

# Matched Field Processing for Underwater Acoustics

Tolstoy, Alexandra

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# Matched Field Processing For Underwater Acoustics

**Acoustical Society of America**



## **Matched Field Processing For Underwater Acoustics:**

**Matched Field Processing for Underwater Acoustics** Dr. Alexandra Tolstoy, 1993 Matched-field Processing for Underwater Acoustics Alexandra Tolstoy, Oceanic Engineering Society (U.S.). Victoria Chapter, 1993 *Underwater Acoustic Modeling* P.C. Etter, 1995-11-30 Underwater Acoustic Modeling provides the only comprehensive source on how to translate our physical understanding of sound in the sea into mathematical formulas solvable by computers **Underwater Acoustics and Ocean Dynamics** Lisheng Zhou, Wen Xu, Qianliu Cheng, Hangfang Zhao, 2016-10-17 These proceedings are a collection of 16 selected scientific papers and reviews by distinguished international experts that were presented at the 4th Pacific Rim Underwater Acoustics Conference PRUAC held in Hangzhou China in October 2013 The topics discussed at the conference include internal wave observation and prediction environmental uncertainty and coupling to sound propagation environmental noise and ocean dynamics dynamic modeling in acoustic fields acoustic tomography and ocean parameter estimation time reversal and matched field processing underwater acoustic localization and communication as well as measurement instrumentations and platforms These proceedings provide insights into the latest developments in underwater acoustics promoting the exchange of ideas for the benefit of future research Underwater Acoustic Modelling and Simulation, Third Edition P.C. Etter, 2003-12-08 Underwater Acoustic Modeling and Simulation examines the translation of our physical understanding of sound in the sea into mathematical models that can simulate acoustic propagation noise and reverberation in the ocean These models are used in a variety of research and operational applications to predict and diagnose the performance of complex sonar systems operating in the undersea environment Previous editions of the book have provided invaluable guidance to sonar technologists acoustical oceanographers and applied mathematicians in the selection and application of underwater acoustic models Now that simulation is fast becoming an accurate efficient and economical alternative to field testing and at sea training this new edition will also provide useful guidance to systems engineers and operations analysts interested in simulating sonar performance Guidelines for selecting and using available propagation noise and reverberation models are highlighted Specific examples of each type of model are discussed to illustrate model formulations assumptions and algorithm efficiency Instructive case studies demonstrate applications in sonar simulation **Advances In Underwater Acoustics, Structural Acoustics, And Computational Methodologies (In 4 Volumes)** Sean F Wu, Steffen Marburg, 2025-04-29 This set of volumes encompasses the study of acoustics to diverse environments ranging from underwater and marine environments to structural and civil engineering computational models and aerospace engineering Each volume comprises peer reviewed publications in the related field of acoustics from the past decade arranged such as to review the existing literature examine new methodologies and then explore novel applications of pioneering acoustic principles With contributions by eminent acoustics researchers this set holds key insights for fellow acoustics researchers and engineers of any field impacted by acoustic phenomena Volume 1 s review chapters summarise

theories like geoacoustic inversion as well as criticism of the Biot theory of propagation in fluid saturated porous solids while the new methodologies shown range from an efficient and stable coupled mode solution to a cell based smoothed radial point interpolation method The book concludes with promising applications like experimental evidence of horizontal refraction and bottom attenuation coefficient inversion Volume 2 reviews topics including radiation boundary conditions for the Helmholtz equation and analytical interpretation of the early literature on the theory of vibrations The methodologies range from coupled boundary element and energy flow method as well as sound radiation of a line source The work concludes with promising applications like Lamb Waves in a poroelastic plate and experimental validations of reconstructed excitation forces acting inside a solid enclosure Volume 3 provides summaries of theories including the benchmark study on eigenfrequencies of fluid loaded structures and the Burton and Miller method while the new methodologies presented range from a coupled boundary element and energy flow method to an efficient approach to the simulation of acoustic radiation The volume concludes with promising applications like a comparison of transient infinite elements and transient Kirchhoff integral methods as well as a fast multi frequency iterative acoustic boundary element method Volume 4 depicts the context of conventional methodologies including short wave components and Galbrun's equation while its new methodologies range from radiation and outflow boundary conditions for direct computation of acoustic and flow disturbances to the effect of airfoil shape on trailing edge noise The collection concludes with promising applications like helicopter noise predictions and conservative source interpolation methods for aeroacoustics

Acoustic Signal Processing for Ocean Exploration J.M.F Moura, Isabel M.G. Lourtie, 2012-12-06 Acoustic Signal Processing for Ocean Exploration has two major goals i to present signal processing algorithms that take into account the models of acoustic propagation in the ocean and ii to give a perspective of the broad set of techniques problems and applications arising in ocean exploration The book discusses related issues and problems focused in model based acoustic signal processing methods Besides addressing the problem of the propagation of acoustics in the ocean it presents relevant acoustic signal processing methods like matched field processing array processing and localization and detection techniques These more traditional contexts are herein enlarged to include imaging and mapping and new signal representation models like time frequency and wavelet transforms Several applied aspects of these topics such as the application of acoustics to fisheries sea floor swath mapping by swath bathymetry and side scan sonar autonomous underwater vehicles and communications in underwater are also considered

*Underwater Acoustic Modeling and Simulation* Paul C. Etter, 2017-12-19 Underwater Acoustic Modeling and Simulation Fourth Edition continues to provide the most authoritative overview of currently available propagation noise reverberation and sonar performance models This fourth edition of a bestseller discusses the fundamental processes involved in simulating the performance of underwater acoustic systems and emphasizes the importance of applying the proper modeling resources to simulate the behavior of sound in virtual ocean environments New to the Fourth Edition Extensive new material that

addresses recent advances in inverse techniques and marine mammal protection Problem sets in each chapter Updated and expanded inventories of available models Designed for readers with an understanding of underwater acoustics but who are unfamiliar with the various aspects of modeling the book includes sufficient mathematical derivations to demonstrate model formulations and provides guidelines for selecting and using the models Examples of each type of model illustrate model formulations model assumptions and algorithm efficiency Simulation case studies are also included to demonstrate practical applications Providing a thorough source of information on modeling resources this book examines the translation of our physical understanding of sound in the sea into mathematical models that simulate acoustic propagation noise and reverberation in the ocean The text shows how these models are used to predict and diagnose the performance of complex sonar systems operating in the undersea environment

**Computational Ocean Acoustics** Finn B. Jensen, William A. Kuperman, Michael B. Porter, Henrik Schmidt, 2011-06-10 Senior level graduate level text reference presenting state of the art numerical techniques to solve the wave equation in heterogeneous fluid solid media Numerical models have become standard research tools in acoustic laboratories and thus computational acoustics is becoming an increasingly important branch of ocean acoustic science The first edition of this successful book written by the recognized leaders of the field was the first to present a comprehensive and modern introduction to computational ocean acoustics accessible to students This revision with 100 additional pages completely updates the material in the first edition and includes new models based on current research It includes problems and solutions in every chapter making the book more useful in teaching the first edition had a separate solutions manual The book is intended for graduate and advanced undergraduate students of acoustics geology and geophysics applied mathematics ocean engineering or as a reference in computational methods courses as well as professionals in these fields particularly those working in government especially Navy and industry labs engaged in the development or use of propagating models

**A History of the Acoustics Division of the Naval Research Laboratory** Fred Tudor Erskine, 2013 European Conference on Underwater Acoustics M. Weydert, 2004-01-14 This book represents the proceedings of the Conference on Underwater Acoustics held in September 1992 to bring together all the various disciplines involved in a forum to present the latest research on all aspects of marine acoustics

**Model-Based Processing for Underwater Acoustic Arrays** Edmund J. Sullivan, 2015-05-14 This monograph presents a unified approach to model based processing for underwater acoustic arrays The use of physical models in passive array processing is not a new idea but it has been used on a case by case basis and as such lacks any unifying structure This work views all such processing methods as estimation procedures which then can be unified by treating them all as a form of joint estimation based on a Kalman type recursive processor which can be recursive either in space or time depending on the application This is done for three reasons First the Kalman filter provides a natural framework for the inclusion of physical models in a processing scheme Second it allows poorly known model parameters to be jointly estimated along with the quantities of

interest This is important since in certain areas of array processing already in use such as those based on matched field processing the so called mismatch problem either degrades performance or indeed prevents any solution at all Thirdly such a unification provides a formal means of quantifying the performance improvement The term model based will be strictly defined as the use of physics based models as a means of introducing a priori information This leads naturally to viewing the method as a Bayesian processor Short expositions of estimation theory and acoustic array theory are presented followed by a presentation of the Kalman filter in its recursive estimator form Examples of applications to localization bearing estimation range estimation and model parameter estimation are provided along with experimental results verifying the method The book is sufficiently self contained to serve as a guide for the application of model based array processing for the practicing engineer

**Characterization and Matched-field Processing Localization of Photoacoustic Signals** Serdar Hakki Yönek,2000 **Important Elements In: Geoacoustic Inversion, Signal Processing, and Reverberation in Underwater Acoustics** Alex Tolstoy,2008-01-01 This book contains a number of papers by leading researchers discussing their work on either geoacoustic inversion GI signal processing SP or reverberation It is intended for scientists entering these fields as well as for experienced researchers Chapter 1 Tolstoy begins the section on GI It is a review article covering the main topics of GI and mentions such subjects as matched field processing MFP improved source localization and tracking array element localization propagation and parameter modeling search methods the nature of the search spaces improving efficiency sensitivities and uncertainty benchmarking and applications to simulated and test data It is intended as a resource for understanding the GI area as well as for locating key references Chapter 2 Dosso describes one of the most successful and most applied methods for GI a Bayesian approach using a hybrid simulated annealing SA variant for optimization and Gibbs sampling to characterize the posterior probability density The formulation is discussed here in mathematical detail The emphasis in this chapter is on rigorous uncertainty estimation where the unknowns are considered to be random variables constrained by the data and prior information Errors are assumed to be Gaussian distributed for the derivation of some key equations and statistical tests are presented to support this assumption Data from the PROSIM 97 experiment at numerous frequencies are analyzed Chapter 3 Chapman Jiang discusses the interpretation of matched field inversion results particularly their limitations and illustrates their analysis using multifrequency experimental data from the New Jersey continental shelf site that was selected on the basis of high spatial and temporal coherence across the array They are concerned with the impact of data errors due to parameter correlations in Bayesian inversions and the effect of the bottom slope in three dimensions they conclude that only two dimensions are needed for their inversions Chapter 4 Michalopoulou Nolte begins as a review of Bayesian source localization methods but is primarily concerned with one such approach which the authors developed the Optimum Uncertain Field Processor OUFPP This is an approach used for target localization and tracking which reduces sensitivity to environmental mismatch by incorporating prior information The method also produces

posterior distributions permitting the quantification of uncertainty and error estimation of calculated parameters including environmental properties Moving and multiple sources are discussed Chapter 5 Taroudakis discusses modal inversion techniques in shallow water Modal observables such as modal phase modal arrivals and dispersion curves using both the time and frequency domains are incorporated into linear and non linear inversion procedures The methods are based on geophysical analysis using normal mode propagation Good separation of modes is required which is affected by the nature of the array and the frequencies used for the inversions in a given scenario Chapter 6 Baxley is a review of the use of GI primarily to 1 show results of simplified approaches to GI 2 review the SWelLEX experiments of 1993 1999 as a good testbed of GI and 3 perform inversion using horizontal as well as vertical line arrays The intention was the optimization of system performance for the localization and tracking of undersea targets using a variety of arrays and the Bartlett processor Range independence was assumed so that a simple normal mode model could be used A number of parameters were estimated using a number of frequencies less than 200Hz assuming a simplified bottom Chapter 7 Rajan et al is a complete and mathematical discussion of modal inverse techniques The chapter presents a formulation of the inverse problem an estimation of the modal eigenvalue demonstrations in RI and RD waveguides with discussions of error sources spectral estimation modal attenuation coefficients sediment characteristics determined from modal dispersion data integral equations matrix inversion resolution and variation of estimates further demonstrations of inversion success for simulated and test data and more A complete coverage of modal issues is presented here Chapter 8 Tolstoy is the final chapter on GI and concerns a volumetric tomographic GI method This approach combines individual 2 D range and depth slice inversions on multiple arrays and for distributed sources into a full consistent 3 D range depth and azimuth image of the region bottom It is discussed within the context of the Haro Strait test and concludes that information about array geometry phone depths and shape is essential for successful inversion where success is defined as high MFP values at any and all frequencies with good signal to noise at a unique set of parameters Additionally 3 D resolution may be improved via regularization to counter scarcity of resources Chapter 9 Arvelo starts the section on signal processing with a detailed discussion of the factors affecting system performance particularly at low frequencies below 1 kHz These include noise especially as it affects coherence temporal and spatial waveguide variability such as bathymetry and scattering processes A review of low frequency coherence modeling and measurements is presented and examples are provided to illustrate key points Methods to circumvent the hard limits imposed by spatial coherence include the exploitation of multiple dimensions such as the design of planar and volumetric arrays Seismic coherence is also discussed Chapter 10 Sullivan Candy is a review of passive synthetic aperture processing PASA This approach to array processing utilizes the towed array motion to enhance its performance by explicitly incorporating this motion into the signal model Historically its name is based on the idea that the improved performance is equivalent to effectively having a longer array the array appears to be larger when multiple phone locations

can be combined coherently and this approach is most effective for short aperture arrays. It is unique in that it treats the problem as a recursive estimation process rather than a beamforming process. Again the primary interest here is system performance. Since it is recursive in time its application is limited to continuous signals such as radiated noise as opposed to short term signals such as pulses. The authors present the PASA development in mathematical detail narrowband and broadband single and multiple sources including both simulated and experimental data. Chapter 11 Zurk completes the section on signal processing where concerns about waveguide mismatch are addressed by the development of more robust processing methods. Rather than attempting to determine ocean properties many signal processors concentrate on the goal of devising techniques less dependent on the channel nature with the intent of improving system performance in uncertain environments. This can involve incorporating the statistics of the environment using a calibration source or developing invariant robust processors. These approaches are discussed here. Chapter 12 Gauss is the only chapter to concentrate on reverberation and presents a review of active sonar components coupled with signal processing for the purpose of detecting localizing and tracking undersea targets. Incomplete knowledge of the environment and clutter reverberation from non targets are the primary limits on system performance. Clutter mechanisms include bathymetry the ocean surface roughness fish bubbles and more. These mechanisms and methods to control their influence using frequencies 50 Hz to 5 kHz single frequency and broadband in deep and shallow water scenarios are discussed. Deconvolution is critical to all reverberation efforts. Additionally Doppler effects can be also used to separate signal contributions. The chapter concludes with a summary of contemporary issues and future trends. Finally the observant reader will notice that this text is dedicated to Leon Sibul. Leon died quite unexpectedly early in 2007 with the intention of contributing a chapter to this book. We in the research community miss his mathematical insights and contributions to signal processing. We miss the chapter he would have given to us in this book. But most of all we miss him.

*Inverse Problems in Underwater Acoustics* Michael I. Taroudakis, George Makrakis, 2001-06-26. This volume provides recent and useful results for bottom recognition inverse scattering in acoustic wave guides and ocean acoustic tomography plus a discussion of some of the new algorithms such as those related to matched field processing which have recently been used for inverting experimental data.

**The Journal of the Acoustical Society of America** Acoustical Society of America, 2007

*Matched Field Processing Based Geo-acoustic Inversion in Shallow Water* Lin Wan, 2010. Shallow water acoustics is one of the most challenging areas of underwater acoustics. It deals with strong sea bottom and surface interactions multipath propagation and it often involves complex variability in the water column. The sea bottom is the dominant environmental influence in shallow water. An accurate solution to the Helmholtz equation in a shallow water waveguide requires accurate seabed acoustic parameters including seabed sound speed and attenuation to define the bottom boundary condition. Direct measurement of these bottom acoustic parameters is excessively time consuming expensive and spatially limited. Thus inverted geo acoustic parameters from acoustic field measurements are



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Geoffrey Fred Edelmann,2003      **Publications - International Congress on Acoustics** ,1995

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