Detailed discussion of backscatter imagery processing

PIBHMC utilizes software developed in-house by HMRG to process seafloor acoustic imagery data. The software was originally developed to process data from the shallow-towed HAWAII-MR1 phase-difference sidescan bathymetry mapping system. In 2003 the software tools were modified to operate on multibeam backscatter data collected by the University of Hawaii research vessel Kilo Moana and the R/V *AHI* to test whether the software could improve the quality of the multibeam backscatter and the resulting data products. These tools are effective in eliminating speckle and stripe noise, and cross-track amplitude variability due to angle-varying gain and can also be used to produce final mosaics of sonar imagery. They have recently been expanded to allow operation on data collected using the multibeam systems aboard the NOAA Ship *Hi'ialakai*.

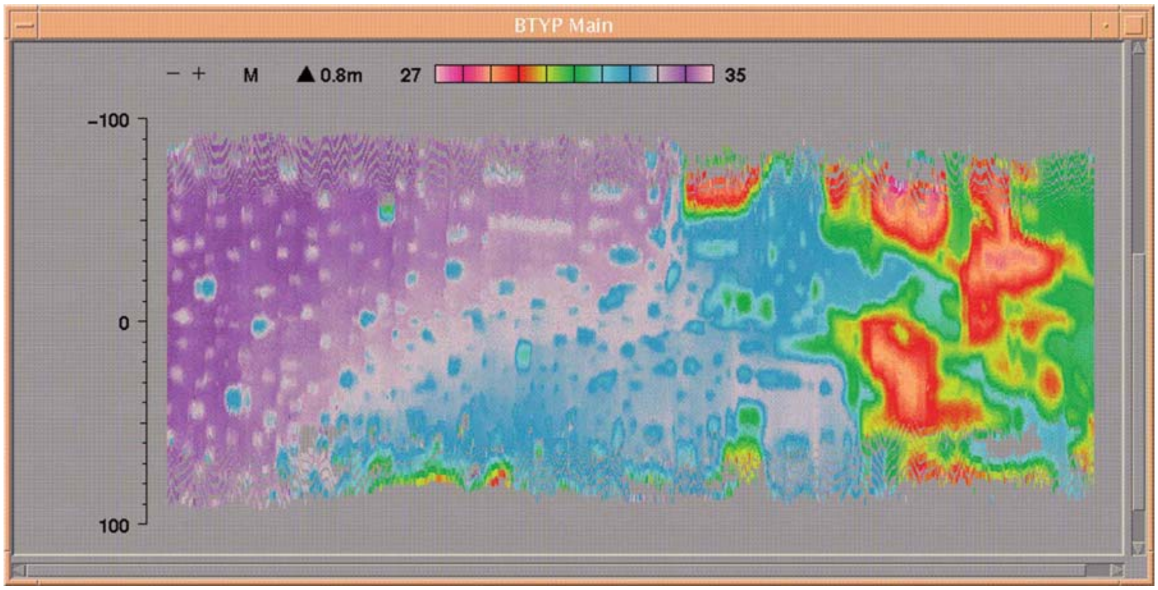
HMRG processing software runs on Linux, UNIX and Irix platforms. Most programs can be run in either graphical or command-line modes. The preferred processing scheme involves using the graphical interface to interactively determine noise filters appropriate for each survey. Once characterized, these filters are then applied in batch processes that run faster than graphical methods allow. After processing is completed, the HMRG software is used to grid the data and then to assemble individual grids into mosaics. The mosaics can be output as Sun raster files, GeoTIFFs, or Generic Mapping Tools (GMT) grids, which allow the mosaics to be imported into other GIS and charting programs.

<u>Convert and Split Files</u>

GSF data swath edited in SABER are converted into HMRG's MR1 format using HMRG conversion software. Some of the GSF and converted BS file sizes are very large -- some more than a gigabyte. The HMRG data display programs cannot open files that big so we split the files into more manageable sizes.

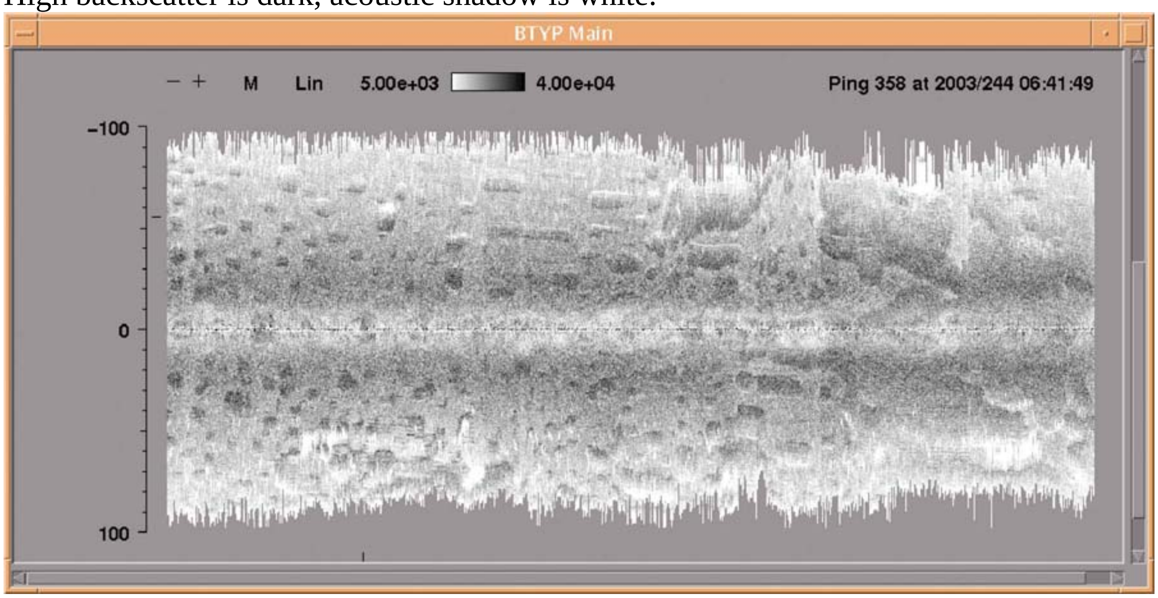
<u>Manual Bathymetry Editing Using BTYP</u>

BS format files contain both bathymetry and backscatter data, and each can be viewed and manually edited using the program BTYP. Bathymetry swath data are shown below, spanning a depth range of 27 to 35 meters. Data can be panned and zoomed, and data editing can be performed using either an interactive swath edge trimming tool, or a rectangle extraction tool. PIBHMC typically uses external software (SABER) for manual bathymetry editing prior to conversion to BS format.



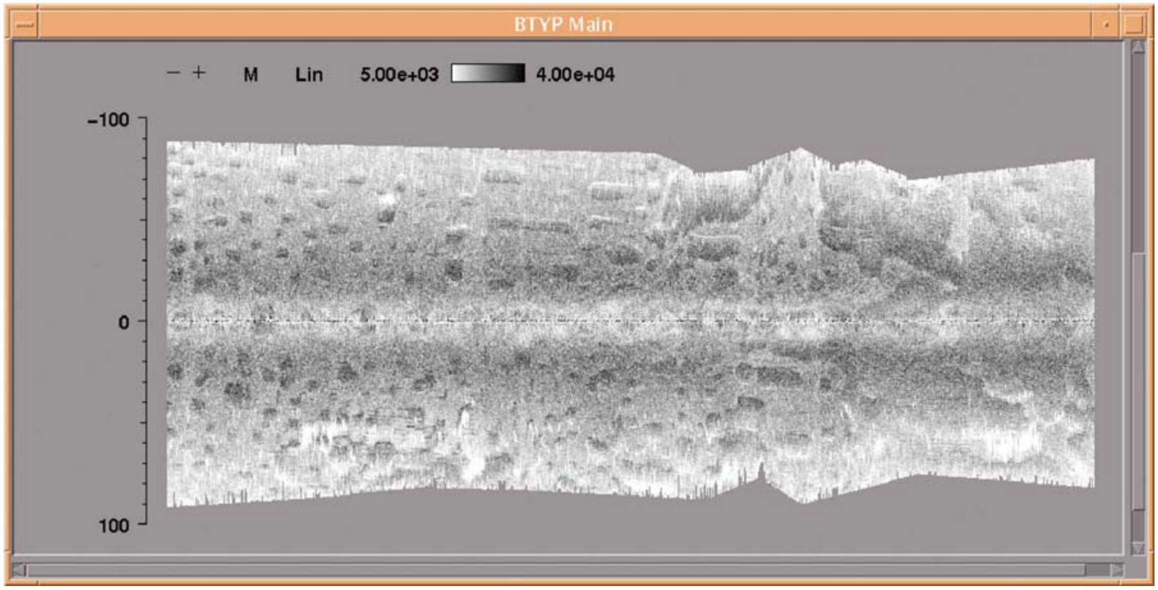
Examine Raw Sidescan Using BTYP

In the same BTYP window, swath data may be toggled between bathymetry and backscatter, allowing users to use the backscatter to evaluate the quality of bathymetry soundings. The figure below shows the same section of data as the bathymetry window above. The Y-axis represents distance in meters away from nadir (nadir is 0), with data from the port side reported as negative values and appearing above nadir in this view. High backscatter is dark, acoustic shadow is white.



Swath Sidescan Editing in BTYP

Backscatter data may be edited in BTYP in the same manner (and at the same time) as swath bathymetry data. The example below has been edited to take the "fuzz" off the edges. This sort of trimming is useful when ping lengths change from ping to ping or as a means to remove noise (acoustic or electronic) that corrupts the backscatter image.



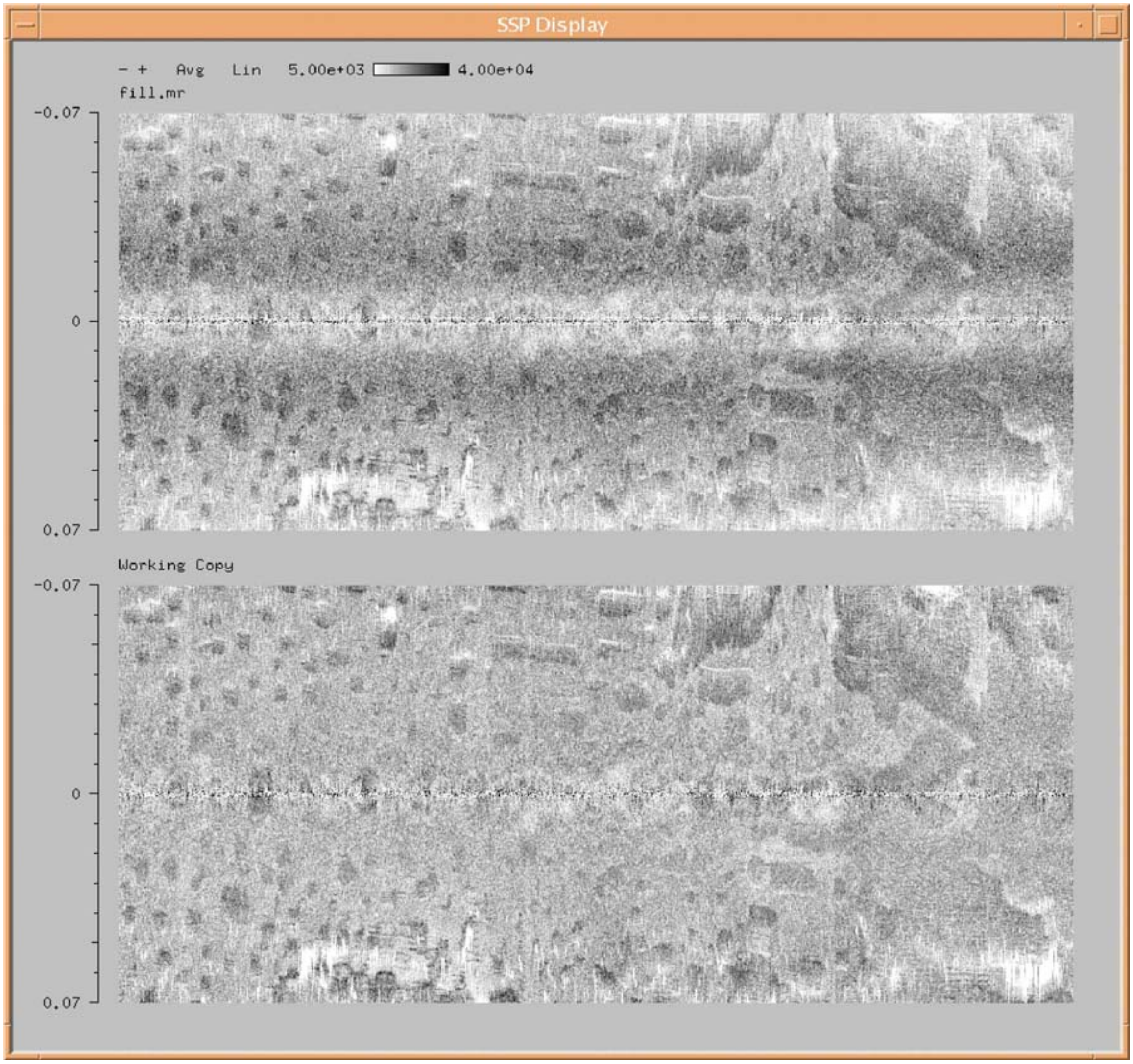
Sidescan Image Processing Using SSP

Sidescan image processing can be conducted graphically using the SSP interface. SSP works by implementing the same processing modules that users may also engage from the command line, and in practice the SSP graphical editor is usually run at the beginning of a processing job in order to determine appropriate processing steps for a particular data set. Once determined, these processing steps can be wrapped into a shell script for batch processing, freeing up data processors to do other important things.

The SSP display below shows the raw sidescan swath on the top of the window, and the processed version of the swath below, allowing users to visually evaluate the effects of processing operations as they work. The example below exhibits several problems that are commonly encountered: along-track striping due to cross-track variations in amplitude; DC scale changes related to changes in power settings, and microstripe noise. The following steps will fix these problems.

Angle Varying Gain

Along-track striping related to systematic cross-track variation in backscatter is removed using the angle-varying gain (AVG) module: bsavg. This tool allows users to create and apply AVG corrections. The image in the bottom of the window below shows the result.

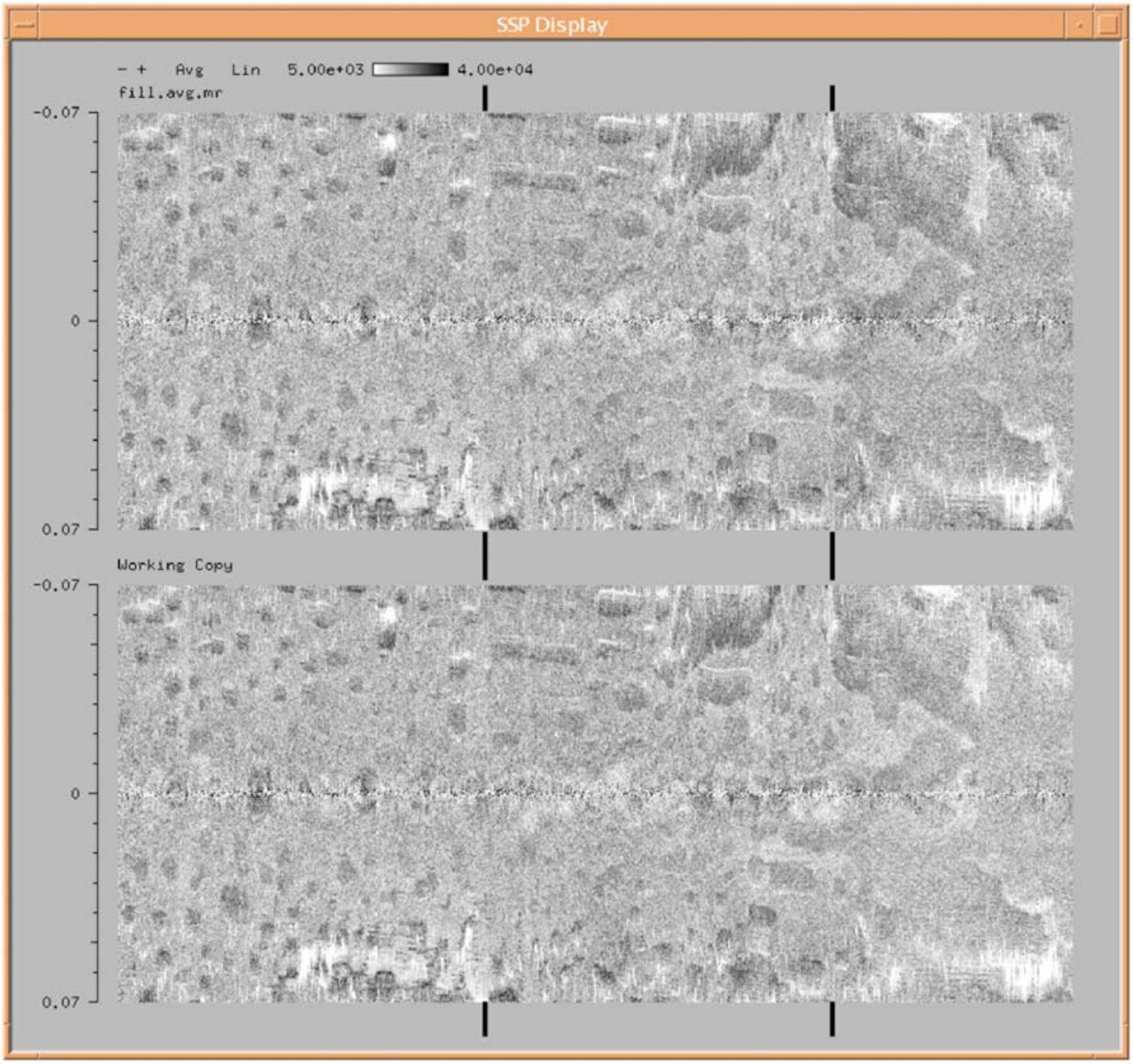


Static Amplitude Corrections

Many sonars change their transmit power or pulse width, often as a function of water depth or due to user interaction. As a result, the backscatter across the entire swath may exhibit a step-like increase (or decrease) at the time of the change. Two such steps are evident in the example below, both involving an increase in transmit power (and a step to higher backscatter) progressing left-to-right. The two steps are indicated by the vertical black lines.

SSP allows users a graphical means to boost or retard the backscatter values across the entire swath to normalize the backscatter along the swath. By correlating the scaling factor determined in this graphical fashion, users can construct scaling schedules so that power settings can be automatically compensated using the bsscale program in batch mode.

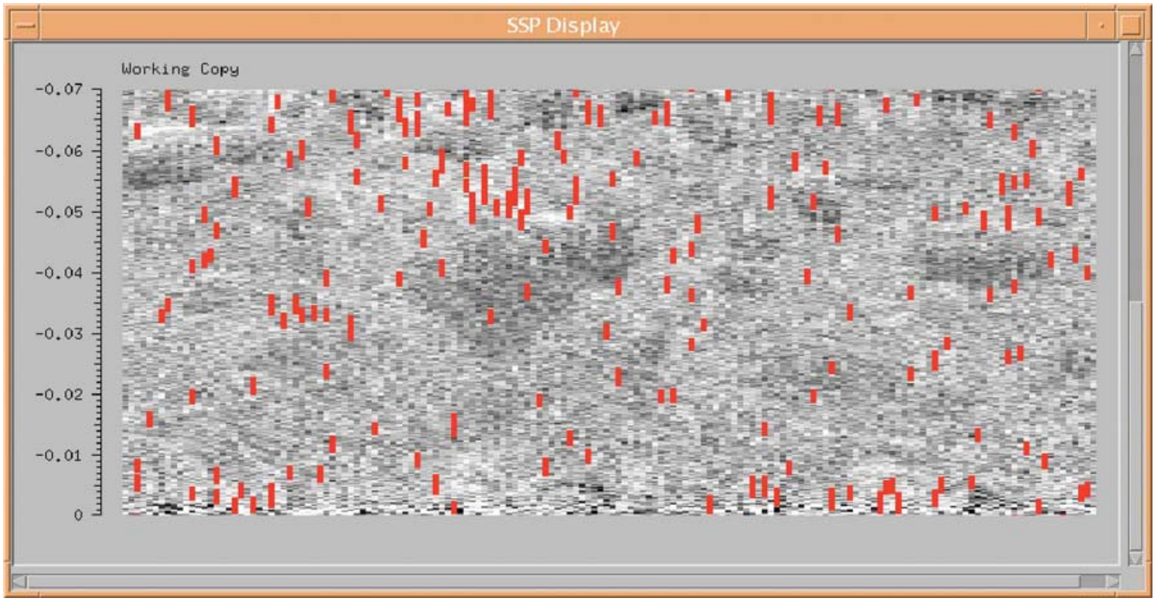
The example below has been partially corrected: one of the amplitude steps (top) has been removed (bottom), but the other has not.



<u>Speckle and Microstripe Removal</u>

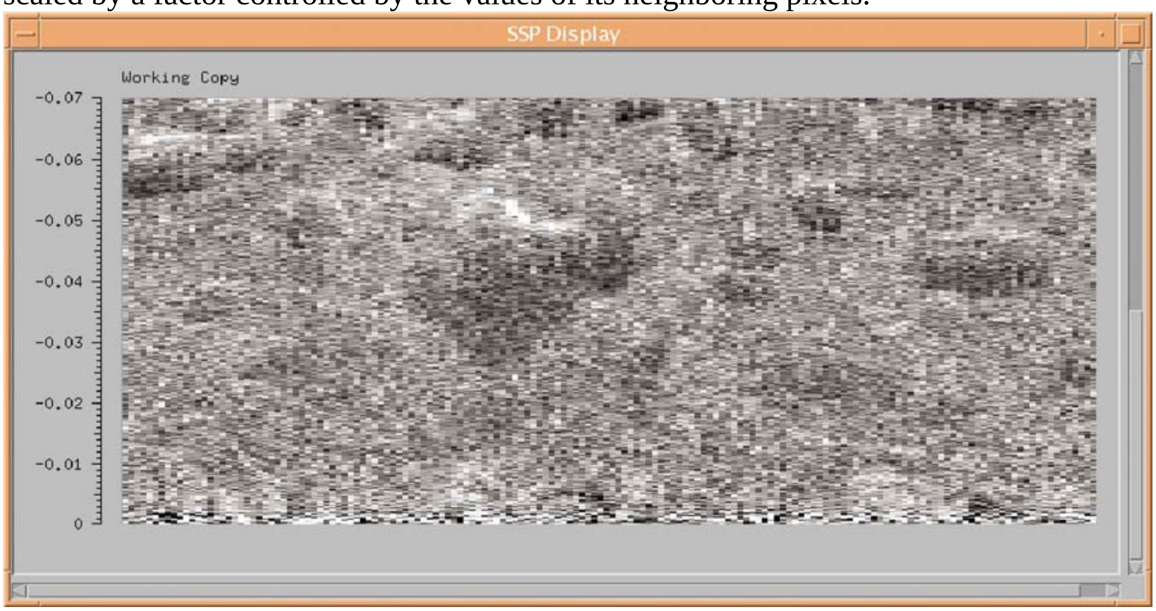
Speckle and stripe noise can result from acoustic or electrical noise, hiccups in the sonar acquisition system, or transducer motion. Noise often appears as a high-amplitude speckle, and transducer motion often results in low-amplitude stripes or microstripes (a microstripe is defined as a stripe oriented in the across-track direction that does not extend across the entire width of the swath).

The example below contains low-amplitude microstripes that are related to the way this particular multibeam sonar records its backscatter imagery. The SSP interface is used to develop a two-dimensional filter that specifically targets a type of noise. The window below shows a subset of the swath being processed, and SSP has been used to highlight in red the pixels that have been identified as microstripe noise by this filter.



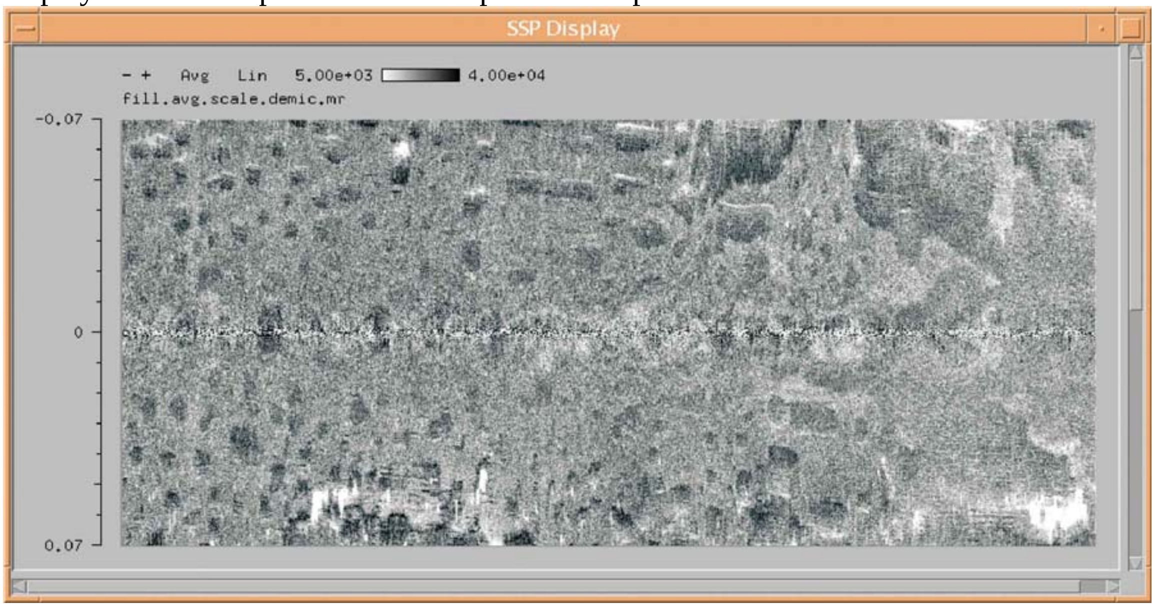
Once the noise can be targeted, SSP can be used to determine the best way to process the microstripe noise. Options include two dimensional filters using square or rectangular dimensions, or more elaborate replacement mechanisms that allow pixels to be scaled up or down depending on the values of their neighbors. The latter replacement scheme is useful when pixels contain real information, for instance periods when the sonar transducer has moved (due to pitch or yaw) and is not listening in the same azimuth as it transmitted.

The image below shows the same close up as above, except the noisy pixels have been scaled by a factor controlled by the values of its neighboring pixels.



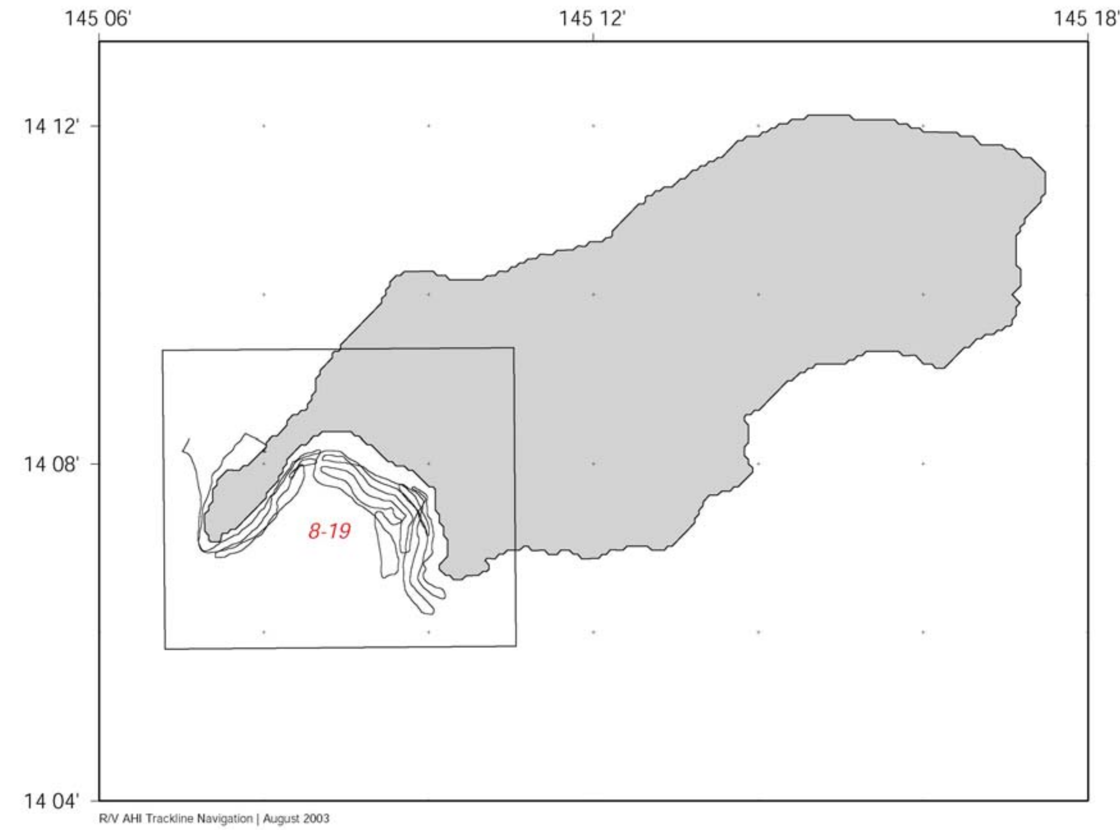
Gray Scale Display Values

Finally, SSP is useful for quickly determining the best gray-scale lookup table to use to display backscatter data. Depending on the dynamic range of the stored data, the material properties and structural characteristics of the seafloor being mapped, different gray scales may be required. The example below shows the final processed swath, displayed using a linear reverse (black=high backscatter) gray scale that goes from 5,000 (white) to 40,000 (black). With two mouse clicks this can be changed to a logarithmic display with high backscatter mapped to white. Sounds trivial, but anybody who's tried to create and display sidescan maps knows what a pain this step is.

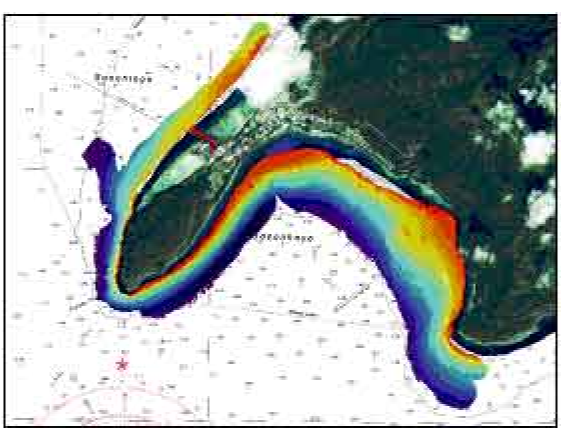


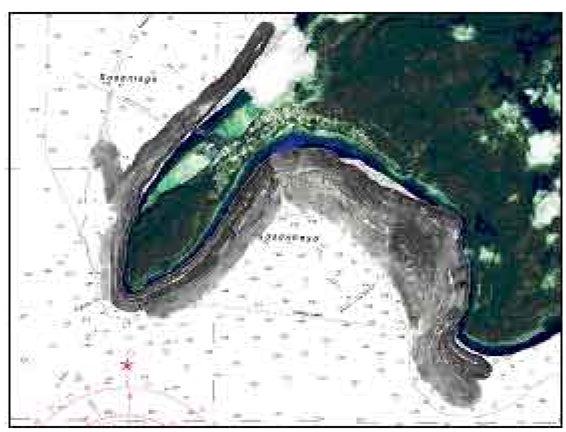
Results

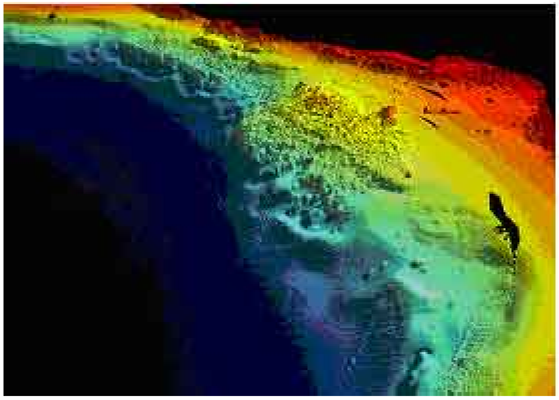
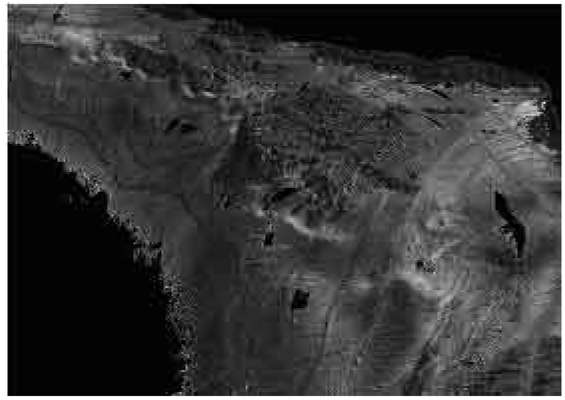
During August and September 2003, data were collected with the R/V *AHI* at Rota and Saipan in the Commonwealth of the Northern Mariana Islands (CNMI). The tools described above were used to process, grid and display the backscatter data in order to create charts of acoustic imagery. Bathymetry data were processed in parallel using other software tools, and then incorporated into digital elevation models that were used to display the backscatter data in three dimensions. These images display high backscatter as black, and acoustic shadow as white.


145 06'
145 12'
145 18'
14 12'
14 08'
14 04'
8-19
R/V AHI Trackline Navigation | August 2003

Rota, CNMI

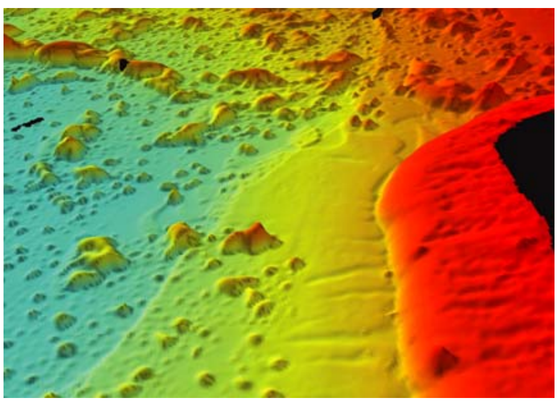




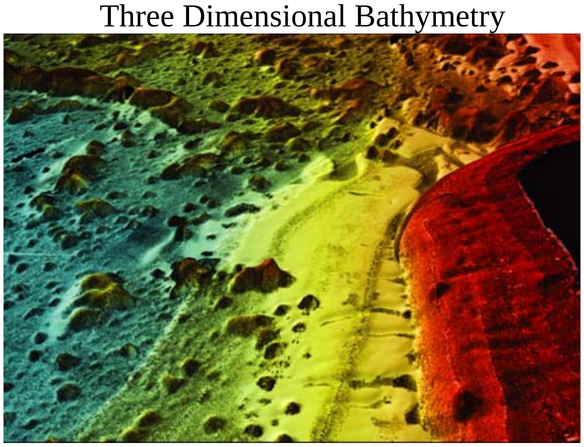
Saipan & Tinian, CNMI

During the CNMI survey, the entire insular margin of Saipan was surveyed. The data shown is a small portion of the data from that survey.



Three Dimensional Bathymetry

Three Dimensional Backscatter



Gridded Multibeam Backscatter Draped on Three Dimensional Bathymetry