IEEE
OCEANIC ENGINEERING SOCIETY
NEWSLETTER

VOLUME XXIII NUMBER 1

EDITOR: HAROLD A. SABBAGH SPRING 1989 (USPS 420-910)

PRESIDENT'S COMMENTS

At the joint meeting of the Marine Technology Society (MTS) and the IEEE Oceanic Engineering Society (OES) Executive Committees held on November 2, 1988, it was mutually decided that it would be in the best interests of both societies to separate the joint annual sponsorship of the Oceans Conference beginning in 1990 and beyond. This decision was ratified at the November meeting of the AdCom of OES.

Oceans '88 was a great success in many ways. The attendance was over 2,500, the booths numbered over 200, and an unprecedented number of Government officials and VIPs attended and participated. However, it was felt by the OES Executive Committee and AdCom that the technical program suffered in terms of organization, coordination, and simply because of the enormous breadth of the conference. In order to better serve the IEEE members' interests, it was felt that two separate conferences (an IEEE conference focusing in areas of ocean engineering with a strong emphasis on technical content and depth, and a separate MTS-sponsored conference focusing on policy and technically softer aspects of ocean problems) would better serve the interests of both societies. In each of these two symposia, it is hoped by both societies that the other society and its members will be participating members in order to continue to serve the best interests of the Oceans community. Invitations will be sent out to MTS and other societies to be participating members.

This change, while it promotes the interests of IEEE members, also raises a great challenge to the membership of IEEE OES. Conference responsibilities and activities that in the past have been handled by stronger local chapters of MTS cry out for support from the grass roots membership of OES. In order to have the type of conference and society we want, we need, far more than ever before, the enthusiasm and active support of our members.

The 1990 IEEE-OES-sponsored Oceans '90 Conference will be held in the Washington D.C. area, and we need volunteers to help make this a great success. The 1991 OES-sponsored Oceans '91 Conference will be held in Honolulu, Hawaii. The Head of the IEEE Hawaii Section, Kiman Wong, is already hard at work with Bill Bass and his staff in the State of Hawaii's High Technology Development Corporation to make this an outstanding event.

I hope to see you in Seattle.

Daniel L. Alspach, President
Oceanic Engineering Society

IEEE OCEANIC ENGINEERING SOCIETY

(Continued on inside back cover)

IEEE Oceanic Engineering Society Newsletter is published quarterly by the Oceanic Engineering Society of the Institute of Electrical and Electronics Engineers, Inc. Headquarters: 345 East 47th Street, NY 10017. $1.00 per member per year (included in Society fee) for each member of the Oceanic Engineering Society. Printed in U.S.A. Second-class postage paid at New York, NY and at additional mailing offices. Postmaster: Send address changes to IEEE OCEANIC ENGINEERING SOCIETY NEWSLETTER, IEEE, 445 Hoes Lane, Piscataway, NJ 08854.

CALL FOR NOMINATIONS

OES DISTINGUISHED SERVICE AWARD

OES DISTINGUISHED TECHNICAL CONTRIBUTIONS AWARD

The OES Awards and Fellows Committee is requesting nominations for the two major Society awards: the OES Distinguished Service Award and the OES Distinguished Technical Contributions Award. The Distinguished Service Award is given to honor an individual IEEE member for outstanding contributions toward fostering the objectives of the Oceanic Engineering Society. The Distinguished Technical Contributions Award is given to honor an outstanding technical contribution to oceanic engineering in either the fundamental or applied areas. The recipient need not be restricted to being a Society or IEEE member. The award shall be for either a single major invention or scientific contribution or for a distinguished series of contributions over a long period of time.

Please submit your nominations with supporting materials no later than May 15, 1989 to:

Anthony I. Eller
OES Jr. Past President
SAIC
1710 Goodridge Dr.
McLean, VA 22102

NEW OES FELLOWS

The following members of the Oceanic Engineering Society were elected IEEE Fellows in 1988. Their citations are given next to their names. IEEE encourages the recognition of outstanding workers by awarding them the grade of Fellow. If you wish to nominate someone for this award, contact IEEE Headquarters for the necessary kit.

Congratulations, Fellows.

Dr. Arthur B. Baggeroer 139 Sycamore Drive Westwood, MA 02090	For contributions to advanced array processing and underwater acoustics.
Dr. Venkatanarayana Ramachandran Dept. of Elec. Engineering Concordia University 1455 de Maisonneuve Blvd. West Montréal, Québec, Canada H3G 1M8	For contributions to theory of multi-variable networks with applications to two-dimensional digital filters.

(Reprinted from the *Proceedings of OCEANS '88)*

THEORY AND TEST OF BATHYMETRIC SIDE SCAN SONAR

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ABSTRACT

Bathymetric, or interferometric, side-scan sonars offer great improvement over conventional hydrographic and bathymetric techniques because their broad swath makes it possible to survey an area more efficiently, their high spatial resolution makes it less likely to miss an obstruction or feature, and their image output gives valuable information about the bottom composition. Accuracy and data processing improvements have appeared necessary before such systems are accepted for routine operational use. A theoretical model of the phase measurement errors which limit accuracy has been developed. Tests of a shallow-water bathymetric side-scan sonar, the Bathyscan 300, were conducted in August, 1987, in the Chesapeake Bay. The results of those tests, as well as the performance demonstrated by other bathymetric side-scan sonars, are compared to the predictions of the model.

INTRODUCTION

The National Ocean Service (NOS) is responsible for mapping and charting of the waters around the United States. Surveys conducted to meet this responsibility must be done efficiently, they must meet international accuracy standards, and they must be adequate to withstand legal scrutiny in liability cases. Bathymetric, or interferometric, side-scan sonar systems offer substantial potential improvements over current techniques in a wide variety of conditions.

The basic interferometric technique uses a pair of transducers which are very similar to those used for conventional side-scan systems. A pulse is transmitted just as in a conventional system. In addition to monitoring the amplitude of the returning echo, the phase difference between these two transducers is monitored. This phase difference indicates the direction of arrival of the echo at any instant. From the angle and time, depth can be computed corresponding to any point in the side-scan image.

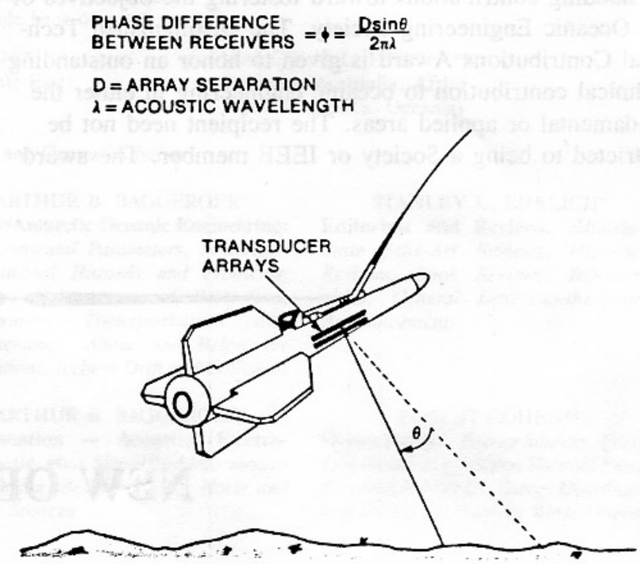

Figure 1. Bathymetric Side-Scan Sonar Technique

Systems of this type can be towed near the surface at the same speeds that hull-mounted systems are operated. They can provide complete coverage of the seafloor over swaths of 3.4, and perhaps as much as 10, times the towfish altitude. High frequency versions can operate in water depths as shallow as 10 meters or less. The spacing between conventional survey lines can be increased and still provide greater confidence that all natural features and obstructions to navigation have been detected. In deeper water, low frequency versions can reach to 6,000 meters or deeper. The broad swath width of these systems means that the rate of area coverage by a survey ship can be four times (or more) greater than with today's multibeam systems. In addition to providing more complete and efficient coverage, bathymetric side-scan systems also provide bottom backscatter imagery indicating bottom composition.

The disadvantages of this technology, as of recently, have been that the accuracy did not meet international standards and that the large amounts of data produced could not be processed efficiently. Progress is being made in both areas. As a contribution to this progress, NOS sponsored the development of a theoretical model of the accuracy of bathymetric side-scan systems. In addition, in order to obtain direct experience, a field test of a shallow-water version was conducted in August of 1987.

BACKGROUND

The first experiments with the interferometric technique for seafloor mapping were conducted in the 1960s (see Chesterman et al, 1967 and Lowenstein, 1970). Research continued through the 1970s and 1980s at a number of locations around the world. The BASS system was built in the United Kingdom (Denbigh, 1979). The SeaMARC II system was built in the United States (Blackinton and Hussong, 1983). The IDSS system was built in West Germany (Kolouch, 1984). The TOPO-SSS system was built in Norway (Klepsvik, 1984). The technique has been employed in Canada (Caulfield, 1984) and the Soviet Union (Aleksandrov, 1983).

Recently, the first systems of this type began to be available as commercial products. The Bathyscan 300, offered by Bathymetrics, Ltd., is a direct descendant of the BASS system and other work done in the United Kingdom. The SeaMARC family of systems is now offered by Honeywell. These systems evolved from equipment developed for manganese nodule exploration and the search for the Titanic. International Submarine Technology (IST), the Hawaii Institute of Geophysics (HIG) and Seafloor Surveys International (SSI) all made important contributions to the development of the bathymetric capability. The newest version of SeaMARC is being developed in cooperation with Texas A&M University (TAMU). The characteristics of the Bathyscan 300 and the SeaMARC systems are shown in table 1.

These systems are not yet available ''off-the-shelf''. However, the SeaMARC II (offered now as Honeywell's series 12) and the SeaMARC/S (offered as Honeywell's series 150) have seen extensive operational use in recent years. They have clearly developed beyond the research phase.

THEORETICAL MODEL

The accuracy of a bathymetric side-scan sonar system is affected by many of the same factors that limit the accuracy of multibeam systems. The most important of these common factors are errors related to sound velocity and errors related to the sonar attitude. The other large factor in a multibeam system is the error in estimating the travel time for an echo to return in a given beam. The travel time error is related to the transmit pulse length, the composite transmit-receive beamwidth, the signal-to-noise ratio, and the shape of the seafloor within the beam.

In an interferometric system, the error source analogous to travel time in a multibeam system is that of estimating the direction of arrival from the phase difference between the transducers. The relationship of this error to the design parameters of the sonar is not well known. Several investigators have considered this problem. The consensus starting point is the probability density function of the phase difference as derived by Ol'shevskii (1967):

$$f(d\varphi)=\frac{1-|R|^2}{2\pi(1-\beta^2)^{3/2}}\left[\beta\sin^{-1}(\beta)+\pi\beta/2+(1-\beta)^{1/2}\right]$$

$$\text{for } |d\varphi-\mu|<\pi$$

$$\text{and } \beta=|R|\cos(d\varphi-\mu)$$

Table 1
Bathymetric Side-Scan Systems

System	SeaMARC Series 12	SeaMARC Series 70	SeaMARC Series 150	Bathyscan 300
Developer	IST/HIG	IST/TAMU	IST/SSI	Bathymetrics
Max. Depth Below Towfish (m)	6,000	2,000	300	60
Frequency (kHz)	11/12	72	150	300
Max. Swath Width (m)	10,000	2,000	1,000	200
(% towfish altitude)	340	340	340	700
Towfish Length (m)	5.5	2.5	2	2
Towfish Weight (kg)	1750	150	204	180
Max. Tow Speed (kt)	10	10	6	8
Number of Systems Fielded	1	under construction	1	

where $d\varphi$ is the phase difference, μ is its mean value, and R is the crosscorrelation coefficient. This is a peaked distribution whose width increases as the crosscorrelation decreases.

The crosscorrelation coefficient is difficult to obtain in circumstances of interest. Alexandrou (1987) considered the cases of homogeneous volume reverberation and single surface boundary reverberation which indicate how the crosscorrelation depends on receiver separation and orientation. Gapper and Hollis (1985) demonstrated the dependence of the crosscorrelation on signal-to-noise ratio and the autocorrelation of the transmit waveform. Klepsvik (1984) showed that the crosscorrelation can be factorized to include the dependence on both the transmit pulse and the reverberation characteristics. Additional effects, primarily interference produced by backscattering from surfaces other than the seafloor, are recognized as limiting factors. Multipath interference involving reflections from the sea surface is the reason that coverage is limited to 3.4 times the water depth in the SeaMARC systems. Glint, or interference produced by multiple strong reflectors on the seafloor, can also have an important effect on the phase distribution (Blackinton, 1986).

Denbigh (1987), in an effort sponsored by NOS, developed a relationship between the probability density function of the phase difference and the signal-to-interference ratio, S/I. The interference was assumed to arrive from a direction different from the desired signal and which would cause a phase difference, φ_1, between the two receivers. He showed that the width of the probability distribution of phase differences, expressed as a standard deviation, could be approximated by:

$$\sigma=1.9/\surd(S/I)$$

when $\varphi_1=\pi$ which caused the broadest distribution. When $\varphi_1=\pi/2$ it was found that the interference not only broadens the distribution, producing a standard deviation of:

$$\sigma=1.5/\surd(S/I)$$

but also shifts the mean of the distribution away from the direction of the wanted signal by:

$$\mu=1.2/(S/I)$$

A program was written by Science Applications International Corporation (SAIC, 1987) to incorporate this result into an overall performance prediction for bathymetric side-scan sonars. The user specifies both the system design parameters and the operating environment. This model includes not only the depth errors related to phase estimation, but also those related to sonar attitude and sound velocity. The program also calculates the errors in positioning soundings produced by the specified system.

Figure 2 is a representative result of this program. For this particular run:

Sonar Design
- frequency: 300 kHz
- transducer width: 0.44 cm
- receiver spacing: 5 cm
- receiver tilt angle: 20° below horizontal
- attitude errors: 0.1° rms (roll, pitch and yaw)
- towfish depth error: 10 cm rms
- sound velocity error: negligible

Environment
- water depth: 50 m
- towfish depth: 10 m
- bottom type: sand
- wind speed: 10 knots

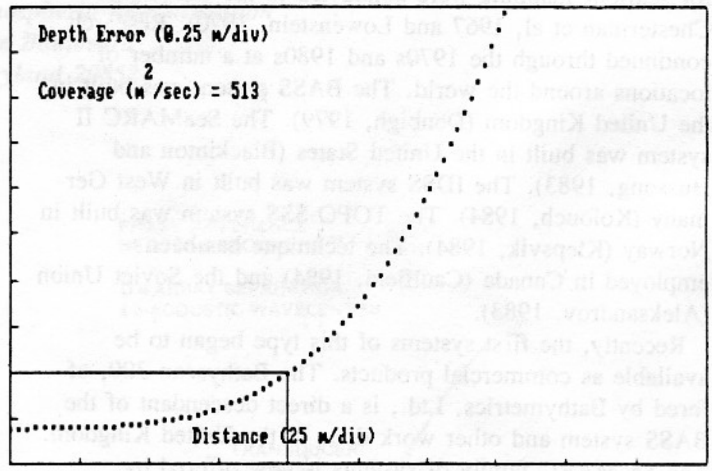

Figure 2. Theoretical Model Performance Prediction

Measurements were allowed to be averaged over a 10 square meter area as the system moved at 5 knots. The figure shows that the rms errors remain below 1% of the water depth out to a range of 100 meters. To meet international standards, which require that the total error not exceed 1% of the depth or 0.3 meters (whichever is greater) with a probability of at least 90%, the range would be restricted to about 75 meters. These parameters are close to the specifications and typical operating conditions for the Bathyscan 300. The model's prediction is in general agreement with the manufacturer's specification. The model indicates only small dependence on bottom type, but strong dependence on wind speed. The model's predictions for other systems are close to the manufacturer's specifications and to the results of operational experience.

FIELD TESTS

Field tests of the Bathyscan 300 were conducted from the NOAA ship Rude during a two-week period during July and August of 1987 in the Chesapeake Bay. The Bathyscan 300 was viewed both as an example of a bathymetric side-scan sonar and as a promising tool for surveying of harbors and harbor approach areas. The tests were divided into three phases to test accuracy, suitability for surveying, and capability for detection of obstacles.

The first portion, designed to check accuracy, was run over a generally flat bottom in approximately 12 meters of water. A 3/4 mile square area was surveyed with two sets of perpendicular lines. Data from the standard conventional echo-sounder, a Raytheon DSF-6000N, was collected simultaneously for intercomparison. The Bathyscan system was towed at a depth of 3 meters and a speed of about 5 knots. The normal 30° depression angle was reduced to 20° to get better coverage in this depth of water. Ranges consistently exceeded 70 meters and typically exceeded 100 meters which is the manufacturer's specification. This is more than 10 times the altitude of the towfish above the bottom. There was no evidence of degradation of the output at the range at which surface-bottom interference would be received. An apparent penalty for this immunity to interference which permits long range operation is a gap in coverage directly beneath the towfish. To fill this gap the line spacing was reduced from the full swath width of 200 meters to 60 and 70 meters for the two sets of lines. This also insured substantial overlap between lines of data which is important in the processing of Bathyscan data. The area coverage rate was slightly less than that of a conventional system which would typically be run at 10 knots and 50 meter line spacing, but the density of coverage was orders of magnitude greater. The final form of the data was as a 5 meter grid. The rms difference between the gridded data from the two sets of lines was about 0.2 meters. Data analysis has not yet been completed but the differences with respect to the conventional echo-sounder data appear to be no greater than the differences between the two grids.

The second portion of the tests, designed to examine survey suitability, was to cover a larger area over the range of conditions available within the Chesapeake Bay. The area chosen was 1 mile by 5 miles in extent and included water depths from 9 to 50 meters. Operations were conducted as a routine survey as much as possible. Conventional echo-sounder data was gathered simultaneously. Figure 3 is a stacked-profile perspective plot of the results of this portion of the tests. The survey lines in this area were also spaced by 70 meters. The work was completed in 3 1/2 days of routine operations. The towing depth was maintained at 3 meters. Adequate returns were obtained out to ranges of 100 meters except in a small region in the deepest part of the survey area. A 5 meter grid was produced from the data and the plot drawn from this grid. Random variations are clearly not greater than a few tenths of a meter. Comparison with the conventional echo-sounder data showed differences of up to 1 meter which extended over fairly large areas of the grid. These appear most likely attributable to errors in the towfish depth. A combination of information from a pressure sensor, an accelerometer and adjacent swath data is used to establish this depth.

The third portion of the tests was designed to examine the capability of this type of system to detect obstacles to navigation. Several objects which had been investigated by other means were used for targets. The most useful data came from the wreck of a pile driving barge. The dimensions of the barge were 60 feet by 25 feet. It had been investigated using conventional side-scan sonar and divers. The bathymetric data from the Bathyscan system forms an image which shows the scouring that has taken place around the wreck. When the discontinuity in the bottom profile at the edge of the hull is less than a few feet, the bathymetric data maintains track and produces an image of the wreck itself. By adjusting the spatial averaging to trade off accuracy for spatial resolution and also by adjusting the ping rate and tow speed, the system can be made to detect smaller objects.

Weather conditions during the tests were consistently good. Within that limited range of conditions the system performance appeared independent of wind speed contrary to the model's prediction. The bottom material in the test areas ranged from soft mud to sand. The ranges achieved by the system were clearly dependent on the type of bottom. Mid-water targets, probably biological, which were very common in the area could also disrupt the system performance but controls available to the operator were generally able to reject these effects.

The Bathyscan system proved to be robust and well-engineered. No major problems were encountered in set-up or field operations. The experience and results of the tests suggested that improvements could be made in the towfish depth sensor, the interface with the positioning system, and the real-time displays. It appears possible to design a system to be towed at higher speed and to provide some form of coverage in the near vertical. Two weeks following the tests had been planned for data processing. The task could not be completed during that time however the processing software has since been considerably improved. The tests provided evidence that it is possible for this type of system to meet international accuracy standards. The ranges that were achieved indicate that it should be possible to design a system based on this technique which would be capable of much higher area coverage rates than conventional systems. The high spatial resolution data produced by such a system will prove to be of great value.

SUMMARY

Bathymetric side-scan sonars have demonstrated considerable promise for hydrographic and bathymetric surveying. The technique has been shown to be applicable to shallow harbor areas as well as the deep ocean. A theoretical framework for prediction of their performance has been established. The development of models and operational hardware will continue. This technology is likely to play an important role in surveying in the near future.

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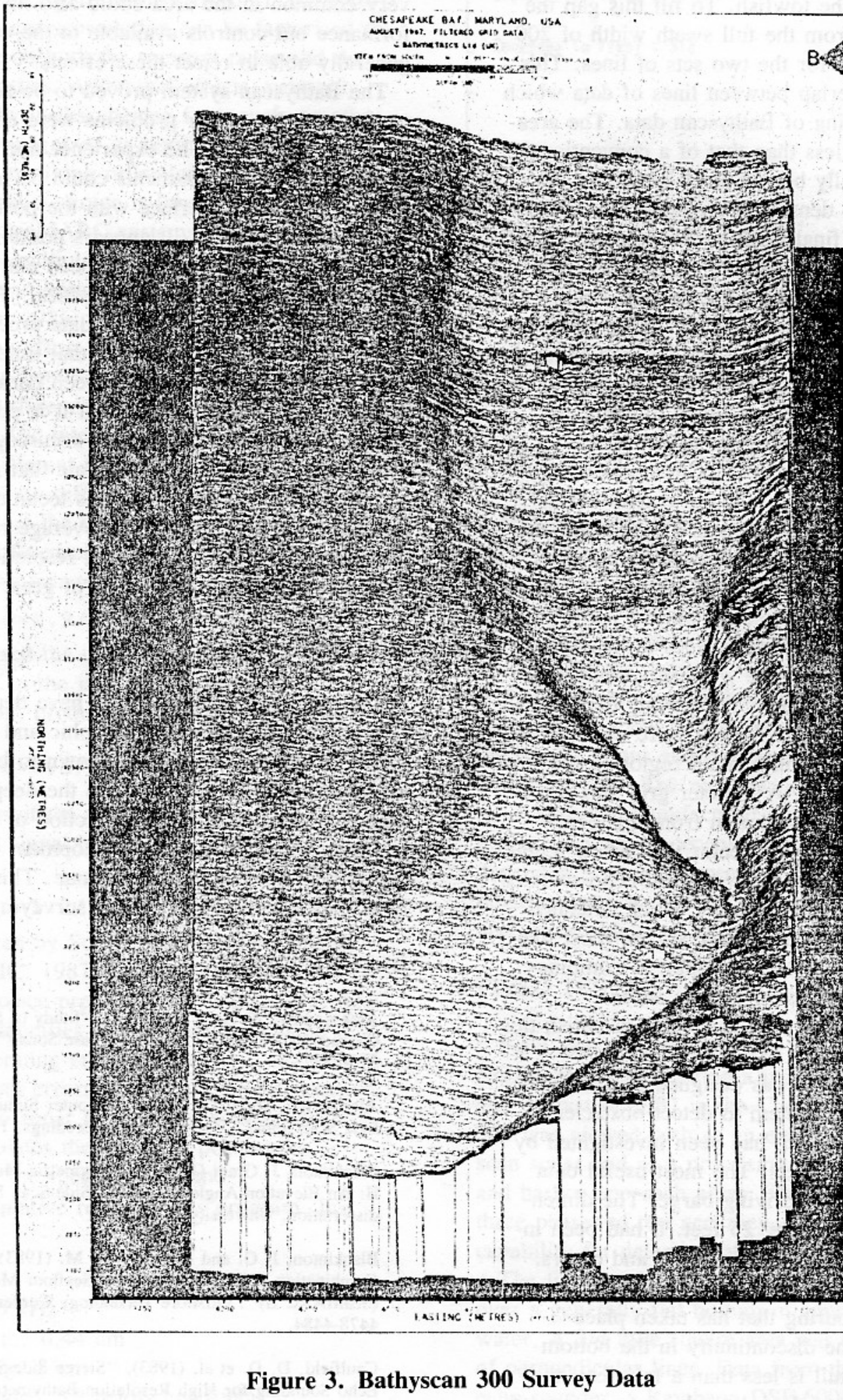

Figure 3. Bathyscan 300 Survey Data

(Reprinted from the *Proceedings of OCEANS '88)*

SIDE SCAN SONAR ACOUSTIC VARIABILITY

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ABSTRACT

This paper reports the results of research conducted on the inherent variability of side scan sonar imagery in order to determine the magnitude and nature of image intensity fluctuations. Two experiments are presented in which a Klein 100 KHz system is operated under controlled conditions which remove all but purely instrumental and acoustic causes of image variability. The result of one experiment in a test tank is a statistical analysis of the transmitted waveform. A second experiment conducted from the Woods Hole Oceanographic Institution Pier allows similar analysis for the combined side scan sonar transmit/receive signal path. The results indicate that intensity fluctuations are multiplicative in nature and spatially and temporally uncorrelated.

INTRODUCTION

Considering the various optical or acoustic methods for imaging large areas of the seafloor, side scan sonar is presently the most common. Throughout three decades of commercial use it has been a tool for obtaining pictures of the bottom. Although images obtained by side scan sonar have always been subject to much scrutiny, conjecture, and interpretation, analytic treatment of the imagery has been limited. However with increasing use of the technique, most notably as the primary means of mapping the Exclusive Economic Zone (EEZ) of the United States [Paluzzi et al., 1979], technical aspects which may influence side scan sonar imagery are receiving increased attention.

One aspect which has received little attention in the past but warrants analysis is the inherent variability of the side scan sonar process. Knowledge of this is important in understanding how individual sonar targets may appear then disappear during repeated surveys of a given area. Variability must also be quantified if meaningful comparisons of two images of the same bottom taken at different times are to be conducted. Many sources of side scan sonar image variability are already recognized. Towfish instability is a well understood aspect of side scan sonar which causes image distortion. The departure of the towfish from constant velocity and attitude result in a misdirection of the sonar beams. This can result in a complicated shuffling of the acquired data which, when displayed normally, produces image distortion [Flemming, 1982]. In this paper we will consider acoustic fluctuations. Previous studies have not included side scan sonar [Urick, 1982]. The resulting changes in side scan images as a result of these fluctuations would still remain after systematic measures had been taken to minimize towfish instability and variable imaging geometry. As such, they represent a fundamental limit to image repeatability.

In order to quantify the acoustic variability of side scan sonar returns and exclude other potential sources of fluctuation it was necessary to operate a sonar system in a manner that permitted a large degree of control. The investigation of image variability was first subdivided into two experiments. In the first experiment the acoustic transmission variability was measured so that the resultant amount of fluctuation due to insonification could be determined. The second experiment was devised so that repeated images of the same bottom were obtained. This allowed examination of numerous images for fluctuations. Results of the first experiment indicate what fraction of overall image variability is due solely to transmission variability. The remaining fraction is intrinsic to the acoustic environment.

METHODS

In the test tank experiment a Klein model 422s-101ef 100 KHz towfish was suspended in a test tank approximately 5 meters from a reference hydrophone. Geometry of the tank, towfish, and hydrophone were adjusted to prevent multipath interference and assure a fixed relative orientation of all components. Only one of two towfish acoustic channels was operated in order to prevent mutual interference. Towfish power and transmit key signal were supplied by a Klein model 521 sonar recorder. The transmitted waveform was sensed by the hydrophone and sent to the data gathering system, which consisted of an IBM PC-AT personal computer containing a Data Translation DT-2851 frame grabber card. The frame grabber digitized each transmitted waveform sensed by the hydrophone to 8 bits at 500 KHz and recorded the waveforms to hard disk files for further processing.

In the second, or pierside, experiment the same sonar system was deployed from the Woods Hole Oceanographic Institution Pier. To eliminate towfish motion the towfish was mounted on a steel box beam which spanned two concrete dock pilings 10.5 M above the bottom in 17 M of water. The towfish was mounted level with the transducer axis oriented 20 degrees below the horizontal to minimize surface scattering. A portion of the bottom extending 100 M outward from the pier was insonified. The experiment consisted of recording consecutive returns over a six minute period during slack tide. It was presumed that the sonar and bottom orientation remained constant during this time. The image obtained from each transmission was recorded on tape and later digitized using the same data gathering equipment as the test tank experiment.

RESULTS

The test tank experiment data was analyzed in order to quantify variability in the transmitted waveform. Figure 1 is a plot of the pressure of the transmitted waveform versus

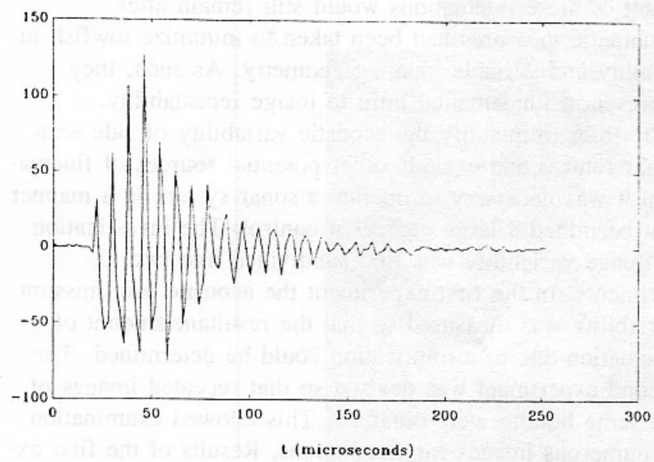

Figure 1. Klein 100 KHz Waveform

time. The observed waveform consists of a 122 KHz carrier modulated by an envelope which rises linearly then decays exponentially in 100 μsec. A noticeable feature of the waveform is that it is clipped at negative pressures. This is most likely due to transducer cavitation caused by the 228 dB re 1 μPa sonar source level [Clay and Medwin, 1977].

Of particular interest is the variation of total energy in each transmission. Knowledge of this allows determination of expected image intensity variation due to transmission power variability. The energy of each waveform in the set was calculated as

$$E = \sum_{n=1}^{128} p[n]^2 \quad (1)$$

where the $p[n]$ are the pressure samples of each waveform. The statistics of this distribution are shown in table 1.

Table 1
100 KHz Towfish Transmit Energy Fluctuations

mean:	77300
standard deviation:	4900
standard deviation/mean:	0.063

Having characterized the temporal variability of the sonar power level, the sonar transmission was decomposed into component frequencies for spectral analysis. The mean power in each frequency bin taken as an ensemble average over all 3500 recorded waveforms density is shown in Figure 2. The predominant frequency is the carrier at 122 KHz with a half power bandwidth of 9.2 KHz. This bandwidth corresponds favorably with the manufacturers advertized specification of a 0.1 msec pulselength which implies a 10 KHz bandwidth. A significant amount of power is seen at the extreme ends of the spectrum, with local maxima at 226 KHz, 241 KHz, and at the extreme frequency 250 KHz. This region is probably the result of the generation of harmonics of the fundamental frequency due to the non-linear response of water to high amplitude pressure fluctuations [McDaniel, 1965]. Lesser energy is seen at frequencies below 122 KHz. The local maximum at 65 KHz is probably a cavitation generated subharmonic [Desantis et al., 1967]. Broadband redistribution of energy across the spectrum is also an effect of cavitation and is observed here.

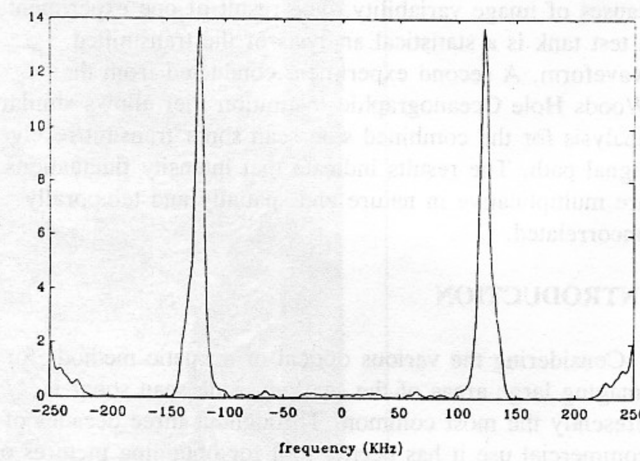

Figure 2. Mean Transmission Power Spectral Density

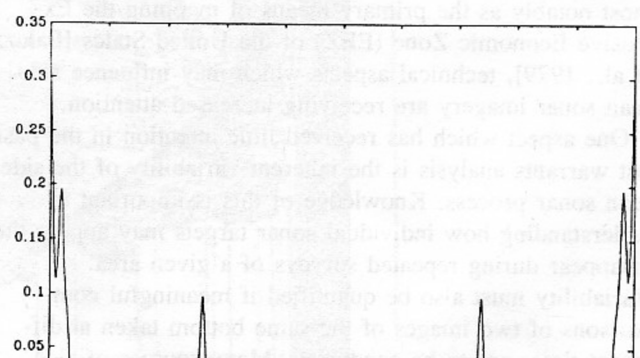

Figure 3. Variance of Transmission Power Spectral Density

The variance of the individual spectral components is shown in Figure 3. It shows a form similar to the mean power spectral density in Figure 2, with peaks in the same areas in both graphs. However the region corresponding to the carrier frequency is proportionately smaller than the regions of significant energy outside the carrier. This indicates that the majority of observed variability in total transmitted energy is found at frequencies of no use to the sonar system, since these frequencies are filtered out in the recording process. The ratio of power standard deviation to mean power in this bandwidth is 0.0201. This is approximately one third the amount of variation found previously in the total energy distribution.

The digitized data set obtained from the pierside experiment may be looked upon as a single side scan sonar image of 3066 rows and 1024 columns. Here each row corresponds to a separate transmission and each column a fixed range bin. In this representation the image coordinates (x, r) correspond to transmission number and range bin, respectively. The n^{th} column $i(x,n)$ of the matrix therefore represents a time series of the image pixel intensity or acoustic pressure amplitude from one independent, non-overlapping region of the bottom, while the n^{th} row $i(n,r)$ corresponds to the same quantity for the n^{th} transmission.

The probability density function of pixel intensity for a given column describes the echo stability of a single object or portion of the bottom. A representative estimated probability density function for this data set is shown in Figure 4, a histogram of the 3066 image intensity values contained in column 200. At this range a strong return is received from the bottom. The figure also displays a Gaussian fit to the observed pdf. The mean and standard deviation of the Gaussian were assumed to be equal to the mean and standard deviation of the data. Compared to the Gaussian distribution, the histogram contains more points at the center. In general, the shape of the distribution for arbitrary columns is Gaussian with a slight skew towards intensity values below the mean. The distributions are sufficiently unlike the Gaussian distribution that they fail the chi-square goodness of fit test [Bendat and Piersol, 1971].

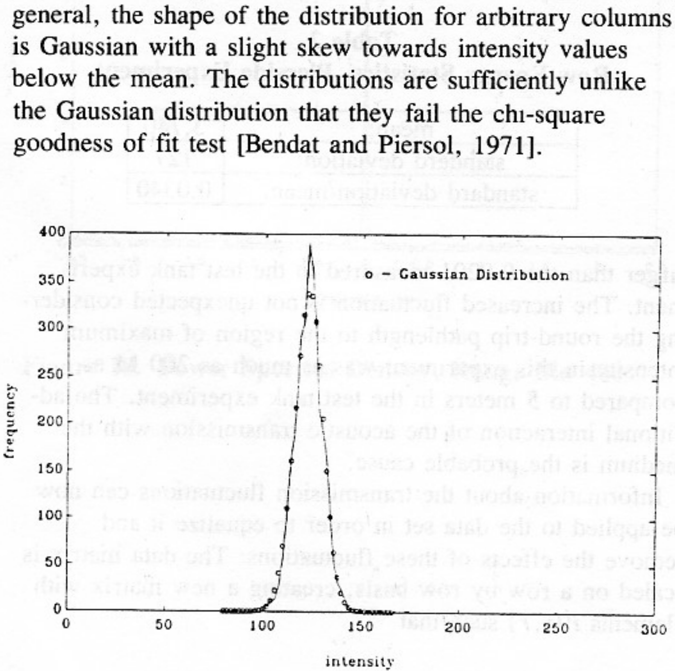

Figure 4. Histogram of Pixel Intensity for Range Bin 200, Pierside Experiment

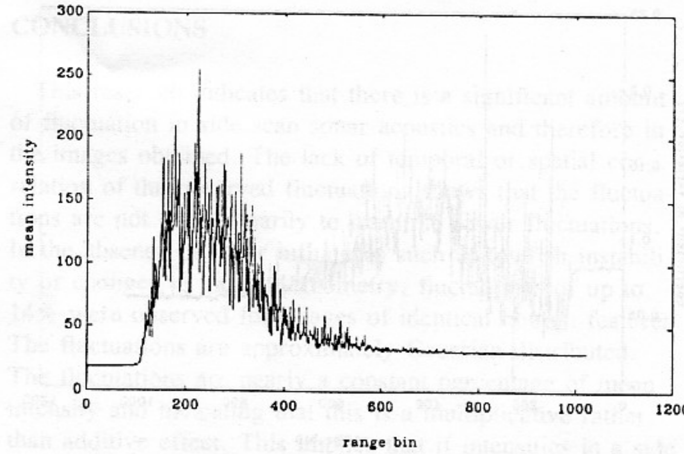

Figure 5. Pixel Intensity Mean Value vs. Range Bin, Pierside Experiment

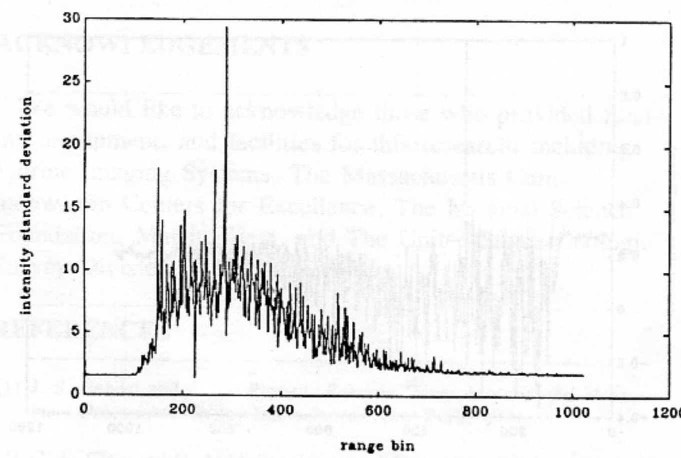

Figure 6. Pixel Intensity Standard Deviation vs. Range Bin, Pierside Experiment

The mean value of each range bin n, $\bar{i}(x,n)$, is shown in Figure 5. It should be noted that time varying gain (TVG), a side scan sonar feature that applies increasing gain with increasing range, was disabled in this experiment. Empirically Figure 5 can be divided into three regions. The region nearest the towfish, approximately the first 100 range bins, corresponds to ranges of 10 M or less and is generated by volume reverberation. This is because the towfish was mounted 10.5 M above the bottom. The region between range bins 100 and 600 contains the portion of the bottom with the most intense returns. The spiky nature of this region is due to the differences in backscatter strength between the various bottom subregions represented by $i(x,n)$. After column 600 the signal is greatly attenuated and increasingly noisy.

A plot of pixel intensity standard deviation σ_n, versus range bin number is shown in Figure 6 and is seen to follow the same trend as Figure 5. This indicates that the fluctuations in $i(x,n)$ are a constant fraction of the mean. This is seen to be approximately true in Figure 7, a plot of the coefficient of variation V [Urick, 1982] versus bin number. The coefficient of variation is defined as

$$V = \frac{\sigma_{i(x,n)}}{\bar{i}(x,n)} \quad (2)$$

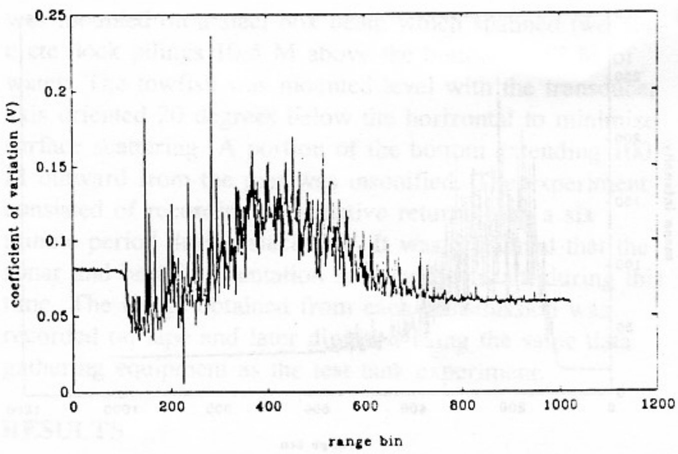

Figure 7. Pixel Intensity Coefficient of Variation (V) vs. Range Bin, Pierside Experiment

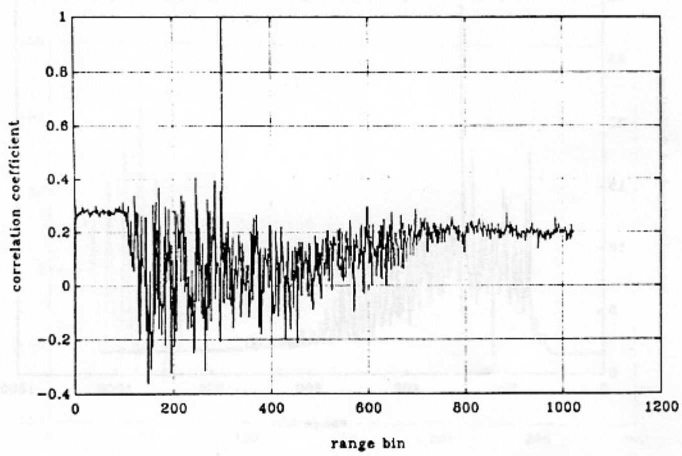

Figure 8. Correlation Coefficients, Range Bin 300, Pierside Experiment

The mean value of V is approximately 0.08, with a range from 0.04 to a peak of 0.14 which occurs at bin 400.

To further evaluate the nature of image intensity fluctuations the joint statistics of the 1024 columns $i(x,n)$ were evaluated. Of interest is the spatial correlation of fluctuations in different range bins. One technique for evaluating this correlation consists of computing the correlation coefficient [Papoulis, 1984] between pairs of range bins n_1 and n_2. The correlation coefficient

$$C_{n_1 n_2} = \frac{\sigma_{n_1 n_2}}{\sigma_{n_1}\sigma_{n_2}} \quad (3)$$

is the ratio of the covariance of the two range bin intensities to the product of the variances of the two range bins.

Figure 8 is a plot of the correlation coefficient for range bin 300 versus all range bins. Note that $C_{300,300} = 1$, as would be expected, while all other values fall between +/− 0.4. This shows that the intensity fluctuations of data set range bin 300 are weakly correlated with the fluctuations in other bins.

The acoustic transmission power fluctuations observed in the test tank experiment are a possible cause of the weak but wide range correlation of intensity fluctuations between

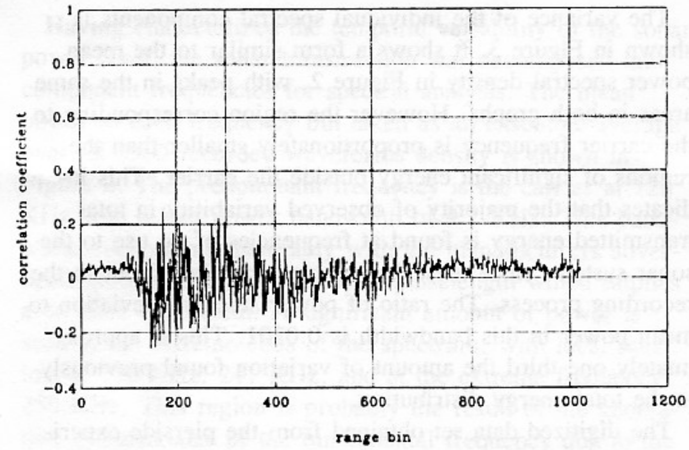

Figure 9. Correlation Coefficients, Range Bin 300, Pierside Experiment, Compensated Data

the various range bins in the data set. Since scattered echo intensity is directly proportional to the intensity of the insonifying transmission and all range bins during one transmission cycle are insonified by the same acoustic transmission, pixel intensity variations due to transmission power fluctuations can be expected to be correlated. Total energy in each transmission was not measured during this experiment, but an estimate based on the total energy contained in each row $i(n,r)$ provides satisfactory results. The total energy of each row is calculated as

$$E_n = \sum_{n=1}^{3066} i^2(n,r) \quad (4)$$

The statistics for this energy distribution are shown in Table 2. The ratio of standard deviation to mean is

Table 2
Row Energy Statistics, Pierside Experiment

mean:	3,740
standard deviation:	127
standard deviation/mean:	0.0340

larger than the 0.0201 measured in the test tank experiment. The increased fluctuation is not unexpected considering the round-trip pathlength to the region of maximum intensity in this experiment was as much as 200 M as compared to 5 meters in the test tank experiment. The additional interaction of the acoustic transmission with the medium is the probable cause.

Information about the transmission fluctuations can now be applied to the data set in order to equalize it and remove the effects of these fluctuations. The data matrix is scaled on a row by row basis, creating a new matrix with elements $i'(x,r)$ such that

$$\sum_{r=1}^{1024} i'(n,r) = \bar{I} \quad (5)$$

for any row n. $\bar{I}$ is the mean intensity of the image as a whole. After removing row-wise image intensity fluctuations the previous analyses were performed again. Figure 9 shows the effect of this compensation on $C_{300,n}$. Compared to the uncorrected case the degree of correlation between column 300 and other columns is significantly reduced, indicating that transmission fluctuations are a probable cause of the weak correlation of pixel intensity fluctuations for a given transmission or side scan sonar image line. This lack of correlation leads to the conclusion that the intensity fluctuations observed at various ranges in a side scan sonar image are essentially independent, in the absence of change in the imaged topography.

Range bin mean, standard deviation, and coefficient of variation analyses were repeated on the row equalized matrix, however the results of these analyses showed that the equalization process did not change these parameters to the same degree that it changed $C_{n_1 n_2}$. This lack of perceptible change indicates that the temporal fluctuations in pixel intensity for a side scan sonar image are largely independent of transmission energy fluctuations and cannot be attributed to them.

One final analysis of the pierside data was the computation of the power spectral density (PSD) of the fluctuations of the column intensity sequences $i(x,n)$. The power spectral density of fluctuations in range bin 400 are shown in Figure 10. Outside of a narrow spike centered around DC which was caused by an overall increasing trend in intensity with time, the spectrum is fairly flat. This implies that the intensity fluctuations are uncorrelated temporally.

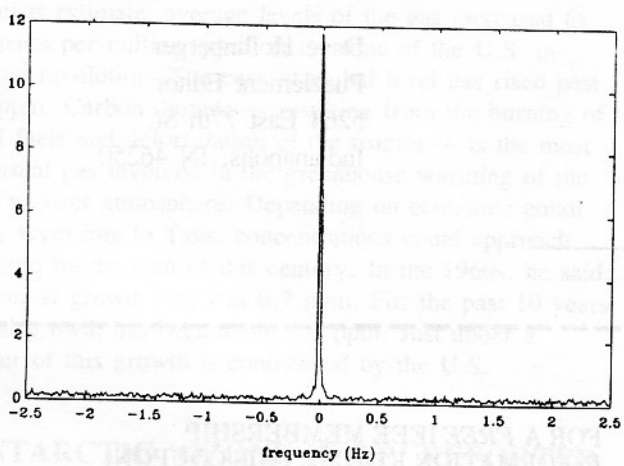

Figure 10. Power Spectral Density, Range Bin 400

CONCLUSIONS

This research indicates that there is a significant amount of fluctuation in side scan sonar acoustics and therefore in the images obtained. The lack of temporal or spatial correlation of the observed fluctuations shows that the fluctuations are not due primarily to transmit power fluctuations. In the absence of other influences such as towfish instability or changes in imaging geometry, fluctuations of up to 14% were observed for images of identical bottom features. The fluctuations are approximately Gaussian distributed. The fluctuations are nearly a constant percentage of mean intensity and indicating that this is a multiplicative rather than additive effect. This implies that if intensities in a side scan image are compensated to produce the same mean intensity throughout a nearly constant amount of fluctuation is observed throughout the image.

ACKNOWLEDGEMENTS

We would like to acknowledge those who provided funding, equipment, and facilities for this research; including Marine Imaging Systems, The Massachusetts Commonwealth Centers for Excellence, The National Science Foundation, Martin Klein, and The United States Geologic Survey Division of Marine Geology.

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'TIS A PUZZLEMENT

LAST QUARTER'S PUZZLE — NAUTICAL PURSUIT II

The answers to last quarter's nautical trivia questions are as follows:

1. The first person to determine the circumference of the Earth was Eratosthenes, who calculated it within 4 percent in 200 B.C.

2. Greek Fire was a flammable mixture of naphtha, sulphur and pitch that was blown through tubes or thrown in grenades onto the deck of enemy ships.

3. Ferdinand Magellan was the first man to circumnavigate the world even though he was killed in the Philippines during the first voyage to circumnavigate the Earth. He managed this seemingly impossible feat by having reached the Philippines from the east on an earlier voyage.

4. The British ship "Mary Rose" was the first warship with gunports cut in its side. It was also the first warship to sink due to flooding through its gunports.

5. The Charlotte Dundas (1802) was the first practical steam powered merchant vessel.

6. Cowper Coles of Great Britain and John Ericsson of the United States were credited with independently inventing the revolving gun turret. Ericsson also invented the USS Monitor and the screw propeller.

7. Charles Parsons invented the first marine steam turbine in 1897.

THIS QUARTER'S PUZZLE — 3-D

This quarter's puzzle is to determine the equations for rotating a three dimensional figure into any orientation and displaying this figure in two dimensions on a computer screen.

Dave Hollinberger
Puzzlement Editor
5264 East 77th St.
Indianapolis, IN 46250

OF OCEANIC INTEREST

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CARBON DIOXIDE CONCENTRATIONS INCREASE 25% OVER 100 YEARS

The magnitude of a problem can sometimes be obscured by statistics, and discussions of the greenhouse effect have certainly been the cause of recent statistics as well as alarm. A new perspective, however, may cast light on the shadows of obscurity. As indicated by analyses of air trapped in ice cores, according to Pieter P. Tans of NOAA's Geophysical Monitoring for Climatic Change program, concentrations of carbon dioxide changed little if at all for many centuries. But in the mid- to late-19th century, scientists estimate, average levels of the gas increased to 280 parts per million (ppm) at the time of the U.S. industrial revolution. The current global level has risen past 350 ppm. Carbon dioxide — resulting from the burning of fossil fuels and deforestation of the tropics — is the most important gas involved in the greenhouse warming of the earth's lower atmosphere. Depending on economic conditions, according to Tans, concentrations could approach 375 ppm by the turn of this century. In the 1960s, he said, the annual growth rate was 0.7 ppm. For the past 10 years annual growth has been about 1.5 ppm. Just under a quarter of this growth is contributed by the U.S.

ANTARCTIC 'OZONE HOLE' REPORTED SMALLER THIS SEASON

Environmental researchers have discovered that the springtime "ozone hole" that has appeared over Antarctica in recent years now appears considerably less deep this season than it was last year. Balloon-borne instruments launched by National Oceanic & Atmospheric Administration scientists from the agency's Environmental Research Laboratories in Boulder, Colorado, showed the average amount of ozone above the South Pole was more than 200 Dobson units.

NOAA/ERL's Walter Komhyr explained that the average October values for 1986 and 1987 were 165 and 135 Dobson units, respectively. "These are remarkably low ozone values for anywhere on Earth," he added.

If present trends continue, Komhyr noted, ozone values during the latter half of October should have approached those last observed at the South Pole prior to 1980 when average values during the latter half of October were more than 250 Dobson units.

Ozone has been decreasing during antarctic springs since the 1970s — typically beginning in early September and reaching minimum values in early October. The downward trend has exhibited slight temporary recoveries in alternate years, with the largest recovery — before this one — occurring in 1986. The ozone hole occurs within the antarctic polar vortex, a belt of strong west-to-east winds that circle Antarctica during winter and spring months. Stratospheric temperatures within the vortex this year were 5-10° C warmer than in 1987 and 2-5° C warmer than in 1986. Komhyr said the warmer temperatures "did not favor formation of polar stratospheric clouds this year," as did the colder temperatures of previous years. Those clouds, he continued, promote photochemical destruction of ozone by chlorine compounds derived from man-made chlorofluorocarbons.

Komhyr warned that the readings do not mean the threat of reduced ozone levels globally no longer exists — nor does it portend the end of the antarctic ozone hole — but simply indicates that large, year-to-year changes in ozone levels can occur from natural variations in atmospheric processes.

CORRESPONDENCE

29 November 1988
CMM:jc
DO-88-114

Dr. Daniel L. Alspach
Oricon Corporation
3366 North Torrey Pines Ct.
LaJolla, CA 92037

Dear Dan:

I would like to express to you and the IEEE-OES my most sincere thanks for being named the 1988 recipient for the society's Distinguished Technical Achievement Award. I am honored, pleased, and very humble for receiving this recognition. I take great pride in hanging the plaque and certificate in my office and in wearing the beautiful Seiko watch. Again, I thank you and the OES for selecting me to receive this award.

I thoroughly enjoyed the entire Oceans 88 conference. I was impressed by the large number of good papers and with the scope of the exhibits. It was a real pleasure to meet you and many others in this area of work and to see many of my old friends. In brief, I had a great time.

Sincerely,

Chester McKinney

cc: Tony Eller, SAI

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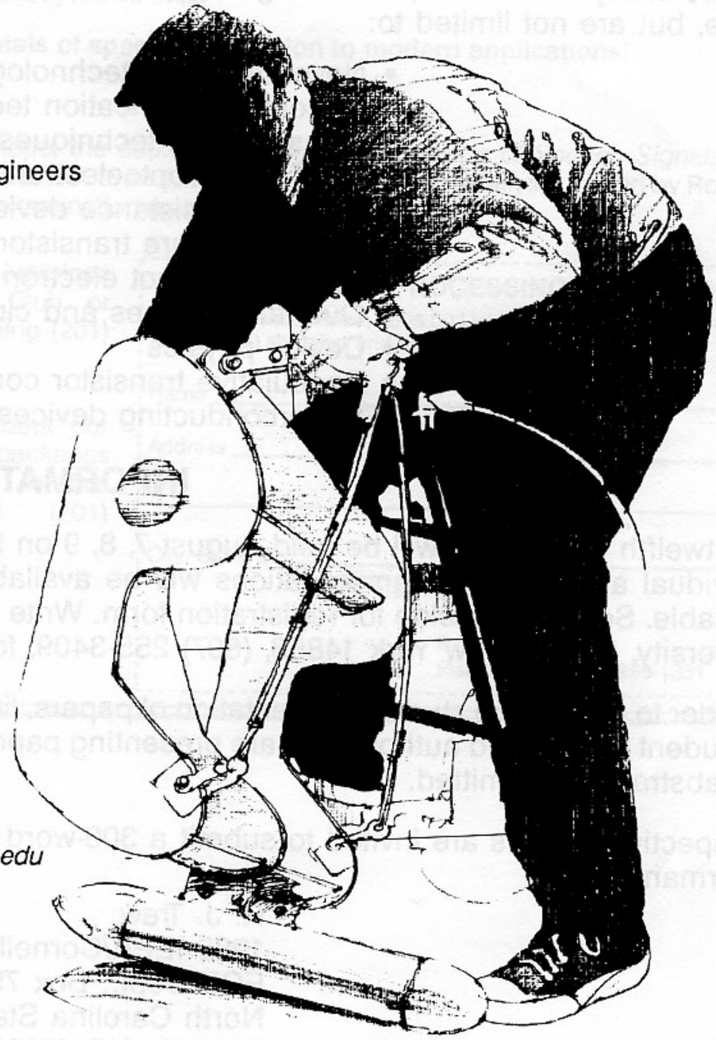

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ANNOUNCEMENT
AND CALL FOR PAPERS

For the Twelfth Biennial
IEEE/Cornell University Conference on

IEEE

ADVANCED CONCEPTS IN HIGH SPEED SEMICONDUCTOR DEVICES AND CIRCUITS

SPONSORED BY: **The ELECTRON DEVICES SOCIETY OF IEEE**

In Cooperation With: **The Microwave Theory and Techniques Society of IEEE**

August 7, 8, 9, 1989 (Mon., Tues., Wed.)

Papers are solicited covering the physics and performance of high speed microwave, millimeter-wave, optoelectronic, and digital devices and circuits. Papers which emphasize innovative device concepts and physical phenomena leading to new devices are particularly encouraged. There will be invited papers in key areas. The proceedings of the conference will be published. Suitable subject areas include, but are not limited to:

- Novel materials technologies for devices
- Nanometer fabrication techniques
- Measurement techniques for high speed devices
- High speed optoelectronic devices and circuits
- Negative resistance devices
- Heterostructure transistors
- Ballistic and hot electron transistors
- Quantum devices and circuits
- Device physics
- Speculative transistor concepts
- Superconducting devices

INFORMATION

The twelfth conference will be held August 7, 8, 9 on the Cornell campus in Ithaca, New York. Both individual and family accommodations will be available in area motels. Dormitory rooms are also available. See reverse side for registration form. Write to Ms. Elma Weaver, 424 Phillips Hall, Cornell University, Ithaca, New York 14853, (607) 255-3409, for help in local arrangements.

In order to encourage student presentation of papers, limited financial assistance for travel is available to student first-named authors who are presenting papers. This assistance should be requested when the abstract is submitted.

Prospective authors are invited to submit a 300-word abstract, before April 3, 1989, to the program chairman:

R. J. Trew
1989 IEEE/Cornell Conference
ECE Dept., Box 7911
North Carolina State University
Raleigh, NC 27695-7911

Please note that all necessary government approvals must be obtained *before* submission of an abstrac reporting work that has any government sponsorship.

PROCEEDINGS WILL BE PUBLISHED

IEEE USAB HOT LINES

Vol. 4, No. 4 Joseph A. Edminister, Editor—Catherine S. McGowan, Associate Editor December 1988

USAB Actions—At its November 16 meeting in San Diego, California, the United States Activities Board approved or revised the following IEEE-USA Entity Position Statements:

- Licensure and Registration
- Opposition to Integration of Social Security Benefits With Private Pension Benefits
- Enhancing U.S. Productivity Through Improved Utilization of Engineers
- NASA's Role in R&D for Communications Satellites
- Biological Effects of Power Frequency Electric and Magnetic Fields

In addition, USAB endorsed a proposal to withdraw an August 1983 IEEE Position Paper on Spent Nuclear Fuel Reprocessing in the United States. This proposal has been forwarded to the IEEE Board of Directors for action.

USAB elected the following members to serve as officers:

- Joseph M. DeSalvo, Chairman, Career Activities Council, 1989–1990
- Jack Lubowsky, Chairman, Government Activities Council, 1989–1990
- Robert P. Noberini, Chairman, Professional Activities Council for Engineers, 1990. Mr. Noberini was elected to finish the unexpired term of George F. Abbott, who was elected 1989 IEEE Executive Vice President.
- James H. Beall, Controller, 1989–1990

Edward C. Bertnolli was re-elected by IEEE's Board of Directors to serve as IEEE Vice President of Professional Activities and Chairman of USAB. A complete list of USAB officers will be published early in 1989.

GEER—The IEEE United States Activities Employment Assistance Committee has implemented a third employment registry. The Graduating Engineers Employment Registry is a non-confidential, computerized data base of credentials of graduating student members who are looking for their first engineering jobs. Employers search the registry for credentials that match their needs.

Like the Professional Engineering Employment Registry (PEER) and the Self-Employed Engineers Registry (SEER), GEER is monitored, operated and sponsored by IEEE. It is offered free for use by IEEE student members. For information or a registration form, contact your Student Branch or the GEER Service Center, 138 Old River Road, Andover, Massachusetts, 01810, Telephone (508) 683-0098.

Federal Legislative Agenda—The IEEE-USA Federal Legislative Agenda Task Force is working on its *Agenda* for the 101st Congress. The booklet, which will be available in January 1989, will address many national public policy issues. This *Agenda* will include IEEE-USA stands on retirement income benefits; tax policy; computers and communications; professional careers of electrical and electronics engineers, including sections on manpower, age discrimination, ethics, and intellectual property; education; energy policy; research and development; space policy; and government policies on technological competitiveness.

For more information contact the IEEE-USA Office in Washington, D.C.

Journalism Awards—The United States Activities Board selected the 1988 recipients of the two IEEE-United States Activities Board awards for literary contributions. Larry Dwon will receive the IEEE-USAB Award for Literary Contributions Furthering Engineering Professionalism. David E. Lundstrom will receive the first IEEE-USAB Award for Literary Contributions Furthering Public Understanding of the Profession.

Mr. Dwon was selected for his "substantive literary contributions to power- and utility-oriented publications, as well as to IEEE, honorary society and other publications destined to be read by the engineering work force and students. His lifelong concern for engineering professionalism is reflected in his writings." Mr. Dwon is a consultant for energy conservation and manpower utilization issues.

Mr. Lundstrom was chosen to receive his journalism award because of his substantive literary efforts to produce *A Few Good Men from Univac*. "This book gives the layman a real look inside the workings of adventurous engineering projects that would shape the entire computer industry in the United States," according to the IEEE-USA Awards and Recognition Committee. Mr. Lundstrom retired from Control Data Corporation in 1985 to work on his book, which was published by MIT Press in 1987.

For more information about or nominations forms for the IEEE-USAB Journalism Awards contact the IEEE-USA Office in Washington, D.C.

Technology Policy—"Policy Imperatives for Commercialization of U.S. Technology" is the theme of the TAB-USAB 1989 U.S. Technology Policy Conference, to be held on February 21, 1989 at the J.W. Marriott Hotel in Washington, D.C. This year's Conference will focus on several aspects of U.S. technology commercialization. The panel groups will discuss imperatives for engineering education; technological innovation; international competitiveness; and effective utilization of science and technology.

For more information about this year's Conference, contact the IEEE-USA Office in Washington, D.C.

R&D—IEEE-USA's Engineering, Defense and Aerospace Research and Development Committees will sponsor a briefing on Federal Research and Development Funding for FY 1990 on March 8, 1989 at the Madison Hotel in Washington, D.C. This year's briefing will be held in conjunction with the Engineering Societies Government Affairs Conference. Speakers will discuss aspects of the Federal R&D budget as they affect various government agencies, including the Departments of Defense and Energy, as well as NASA and the National Science Foundation. For more information contact the IEEE-USA Office in Washington, D.C.

IEEE USA HOT LINES

Joseph A. Edminister, Editor—Catherine S. McGowan, Associate Editor

Retirement—The United States Activities Board sent a letter to the Executive Secretariat of the Equal Employment Opportunity Commission in response to a request for comment on EEOC's Advance Notice of Proposed Rulemaking relating to early retirement plans. In the letter, IEEE-USA suggested that any early retirement plan should:

- allow employees to take two months to consider the benefits and disadvantages of the offer;
- include a period of from three to six months for employees to reverse their decision to retire and return to the company without loss of benefits. All early retirement benefits paid to the individual up to that time would be repaid to the company.
- include a clear list of the advantages and disadvantages of early retirement for both the employee and the employer.

"Early retirement offers usually are contingent upon signing a waiver of the employee's rights under the Age Discrimination in Employment Act (ADEA)," IEEE-USA wrote. "The threat is obvious to the employee, but the long-term effects of signing the waiver are not. We believe waivers should be utilized only in special instances, with the procedures of the Fair Labor Standards Act being followed as the ADEA specifically mandates, and that their use should be supervised by EEOC."

For more information, contact the IEEE-USA Office in Washington, D.C.

Congressional Fellows—The 1989 IEEE Congressional Fellows have chosen their Capitol Hill assignments. Mr. Denis J. King accepted a position as a staff member for the House Subcommittee on Science, Research and Technology. He will be working on issues concerning technology competitiveness and technology transfer from research to commercial markets.

Dr. Charles W. Bostian will be working as a staff member for Rep. Don Ritter (D-Pennsylvania). He will concentrate on high-definition television (HDTV) issues, among others. Dr. Bostian is the second IEEE Congressional Fellow to work for Rep. Ritter. Former IEEE-USA Energy Committee Chairman Frederick J. Twogood served on Rep. Ritter's staff in 1981.

Applications for 1989-1990 IEEE Congressional Fellowships will be accepted until March 31. Information and application kits are available from the IEEE-USA Office in Washington, D.C.

New Employment Registry—The United States Activities Board recently approved establishing a new employment registry. The Non-Employed Engineers Registry (NEER) will be operated in much the same way as PEER (Professional Engineering Employment Registry), SEER (Self-Employed Engineers Registry), and GEER (Graduating Engineers Employment Registry), the other employment registries operated by IEEE-USA. It will be a non-confidential database, since unemployed people are not concerned about a current employer learning they are job-hunting. Prospective employers will be able to contact the individuals directly.

GEER will be offered without charge to employers who are seeking employees. At the same time, IEEE members may place their names and credentials in the database free of charge. Their names will also be listed in the PEER database.

For information about GEER or any of the other three employment registries, contact the IEEE-USA Office in Washington, D.C

Health Care—IEEE-USA's Health Care Engineering Policy Committee is looking for IEEE members who are interested in serving on one of three newly established subcommittees. Beginning in 1989, the Committee will establish groups to consider the impact of regulation on device development; Federal funding of biomedical engineering research; and the role of biomedical engineers in health care delivery.

The Committee was established 10 years ago "to bring IEEE's interests and capabilities health care-related technologies to bear on national health care policy issues." For more information about the Committee and its activities, or to offer your efforts to the subcommittees, contact the IEEE-USA Office in Washington, D.C.

Awards—Nominations for 1989 IEEE United States Activities Awards are being accepted until March 15 by the IEEE-USA Awards and Recognition Committee. Nominees will be considered for the following awards:

- *Engineering Professionalism:* IEEE-USA's highest award, which honors one member in the engineering profession or allied arts and sciences for dedicated effort and successful accomplishments in advancing the social, economic, legal and ethical aims of IEEE professional activities in the United States.
- *Distinguished Contributions to Public Service:* honors individuals not currently in the engineering profession for contributions toward furthering the professional goals of IEEE in the United States by such means as (but not limited to) promulgating laws or regulations benefiting the profession; influencing industrial environments to foster professionalism; creating curricula or publications designed to enhance professionalism; and similar activities.
- *Citation of Honor:* given to up to four members each year who have made exemplary contributions toward securing recognition of professional activities in the United States.
- *Regional and Divisional Professional Leadership:* given to as many as 10 members in IEEE's Regions or Divisions for their outstanding leadership efforts in advancing the professional aims of IEEE in the United States.
- *Professional Achievement:* given as warranted to recognize significant, specific contributions, achievements and individual efforts in the development and implementation of U.S. professional activities.

Information and nomination forms are available from the IEEE-USA Office in Washington, D.C.

IEEE USAB HOT LINES

Joseph A. Edminister, Editor—Catherine S. McGowan, Associate Editor

Salary Survey—Orders are being accepted for the *1989 IEEE U.S. Member Salary and Fringe Benefit Survey.* This year's Survey is more comprehensive and informative than ever before. It explores more than 50 variables affecting engineers' salaries and fringe benefits. Highlighted are retirement planning and pension practices, early retirement issues, and salary progression. Separate results are presented for several industry sectors and electrical engineering areas.

The *IEEE U.S. Member Salary and Fringe Benefit Survey* is an essential source of current information on salaries and fringe benefits for engineers in the United States. It's especially useful to engineers, corporate and engineering managers, and personnel and salary administrators.

Again this year, IEEE-USA is offering special pre-publication prices until May 15. For orders placed before May 15, the price is $47.95 for members and $67.95 for nonmembers. After May 15, the price will be $59.95 for members and $79.95 for nonmembers. Shipping and handling charges will also apply, and New Jersey residents should add six percent sales tax.

Orders should be placed with the IEEE Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, New Jersey, 08855-1331, Telephone (201) 981-1393. Please specify IEEE Catalog Number UH0183-4.

1989 USAB Members—The following members will serve on IEEE's United States Activities Board in 1989:

- Edward C. Bertnolli, Chairman, and IEEE Vice President, Professional Activities
- Victor G. Zourides, Director, Region 1
- Herbert H. Heller, Director, Region 2
- Vernon B. Powers, Director, Region 3
- Judith R. Grady, Director, Region 4
- Mary Alys Lillard, Director, Region 5
- Allen R. Stubberud, Director, Region 6
- Harold S. Goldberg, Director, Division I
- Ralph W. Wyndrum, Jr., Director, Division V
- Arthur Goldsmith, Director, Division VI
- Eric E. Sumner, Member at Large (1988–1989)
- Martha Sloan, Member at Large (1989–1990)
- Joseph M. DeSalvo, Chairman, Career Activities Council, and Vice Chairman, United States Activities Board
- Jack Lubowsky, Chairman, Government Activities Council
- Gerald W. Gordon, Chairman, Member Activities Council
- Robert P. Noberini, Chairman, Professional Activities Council for Engineers
- William R. Tackaberry, Chairman, Technology Activities Council
- James H. Beall, Controller
- Leo C. Fanning, Staff Director (non-voting)

Information on how to contact any of the USAB members is available from the IEEE-USA Office in Washington, D.C.

Legislative Agenda—The IEEE-USA Federal Legislative Agenda Task Force has published an *Agenda* for the 101st Congress. This year's booklet, which is available from the IEEE-USA Office in Washington, D.C., provides a synopsis of the legislative and public policy concerns of IEEE's U.S. members. Through the issue briefs, index of key words and phrases, and lists of IEEE and IEEE-USA Positions, the Task Force hopes to acquaint members of Congress, the Executive agencies, and the general public with U.S. members' interest in a spectrum of issues.

The issues included in this *Federal Legislative Agenda* are technological competitiveness; retirement income policy; computers and communications; energy; the professional careers of electrical and electronics engineers, which includes sections on manpower, intellectual property, age discrimination, and engineering ethics; research and development; tax policy; the U.S. civilian space program; and education.

Annual Report—The IEEE United States Activities Annual Report for 1988 is now available from the IEEE-USA Office in Washington, D.C. This pictorial look at 1988 highlights some of the successes made in U.S. professional activities during the year.

Copies are available from IEEE-USA Public Relations, Telephone (202) 785-0017.

Age Discrimination—The IEEE-USA Age Discrimination Committee is now offering *Age Discrimination in Employment—What Are Your Rights and Protections?* to unemployed IEEE members free of charge. This "PACE Guide to Age Discrimination" outlines the Age Discrimination in Employment Act (ADEA) and includes information on employees' rights within ADEA guidelines, recognizing illegal employment practices, and filing age discrimination complaints and lawsuits. References include summaries of ADEA lawsuits filed by the Equal Employment Opportunity Commission, state agencies responsible for age discrimination law enforcement in the private sector, and legal counsel for age discrimination lawsuits.

Unemployed members may request a complimentary copy by including their IEEE member number with a written request to the IEEE-USA Office in Washington, D.C. Others may purchase the booklet from the IEEE Service Center for $5.00 (member) and $7.50 (nonmember). Call (201) 981-1393 and specify IEEE Catalog No. UH0180-0.

Congressional Fellowships—The deadline for application for the 1989–1990 IEEE-USA Congressional Fellowships is nearing. Anyone interested in becoming a Congressional Fellow should contact the IEEE-USA Office in Washington, D.C., for an application kit. Completed applications must be postmarked by March 31, 1989 to be considered for this year's Fellowship selections.

IEEE-USA telephone hotline recording: (202) 785-2180

OCEANS '89

. . . . an international conference addressing methods for understanding The Global Ocean

Eleven tutorials are currently scheduled for the OCEANS '89 conference, which will be held in Seattle, Washington September 18-21. The tutorials will take place on the first day of the conference, Monday, September 18. Cost for each tutorial is $60 per person and registration by July 15 is encouraged.

Scheduled tutorials for the morning session, 0900-1200, are:

Corrosion-Resistant Design of Marine Cable, Connector, and Housing Systems, presented by Colin Sandwith of the Applied Physics Laboratory, University of Washington, Seattle, Washington;

Global Positioning System (GPS), presented by Robert C. Dixon of R. C. Dixon and Associates, Palmer Lakes, Colorado;

Laser-Based Underwater Optical Systems, presented by Bryan W. Coles, Subsea Engineering Associates, San Diego, California;

Logistic and On-Ice Support of Research in the Arctic, presented by Fred Karig and Andreas Heiberg of the Applied Physics Laboratory, University of Washington, Seattle, Washington;

Underwater Tracking Technology, presented by Arthur Ayres and Miles McLennan of SAIC Maripro, Goleta, California; and

Adaptive Management: A Technique for Resolving Marine Technology Controversies, presented by Dave Bernard, Environmental and Social Systems (ESSA), Ltd., Vancouver, British Columbia, Canada, and David Fluharty, Institute for Marine Studies, University of Washington, Seattle.

Scheduled tutorials for the afternoon session, 1400-1700, are:

Noise and Vibration in Marine Vessels — Causes and Cures, presented by Bertel Lundgaard, DLI Engineering Corporation, Bainbridge Island, Washington;

CTD Sensors: Principles of Operation and Sources of Error, presented by Nordeen Larson, Sea Bird Electronics, Bellevue, Washington;

Logistics of Seafloor Saturation Diving Systems and Environments, presented by Richard W. Berey, National Undersea Research Center of Fairleigh Dickinson University, U.S. Virgin Islands;

Marine Geophysical Acoustical Techniques: Fundamentals and Application, presented by Dick Sylwester, Williamson Associates, Seattle, Washington; and

The Regulation of Marine Pollution, presented by Don Baur and James Moore, of Perkins Coie, Washington D.C. and Seattle.

For further information about the tutorials or the conference, please contact Nancy Penrose, Program Coordinator, OCEANS '89, (206) 543-3445; Applied Physics Laboratory, University of Washington, HN-10, 1013 NE 40th Street, Seattle, WA 98105; or via OMNET at the OCEANS '89 mailbox.