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Abstract

A variety of signal processing techniques are available which can assist the interpretation of side-scan sonar. In exploring the range of possibilities for processing with these techniques we have developed selective tuning of textural enhancement for different textural wavelengths. In practice we have found it desirable to be free to decide on tuning, or whether to use textural enhancement at all, based on tests simulating the survey conditions as faithfully as possible.

Test targets 1-2 meters long were recorded well on three alternative recordings, but were more readily identifiable when fine and grose bottom textures were suppressed by an intermediate selection of textural enhancement. If the bottom texture had been of interest, a different choice would have been made.

1. Introduction

Side-scan sonar (Klein '67) has become a recognized tool for surveying the ocean bottom in geologic investigations, searches for objects on the bottom, and for hazard surveys (Grice, Klein and Edgerton, Van Reenan, Tinkle et al). Hard-copy sonographs which recognizably record images of bottom textures and objects are the key to this success. Prerequisites for the necessary image quality are narrow horizontal beamwidth and stable orientation of the transducer. Signal processing is also crucial to condition amplitudes to within the threshold and saturation limitations of the display system (Klein '73, Henderson).

Side-scan signal return from the sea floor is principally backscatter from bottom texture. The returns from many elements of bottom roughness add to form a gross signal which retains a variation with time which is related to texture of the bottom. The strength of the gross signal returned depends on angle of incidence of the sonar pulse on the bottom, spreading and diffraction losses and absorbtion loss in propagation, and on the summation of returns from textural elements at any instant. The last category is of interest, the others are unavoidable complications which must be compensated with time-varied gain (TVG) or other signal processing.

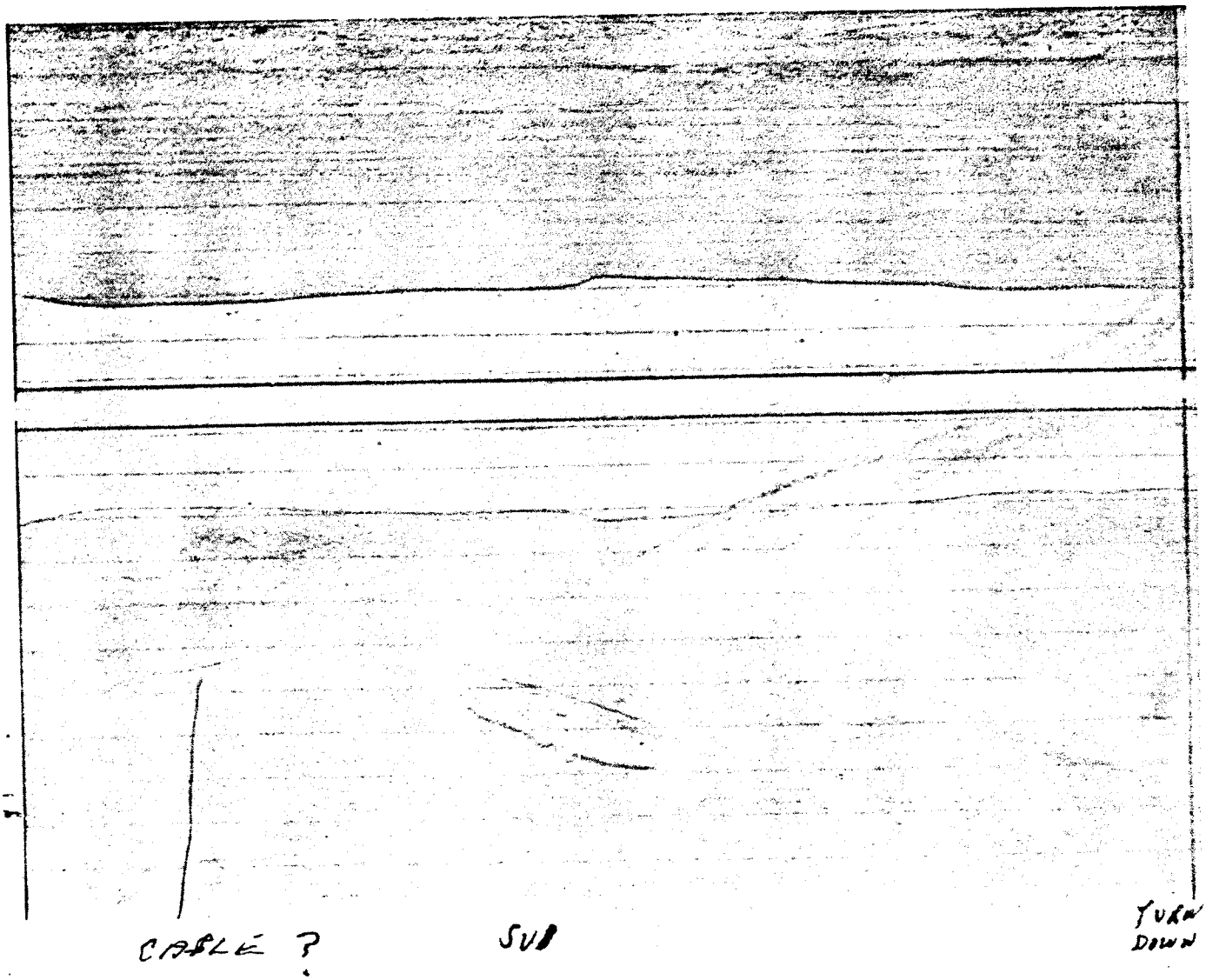
The textural variation of the signal may be enhanced by filtering to suppress the gross signal while allowing the texture to pass. This technique and a proprietary technique trademarked Hands-Off-Tuning were introduced by Klein Associates at Offshore Technology Conference 1974. Together they make it possible to make good side-scan records without TVG, or other techniques such as automatic gain control (AGC) which can introduce unwanted modifications to the signal. These techniques were introduced to relieve the operator of the responsibility of establishing and maintaining settings of the TVG controls. An example record made with these techniques is presented in figure 1.

In this paper we present comparative results of textural enhancement tuned for different wavelengths and of normal recording of the gross signal.

2. Application

The U. S. Naval Explosive Ordnance Disposal Facility Research Department requested training for side-scan sonar operators to be conducted at Solomons Island, Maryland in May 1974. The personnel were to be trained to use and maintain side-scan equipment in Egypt for survey of the Suez Canal and entrances for unexploded ordnance (Rice and Burdette). I (D.K.) was sent to conduct this training and to offer to test alternatives to the

* The work reported here was performed before this author's current employment with the Geological Survey, Conservation Division.



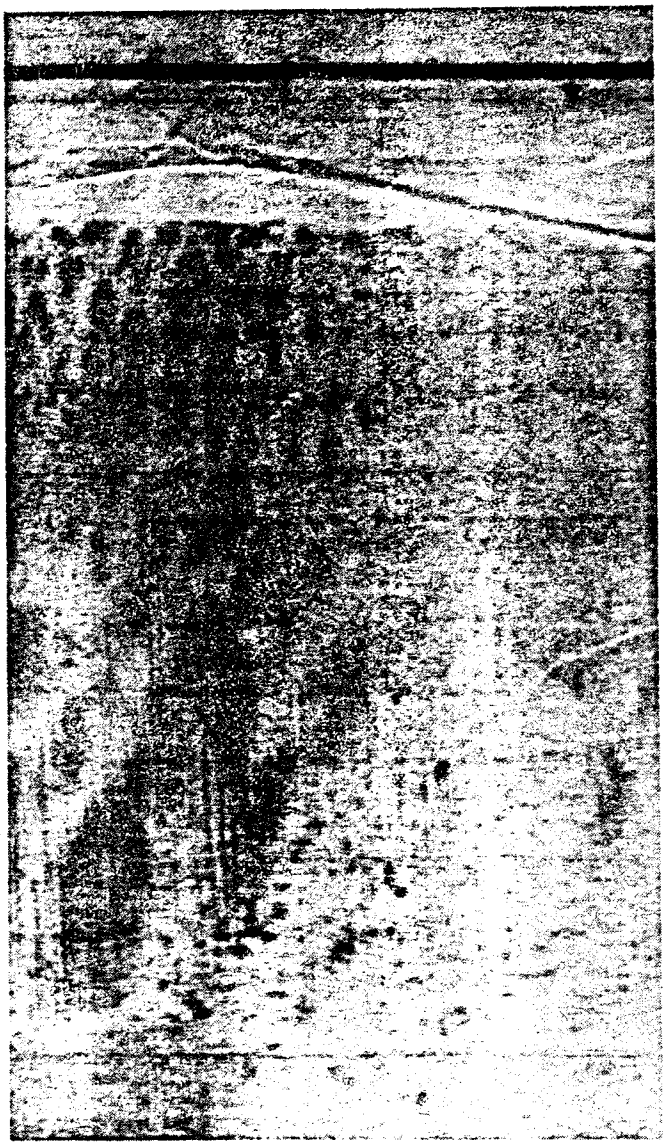
1. Standard Textural Enhancement with Hands-Off-Tuning™

signal processing which we believed best suited to the task.

The site of the on-board training and experiments was a lead of the lower Patuxent River along the west side downstream from the Naval Ordinance Laboratories test facility and upstream of the town of Solomons Island. The personnel had been training in the use of a precision navigation system during the previous week in the same area, so we added the sonar to the systems already on board their training vessel and used the precision navigation for the sonar training and tests in this area.

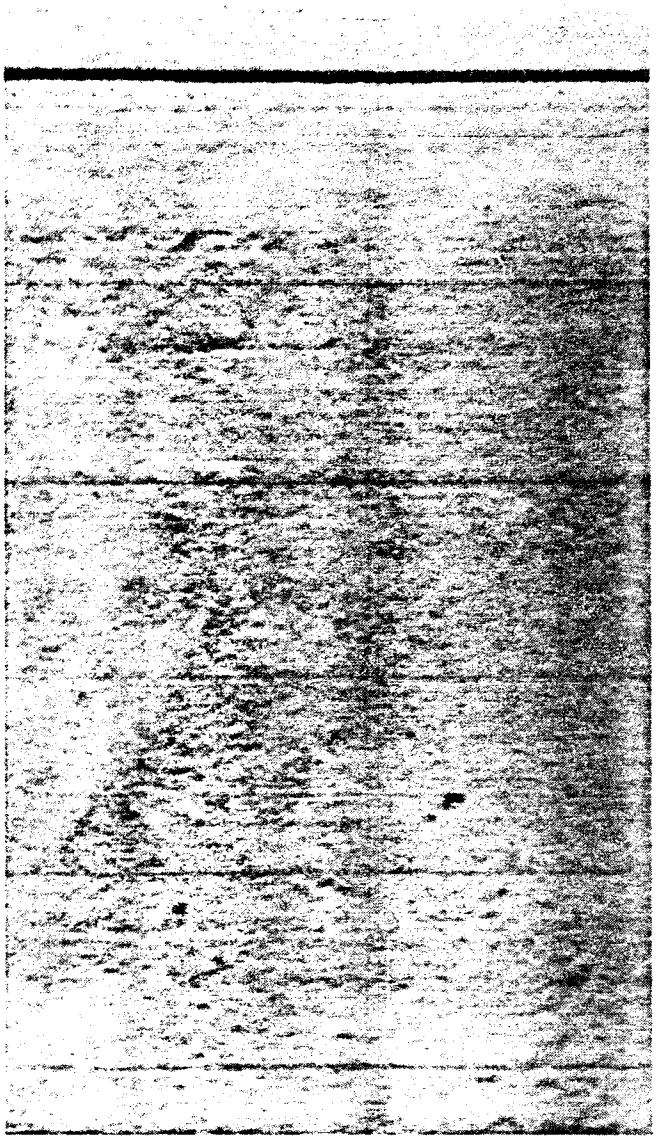
On the first day a test target was dropped at a location marked by precision navigation. When we returned to look for it the next day, we found nothing, even by diver search. Assuming that the navigation was correct, the most likely explanation is that the cylindrical, light-weight test object was rolled away from the drop location by currents along the gently-sloping bottom.

A rope and buoy were attached to a pair of test objects after this to provide continuing assurance of the presence of the test objects, and to aid in establishing lines of steering close

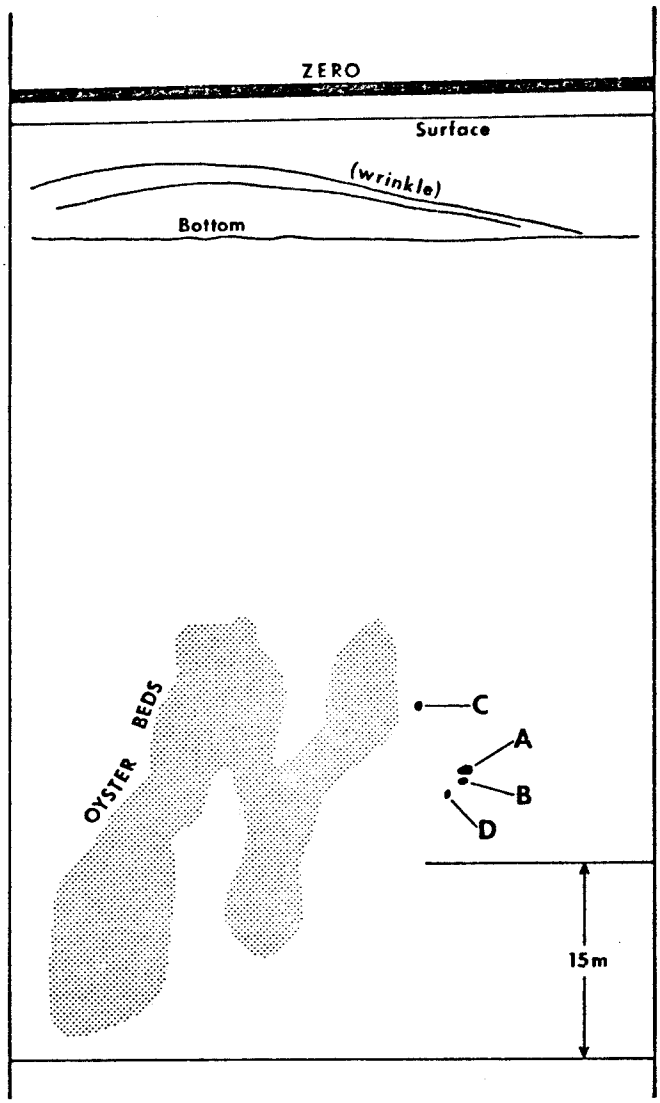


2. Gross Signal

3. Fine Textural Enhancement



4. Standard Textural Enhancement



5. Tracing from Figure 2

enough for the targets to be seen on the sonar record. One of the targets was a cylinder of rather heavy metal, about 1 1/2 meters long by 20 centimeters in diameter. The other object was composed of several pieces of formed sheet aluminum in an umbrella-like array about 2 meters across. They were tied about 2 meters apart on the same polypropylene rope which extended up to the surface float of foam painted day-glow pink.

3. Results

After the training of operators had progressed satisfactorily, we attempted alternatives to the Hands-Off-Tuning and standard textural enhancement initially provided. The results of these alternatives became clearly evident only after Captain Peter Hill and I spread out all of the records for comparative examination at the diving facility at Indian Head, Md. after completion of the initial training exercise.

The first result of the comparisons was the decision not to use Hands-Off-Tuning (TM): The intensity of the recordings of these targets was stronger without it, and in greater contrast with the bottom textures. The risk inherent in this decision was that the operators would now have full responsibility to maintain the TVG settings.

Comparison between gross signal, fine texture enhancement, and standard textural enhancement are presented in figures 2, 3, and 4, respectively. A reference drawing traced from figure 2 is presented as figure 5.

The value of the precision navigation for these tests is evident in the relatively constant geometry among the three illustrations. The principal difference in geometry is due to boat speed, which was not a controlled variable.

It can be seen in the figures that the test targets, A and B, are best distinguished from bottom return using standard textural enhancement. These two targets are better distinguished from each other with either textural enhancement than with recording of the gross signal also, in which case their images seem to merge. We do not know what the objects at C and D are, but one might guess that the surface float accounts for one of them. A cause for concern in tests, such as this, is that even a rope to the surface might be recorded if there were air trapped in the fibers, or other reason for considerable acoustic cross section.

4. Conclusions

Selective filtering of side-scan sonar returns can enhance certain textural wavelengths while suppressing others. In the case presented here, bottom texture was suppressed while retaining a strong recording of test targets which were chosen to simulate targets of the proposed survey. With this selection it was expected that interpretation of possible targets on the recordings during the survey would be simplified.

The tests reported here were not conducted in the survey area, and the objectives of the survey changed to include smaller objects than the targets used in the tests reported here. However, similar tests can and should be conducted in actual search areas with more appropriate test targets, if the full value of selective tuning is to be realized.

Side-scan sonar returns could be recorded on magnetic tape before processing for enhancement. These recordings might then be replayed several times using different enhancements if more than one purpose were to be served by the recordings, or if the selection of desired processing could be more easily made in this way than by several live tests.

In some circumstances textural enhancement may be disadvantageous: The oyster beds in the area of these tests are recorded most strongly in figure 2, so a biologist might prefer not to select textural enhancement in a survey for oysters.

Acknowledgement

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