to draw a new bottom track. Try to follow, as closely as possible, the first bottom return. After drawing is complete, click on the 3rd mouse button to escape the drawing mode.

To make it easier to draw and see the first bottom return, magnify the image:

Options:

Magnify

Save Changes made to the altitude values:

Altitude:

Write Altitudes:

This stage is important. If the altitudes are not written, the changes made **will not be saved.**

Zoom in on the bottom half of the display in the main ShowImage window to correct the next portion of the file. To continue with altitude corrections the user must pan through the rest of the sonar file. When the end of the file has been reached - a popup window will appear saying End Of File.

To pan through a sonar file, return to the main ShowImage display and select:

Image:

Display:

Sonar

The next section of the file will be displayed in the ShowImage window. Correct the altitudes (bottom tracking) for this portion of the data file. Continue through the file until the end of file is reached. After the altitudes (bottom tracking) have been corrected, proceed with the processing using Xsonar. The '.' file is now ready for slant range, destripe, and beam pattern routines.

ShowImage has many other capabilities for analyzing and view sonar data files. See the Xsonar/ShowImage User's Manual for a discussion of these capabilities.

Appendix B: QMIPS™ FILE FORMAT

The following file format is copyrighted by Triton Technologies Inc., Watsonville, CA.

```
/*
  Q-MIPS data format as used by Isis
  written as C-language structures.
  Current 13 December 1994
*/

#define    FORMAT1   1   /* old format (smips) */
#define    FORMAT2   50  /* new format (QMIPS™) */

#ifndef BYTE
#define BYTE unsigned char
#endif

#ifndef WORD
#define WORD unsigned short
#endif

#ifndef DWORD
#define DWORD unsigned int
#endif

typedef struct header_format {
/*************************************************************************/

/* header record */
/*****************/

  BYTE   fileFormat;        /* equal to 50 for Q-MIPS files */
  BYTE   systemType;        /* equal to 202 for Isis-recorded files */
  BYTE   softwareRev[6];    /* String "Isis" or ASCII software rev  */
  BYTE   spare1[18];        /* not used. */

  /* Data storage parameters */
  /*-------------------------*/
  float   sampleRate;              /* Not valid for Isis.  set to 20. */
  WORD    numImageryChannels;      /* 0..4 for Isis-recorded files */
```

```
WORD   bitsPerPixel;         /* 8 or 16 bits per pixel */
WORD   pixelsPerChannelPerPing; /* 0..65535 samples per chan saved */
float  speedOfSoundInWater;   /* Ususlly 750 m/s, 2-way travel time */
float  noLongerUsed;          /* Not used in Isis. */
WORD   asyncChannelNumber;    /* Not used in Isis. */
WORD   numSonarChannels;      /* 0..4 Number of recorded channels */
WORD   ch1_processingAvailable; /* Set to 1 if Chan 1 logged */
WORD   ch2_processingAvailable; /* Set to 1 if Chan 2 logged */
WORD   ch3_processingAvailable; /* Set to 1 if Chan 3 logged */
WORD   ch4_processingAvailable; /* Set to 1 if Chan 4 logged */

/* nav system parameters */
/*-----------------------*/
WORD   timeDelay;             /* Not used */
BYTE   navSystemName[100];    /* Not used */
BYTE   projectionType[12];    /* Not used */
BYTE   spheriodType[12];      /* Not used */
WORD   zone;                  /* Not used */
float  originLat;             /* Not used */
float  originLong;            /* Not used */
float  offsetLat;             /* Not used */
float  offsetLong;            /* Not used */
WORD   navUnits; /* 0 = meters, 1 = feet, 2 = yards, 3 = degrees */


/* site parameters */
/*-----------------*/
WORD   diveNumber;            /* Not used */
WORD   blockNumber;           /* Not used */
WORD   trackNumber;           /* Not used */
WORD   runNumber;             /* Not used */
BYTE   spare4[100];           /* Not used */

/* annotation */
/*------------*/
BYTE   operatorAnnotation[100]; /* Not used */
BYTE   sonarName[40];         /* "Isis Analog Server" */


/* sonar parameters */
/*------------------*/
WORD   triggerDirection;      /* Not used in Isis */
```

```
DWORD  triggerMagnitude;      /* Not used in Isis */
float  triggerWidth;          /* Not used in Isis */

WORD   ch1_frequency;         /* Defaults to 100 */
WORD   ch2_frequency;         /* Defaults to 100 */
WORD   ch3_frequency;         /* Defaults to 100 */
WORD   ch4_frequency;         /* Defaults to 100 */

float  ch1_horizBeamAngle;    /* Not yet used in Isis */
float  ch2_horizBeamAngle;    /* Not yet used in Isis */
float  ch3_horizBeamAngle;    /* Not yet used in Isis */
float  ch4_horizBeamAngle;    /* Not yet used in Isis */

/* name of this file */
/*------------------*/
char   thisFileName[45];      /* Original name of logged file */
char   reserved2;             /* reserved */

/* which channels are half-wave rectified */
/*----------------------------------------*/
WORD   ch1_halfWaveRectify;   /* Set to 0 */
WORD   ch2_halfWaveRectify;   /* Set to 0 */
WORD   ch3_halfWaveRectify;   /* Set to 0 */
WORD   ch4_halfWaveRectify;   /* Set to 0 */


/* Sonar Transducer Tilt Angles (off horizontal) */
/*-----------------------------------------------*/
float  ch1_tiltAngle;         /* defaults to 30 */
float  ch2_tiltAngle;         /* defaults to 30 */
float  ch3_tiltAngle;         /* defaults to 30 */
float  ch4_tiltAngle;         /* defaults to 30 */

/* Sonar Transducer beamWidth at 3dB points */
/*------------------------------------------*/
float  ch1_beamWidth_3dB;     /* defaults to 50 */
float  ch2_beamWidth_3dB;     /* defaults to 50 */
float  ch3_beamWidth_3dB;     /* defaults to 50 */
float  ch4_beamWidth_3dB;     /* defaults to 50 */

float  ch1_realSampleRate;    /* Unused in Isis */
float  ch2_realSampleRate;    /* Unused in Isis */
```

```
  float   ch3_realSampleRate;     /* Unused in Isis */
  float   ch4_realSampleRate;     /* Unused in Isis */

  /* left over */
  /*----------*/
  BYTE    spare5[438];          /* reserved */


} QMIPSHEADER;


/*******************************************************************
  Note: in the comments below, the bracketed characters represent
  the Navigation Template characters that can be used to fill the
  given fields.
*******************************************************************/


typedef struct sonar_struct2 {
/*****************************************************************/
/*  Every ping ends with this 256-byte structure. Note that not
   all fields will be used during every run. If not all
   channels are being used, the remaining channels will contain
   0's for all fields.
*/

  /* time and date stamp */
  /*-------------------*/
  BYTE    day;
  BYTE    month;        /* will be time and date of nav system */
  BYTE    year;        /* user specifies 'AB' in nav template */
  BYTE    hour;
  BYTE    minute;
  BYTE    seconds;
  WORD    thousandsSeconds; /* 1000th of seconds */

  float   magX;        /* [e] X-axis magnetometer data */
  float   magY;        /* [w] Y-axis magnetometer data */
  float   magZ;        /* [z] Z-axis magnetometer data */

  DWORD   pingNumber;   /* counts from 0 at start of file */

  WORD    asyncByteOffset; /* not used in Isis */
```

```
WORD    shipSpeed;      /* [v] speed of ship (knots * 100) */

float   auxVal1;        /* [1] Aux value displayed in Sensors box */
float   auxVal2;        /* [2] Aux value displayed in Sensors box */
float   auxVal3;        /* [3] Aux value displayed in Sensors box */
float   auxVal5;        /* [5] Aux value displayed in Sensors box */

/* processing parameters */
/*----------------------*/
float   auxAltitude;    /* [a] auxiliary altitude */

WORD    triggerChannel; /* not used in Isis */
WORD    altSource;      /* not used in Isis */
DWORD   waterColumn;    /* not used in Isis */
DWORD   triggerPeriod;  /* not used in Isis */
WORD    ch1_signalDivisor; /* set to 1 */

/* telemetry from towfish */
/*------------------------*/
float   telemFishDepth;   /* [0] depth (sea surface to sonar) in meters */
float   telemFishHeading; /* [h] heading in degrees */
float   telemFishPitch;   /* [8] pitch in degrees (positive=nose up) */
float   telemFishRoll;    /* [9] roll in degrees (positive=roll to stbd) */
float   telemFishAlt;     /* [7] Altitude tracked by Isis - in meters */
float   telemSbotAlt;     /* unused in Isis (reserved) */
float   telemSpeedLog;    /* [s] speed log sensor on towfish - knots */
WORD    soundVelocity;    /* [{v}] sound velocity in m/s, can also be computed, */
                /* stored times 30 */

/* sonar parameters */
/*------------------*/
float   ch1_floatRawRange; /* Chan 1 slant range in meters */
float   ch1_delayRange;    /* Not used in Isis - reserved */
WORD    ch1_bandWidth;     /* Not used in Isis */
WORD    ch1_sampleScheme;  /* Set to 2 */
WORD    ch1_rawRange;      /* integer slant range Chan 1 */
BYTE    ch1_initialGain;   /* [q] Chan 1 initial gain code */
BYTE    ch1_gain;          /* [g] Chan 1 gain code */
WORD    reservedForFloatSampleRate; /* Not used in Isis */
WORD    sampleRate;        /* Not used in Isis - reserved */
WORD    ch1_correctedRange;/* Not used in Isis */
                /* compute ground range as
```

```
                sqrt(ch1_floatRawRange^2 - telemFishAlt^2)
              */
float   ch2_floatRawRange; /* Chan 2 slant range in meters */
float   waterTemperature;  /* [{w}] Water Temperature in C, can be computed from [b] */
WORD    ch2_bandWidth;     /* Not used in Isis */
WORD    ch2_sampleScheme;  /* Set to 2 */
WORD    ch2_rawRange;      /* integer slant range Chan 2 */
BYTE    ch2_initialGain;   /* [r] Chan 2 initial gain code */
BYTE    ch2_gain;          /* [j] Chan 2 gain code */
WORD    oceanTide;         /* [{t}] Ocean tide in meters times 100 */
WORD    ch2_signalDivisor; /* Set to 1 */
WORD    ch2_correctedRange;/* Not used in Isis */
              /* compute ground range as
                sqrt(ch2_floatRawRange^2 - telemFishAlt^2)
              */
float   ch3_floatRawRange; /* Chan 3 slant range in meters */
float   pressure;          /* [{p}] water pressure in psia, can be computed from [0] */
WORD    ch3_bandWidth;     /* Not used in Isis */
WORD    ch3_sampleScheme;  /* Set to 2 */
WORD    ch3_rawRange;      /* integer slant range Chan 3 */
BYTE    ch3_initialGain;   /* [t] Chan 3 initial gain code */
BYTE    ch3_gain;          /* [k] Chan 3 gain code */
WORD    range_to_fish;     /* [?] slant range to fish times 10 */
WORD    ch3_signalDivisor; /* Set to 1 */
WORD    ch3_correctedRange;/* Not used in Isis */
              /* compute ground range as
                sqrt(ch3_floatRawRange^2 - telemFishAlt^2)
              */
float   ch4_floatRawRange; /* Chan 4 slant range in meters */
float   ch4_delayRange;    /* Not used in Isis - reserved */
WORD    ch4_bandWidth;     /* Not used in Isis */
WORD    ch4_sampleScheme;  /* Set to 2 */
WORD    ch4_rawRange;      /* integer slant range Chan 4 */
BYTE    ch4_initialGain;   /* [u] Chan 4 initial gain code */
BYTE    ch4_gain;          /* [n] Chan 4 gain code */
WORD    bearing_to_fish;   /* [>] bearing to fish in degrees * 100 */
WORD    ch4_signalDivisor; /* set to 1 */
WORD    ch4_correctedRange;/* Not used in Isis */
              /* compute ground range as
                sqrt(ch4_floatRawRange^2 - telemFishAlt^2)
              */
```

```
/* nav system parameters */
/*-----------------------*/
WORD    turbidity;          /* [I] turbidity sensor (0 to +5 volts) stored times 10000 */
int     currentLineIdentifier; /* [i] Current line ID from serial nav */
int     eventNumber;        /* [O] last unique event number */

float   auxVal6;          /* [6] Aux value displayed in Sensors box */

double  shipLatitude;     /* [y] Ship latitude */
double  shipLongitude;     /* [x] Ship longitude */

float   navEasting;       /* [E] fish easting */
float   navNorthing;       /* [N] fish northing */

float   cableTension;     /* [P] cable tension from serial port */

float   conductivity;     /* [{c}] Conductivity in S/m can be computed from [Q] */
float   navFishHeading;   /* Unused by Isis - see telemFishHeading */
float   navFishSpeed;     /* [V] Speed of towfish in knots */
float   navShipGyro;      /* [G] Gyro of ship */

float   auxVal4;          /* [4] Aux value displayed in Sensors box */
double  navLongitude;     /* [E] with '$' in nav lemplate; longitude
                    of fish (header.navUnits==3) */

WORD    fishLayback;      /* [l] horizontal distance from ship to fish */
BYTE    navFixHour;       /* [H] Hour of last nav update */
BYTE    navFixMinute;     /* [I] Minute of last nav update */
BYTE    navFixSeconds;    /* [S] Seconds of last nav update */
BYTE    onLineFlag;       /* unused in Isis */
WORD    julianDay;        /* Number of days since January 1 */
WORD    cableOut;         /* [o] amount of cable payed out in meters */

} QMIPSFOOTER;
```

Appendix C: XSONAR FILE FORMAT

```
#if defined(__alpha) || defined(ultrix) || defined(__ultrix) || defined(i386)
#define INTEL 1
#else
#define INTEL 0
#endif

#if defined(mc68000) || defined(sony) || defined(sgi) || defined(sun)
#define MOTOROLA 1
#else
#define MOTOROLA 0
#endif

/*
 *   New structure for compacted data which has been expanded
 *   to hold more variables -- updated 6/11/90 -- bwd
 *   expanded this out to 256k, will accomodate 16/32 bit systems -- 11/13/90 -- bwd
 *   updated 4/18/94 -> added clon variable (central longitude) -- bwd
 *   updated 12/2/95 -> added all variables after clon to account for systems which include
 *   these parameters -- bwd
 */

typedef struct {           /* total header size = 256 bytes                */
   double djday;           /* 0 decimal julian day for time                */
   double utm_n;           /* 8 UTM northing for ping position             */
   double utm_e;           /* 16 UTM easting for ping position             */
   double utm_azi;         /* 24 towfish azimuth determined from spline    */
   float fish_azi;         /* 32 original azimuth readings from towfish    */
   float latitude;         /* 36 latitude from QMIPS™ data file            */
   float longitude;        /* 40 longitude from QMIPS™ data file           */
   float course;           /* 44 course from nav -- Ship Gyro              */
   float pitch;            /* 48 fish pitch from telemetry                 */
   float roll;             /* 52 fish roll from telemetry                  */
   float depth;            /* 56 pressure depth in meters                  */
   float alt;              /* 60 altitude in meters of sonar vehicle       */
   float total_depth;      /* 64 depth of seafloor at vehicle position     */
   float range;            /* 68 slant range to fish from Sonotech system  */
   float sec;              /* 72 total seconds from 00:00 GMT              */
   int year;               /* 76 from nav system, saved in data file       */
   int julian_day;         /* 80 from nav system, saved in data file       */
```

```
   int sdatasize;        /* 84 # of bytes in ping: header + data          */
   int swath_width;      /* 88 swath width in meters                      */
   float pulse_width;    /* 92 pulse width of outgoing in milliseconds    */
   int power;            /* 96 transmit power                             */
   float clon;           /* 100 central longitude for UTM zone calculations */
   int merged;           /* 104 flag to indicate whether nav is merged    */
   int fileType;         /* 108 flag to indicate file type (XSONAR)       */
   int byteOrder;        /* 112 flag for processor type used to create file */
   float temperature;    /* 116 water temp in degrees C                   */
   float conductivity;   /* 120 in siemens / meter                        */
   float waterPressure;  /* 124 in psia                                   */
   float shipsSpeed;     /* 128 in knots                                  */
   int spare[31];        /* 124 spare bytes for future use                */
} PingHeader;


/*
 *   structure for the header of screen image files put directly on disc
 */

typedef struct {
   int type;
   int byteOrder;
   int width;
   int height;
   float pix_size;
   int back_color;
   int spare[3];
   double east;
   double west;
   double north;
   double south;
   double centralLon;
} ImageHeader;
```

Appendix D: XSONAR ASCII NAVIGATION FORMAT

This format is provided as a convenience for programmers and those who wish to construct an ASCII navigation file to be merged with an Xsonar format data file if none exists. For further information, consult the file "sonar_struct.h" in the Xsonar/Showimage distribution. The fields can be delimited by any white space (tabs, spaces) and the floating point fields can contain as many decimal places as deemed necessary (the input is scanned by fscanf with a format of %f). West longitude as well as south latitude is always negative. Example:

Julian Day	Hour	Minute	Second	Latitude		Longitude	
				Degrees	Minutes	Degrees	Minutes
250	18	30	20	37	42.14	-73	21.2123
250	18	30	25	37	42.1633	-73	21.23

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