REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
02-01-2003

2. REPORT DATE

3. DATES COVERED *(From - To)*
From 15-04-2001To 27-03-2002

4. TITLE AND SUBTITLE
STATISTICAL ANYALYSIS OF SEDIMENT CORES

5a. CONTRACT NUMBER

5b. GRANT NUMBER
N00014-01-1-0756

5c. PROGRAM ELEMENT NUMBER

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

6. AUTHOR(S)
PERCIVAL, DONALD B. JACKSON, DARNELL R. AND BRIGGS, KEVIN B.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Applied Physics Laboratory, Unversity of Washington
1013 NE 40th Street
Seattle, WA 98105

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Research
800 North Quincy Street
Arlington, Virginia 22217-5660

10. SPONSOR/MONITOR'S ACRONYM(S)
ONR

11. SPONSORING/MONITORING AGENCY REPORT NUMBER

12. DISTRIBUTION AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE

20030130 157

13. SUPPLEMENTARY NOTES

14. ABSTRACT
THE GOAL OF THIS GRANT WAS TO DETERMINE THE RELATIONSHIP BETWEEN VARIOUS CORRELATION LENGTHS FOR POROSITY AND DENSITY VARIATIONS IN SEDIMENT CORES AS DERIVED FROM ONE DIMENSINAL AND THREE DIMENSIONAL MODELS. THIS GOAL WAS MET BY FORMULATING BOTH DIRECT ONE DIMENSIONAL AND INDIRECT ONE AND THREE DIMENSINAL MODELS FOR SAMPLED MEASUREMENTS OF THESE VARIABLES AND BY DETERMING RELATIONSHIPS BETWEEN THE CORRELATION LENGTHS DEFINED FOR EACH THEORETICAL MODEL. THE END RESULT OF THIS EFFORT WAS A METHODOLOGY FOR TRANSFORMING THE CORRELATION LENGTH FOR A ONE DIMENSIONAL DISCRETE PARAMETER MODEL INTO LENGTHS APPROPRIATE FOR ONE AND THREE DIMENSIONAL CONTINUOUS PARAMETER MODELS, THUS ALLOWING A MORE ACCURATE DETERMINATION OF A PARAMETER NEEDED BY ACOUSTIC SCATTERING MODELS.

15. SUBJECT TERMS
ACOUSTIC VOLUME SCATTERING, AUTOREGRESSIVE PROCESS, CORRELATION LENGTHS, DENSITY, LORENZIAN PROCESS, POROSITY, SAMPLED DATE,

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			DONALD B. PERCIVAL
U	U	U	UU	2	19b. TELEPONE NUMBER *(Include area code)* 206-543-1368

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI-Std Z39-18

Statistical Analysis of Sediment Cores: Final Report

Principal Investigator

Donald B. Percival — Principal Mathematician, Applied Physics Laboratory; Affiliate Associate Professor, Department of Statistics; University of Washington, Seattle, WA 98105

Co-Investigators

Darrell R. Jackson — Principal Electrical Engineer, Applied Physics Laboratory; Research Professor, Electrical Engineering; University of Washington, Seattle, WA 98105

Kevin B. Briggs — Oceanographer, Seafloor Sciences Branch; Naval Research Laboratory; Stennis Space Center, MS 39529

1. Background

The correlation length associated with sediment density and sound velocity fluctuations is used as a physical parameter by various volume scattering models. In order to estimate this correlation length, porosity and density measurements are obtained from a cylindrical core sample, which is extracted and then sliced into K discs of equal thickness Δ. Average porosities n_k and densities ρ_k, $k = 1, \ldots, K$, are determined for each disc (typically using a gravimetric method). Each set of measurements is then treated as a 'time' series, in which the independent variable is taken to be the distance from the midpoint of the disc to the top of the core sample. The estimate of the correlation length is based upon assuming that the series is a sample of an autoregressive (AR) process of unit order, which has a well-defined correlation length $\bar{l}_\Delta$. While effective, direct modeling of the sampled data is subject to criticism because it ignores the manner in which the discs were created. In particular, the length of the core subsamples defines an averaging interval that is identical to the sampling interval.

2. Approach and Results

In order to investigate the effect of the sampling scheme on the estimated correlation length, we first considered two indirect one dimensional continuous parameter models for the sampled data. The first such model assumes that the data are sampled from a stationary Lorenzian process with correlation length $\bar{l}$. In this case, the sampled data constitute a sample from an AR process. If the correlation length is large compared to the sampling interval Δ, we found that $\bar{l} \approx \bar{l}_\Delta$. When this condition does not hold (often the case in practice), the two correlation lengths can be quite different; however, we determined theoretical relationships between $\bar{l}$ and $\bar{l}_\Delta$ such that an estimate of one can be translated into an estimate of the other. In the second indirect one dimensional model, we explicitly account for averaging in the following manner. We assume that, prior to averaging, the underlaying porosity or density process is a continuous parameter stationary Lorenzian process with correlation length l. In this case, the sampled data do not constitute a sample from an AR process, but it is possible to use the correlation length $\bar{l}_\Delta$ obtained from fitting this incorrect model to the sampled data by interpreting it in terms of a unit lag autocorrelation, which can then be related to the correlation length l. Although the relationship between $\bar{l}_\Delta$ and l is not simple, we were able to develop methods for converting an estimate of $\bar{l}_\Delta$ into an estimate of l.

In addition to the two indirect one dimensional models, we also considered an indirect three dimensional model for the data based upon the assumption of a homogeneous Gaussian medium with a covariance structure that depends just on the distance between points in the core. While idealized, we found this model to provide a reasonable description of surficial sediments and to be amenable to numerical techniques for relating its correlation length to the length $\bar{l}_\Delta$ estimated via the direct AR approach.

Details of work supported by this grant can be found in the paper 'Fine-Scale Volume Heterogeneity Measurements in Sand' by D. Tang, K. B. Briggs, K. L. Williams, D. R. Jackson, E. I. Thorsos and D. B. Percival, *IEEE Journal of Oceanic Engineering*, **27** (2002), pp. 546–60, and in the technical report 'Comparison of Correlation Lengths from Direct and Indirect Models for Sediment Cores' by D. B. Percival, D. R. Jackson and K. B. Briggs (2002).