The Bulletin

AUSTRALIAN ACOUSTICAL SOCIETY

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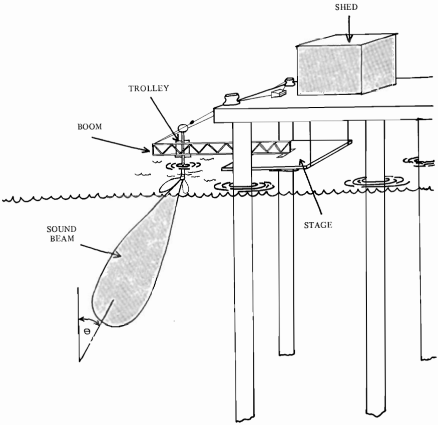
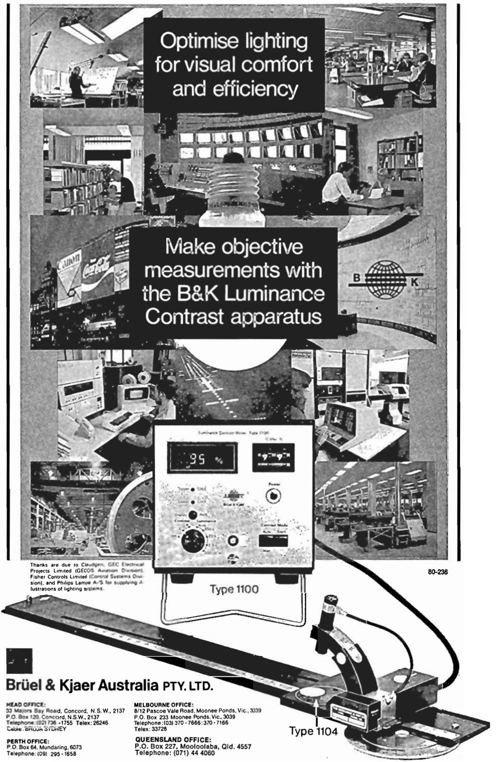


Special Issue: UNDERWATER ACOUSTICS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From the President

Early this year, I was informed by the Editor of "The Bulletin" that whilst the new editorial policy does not expect a regular "President's Column" an occasional contribution of presidential comment is welcome. It is interesting to note, that the "Canadian Acoustics —Acoustique Canadienne" journal in the April 1984, Vol. 12 No. 2 issue introduced a new regular feature titled "News from the President".

Actually, I am quite happy with the new editorial policy of "The Bulletin" (or should it be "Australian Acoustics—Acoustique Australienne"?).

Out of curiosity, I browsed through past issues of "The Bulletin" and if you have your old copies and some spare time, you may find it also a very interesting exercise. I especially read some of the columns entitled "From the President", which reflected the President's and the Society's concern on matters preoccupying members then and found that many of those are still unresolved today.

. . . . "This is the first year of the official incorporation . . . the creation of a new division in W.A. is a forward move . . . the Society has made and is still making a significant contribution in the formulation of acoustic standard . . . formulation of A Code of Ethics . . . this is needed . . . ."

—V. Taylor, 1972, Vol. 1 No. 2

. . . . "The formation of the S.A. Division was ratified . . . discussed at the 15th Council Meeting — the qualifications required for members to be elevated to the grade of Fellow and the formulation of a professional practice group . . . hope to compile a register of consultants . . . ."

—C. Mather, 1976, Vol. 4 No. 1.

. . . . "The 10th International Congress on Acoustics has been awarded to Australia (July, 1980) . . . (which) provides us with a wonderful opportunity to strengthen the Society . . . ."

—G. Riley, 1978, Vol. 6 Nos 1 and 2.

. . . . "a number of recommendations bearing on membership structures and financial matters will require careful considerations as they may involve the first series of changes to the 'Articles of Association' of the Society since its incorporation . . . ."

—R. Piesse, 1980, Vol. 8 No. 1.

The next President, my predecessor, Anita Lawrence, to whom I would like to pay tribute for her capable, untiring leadership, expressed her concern by saying:

. . . . "unfortunately, it is clear that we now have a great division in our Society — between those members who consider themselves 'acousticians' and the organisation as one representing the profession of acoustics, and those members (or whatever grade) who see it simply as a learned society or club . . . they (the above) will surely dictate the direction that the Australian Acoustical Society will take over the next few years . . . ."

—A. Lawrence, 1981, Vol. 9 No. 3.

While this issue has not been resolved, yet others emerge . . .

I received a circular from authors who chose to remain anonymous stating:

. . . . "to ensure that the substance of the criticism is examined rather than any inferred motives in its making . . . ."

The circular referred to a member of the Australian Acoustical Society who, according to the circular:

. . . . "was admitted to membership of the Society through the gate which has caused considerable debate and soul-searching over recent years . . . ." The circular stated further that . . . . "This criticism is not intended to reflect upon the character of the author (the member under criticism) . . . . is, however, directed at the Society and the entrance standards imposed on applicants without any formal qualifications . . . ."

Instead of writing an anonymous letter or circular, the authors, whom I assume to be members (non-ethical) of the Australian Acoustical Society, should have taken action in one of the following ways:

(i) If their grievance was caused by the action(s) of the Council of the Society, they should have forwarded their case through their Divisional representatives or through the General Secretary of the Council to the Society's next Council Meeting, where their grievance would have been handled according to Articles 130 and 131.

(ii) If the matter had not been resolved to their satisfaction at the appropriate Council Meeting (which are held twice a year) then the grievance could have been tabled at an Extraordinary General Meeting, convened and conducted according to Articles 53, 54 and 58.

Either of the above courses of action would have been a correct approach to deal with a grievance, and it would have been in keeping with the spirit of a "Learned Society" or that of a "Professional Society". I am sure that this would have been the only PROPER way in which . . . "the substance of the criticism . . ." could have been and should have been examined.

—TIBOR VASS, President.

Editorial

Special issue

This issue of the Bulletin is a special one devoted to Underwater Acoustics in Australia, an area of acoustics in which we have a number of distinguished researchers. For some time it has been our intention to have special issues on topics of interest to substantial groups of our membership. Another is being planned for December on aspects of environmental acoustics. We are grateful to Dr. Marshall Hall of the Royal Australian Navy Research Laboratory, who is one of our consulting editors, for organising the special articles and reports that follow.

Advertising

As with most publications these days, the Bulletin is not finding it easy to live within its budget. Our major current problem is to build up the volume of advertising. During the recession many regular advertisers dropped out on the grounds that their "limited advertising budget was fully committed elsewhere". There is a welcome turn around in the current issue with a small increase in the number of advertisements but much more could be achieved. To help in the time-consuming task of making new contacts, we need your help in suggesting names of interested companies in each State together with the name and telephone number of a contact person. The personal touch is an essential part of our follow-up process.

Proposed change of name

For some time there has been a problem with the present name of this publication. To some potential advertisers and subscribers the title suggests a house journal and does not adequately describe the contents or style.

At a recent council meeting it was decided to seek the opinion of members for a change to Acoustics Australia, at the same time making it clear that it was a publication of the Australian Acoustical Society. Such a title would reflect the new Australia-wide emphasis we are trying to achieve with the contents.

—HOWARD POLLARD, Chief Editor.

Australian News

Questionnaire Response

There were 45 replies to the questionnaire included in the December 1983 issue of the Bulletin. This represents slightly in excess of 10 per cent of the membership. While this return may be thought to represent an advanced state of apathy, I am assured by experienced hands that such a response is indeed a sign of more than average interest. Be that as it may, the replies by state of origin were: N.S.W. 21, Vic. 15, S.A. 7, Qld. 1, W.A. 1.

The editorial committee wishes to thank all who submitted a return. Your opinions and remarks will prove most helpful in planning future issues.

The majority (and some minor) responses to the various questions were as follows —

1. (a) AUSTRALIAN NEWS — interesting 41.
   (b) Length of Australian News — about right 39.
2. PEOPLE — interesting 35 (little interest 9).
3. INTERNATIONAL NEWS — continue 33 (neutral 9).
4. ARTICLES AND REPORTS
   (a) Space allotted — about right 30 (not enough 11).
   (b) More short reports — yes 34 (no 7).
   (c) Range of topics — satisfactory 27 (passable 15).
5. TECHNICAL NOTES
   (a) Interesting 40.
   (b) Space allotted — about right 27 (too little 10).
6. NEW PRODUCTS — interested 30 (neutral 11).
7. PUBLICATIONS BY AUSTRALIANS
   (a) Continue 30 (no 8).
   (b) Usage — occasionally 28 (never 14).
8. ABSTRACTS — continue 29 (no 8).
9. FUTURE EVENTS — continue 36.

A number of useful suggestions and comments were received. As might be expected these covered a wide spectrum of views. For each of the main sections of the Bulletin there were those who considered we were wasting paper as well as those who wanted more. A selection of views expressed is given below.

ARTICLES: 'more articles of direct use to practising acousticians' — 'more commercial case studies' — 'invited papers on each of the main aspects of acoustics with examples of recent developments' — 'articles on peripheral topics such as electronics, computers, signal processing, behaviour, etc.' — 'topics on industrial noise, community noise, signal analysis'.

REPORTS: 'more *Work in Progress* reports featuring consultations, R & D etc.' — 'more interviews with acousticians' — 'regular reports on noise legislation, both States and Federal' — 'computer programmes for acoustical formulas' — 'abstracts of papers given at annual conferences' — 'regular reports from Government authorities' — 'more input from consultants and private firms' — 'section on available software relating to data processing, frequency analysis, etc.'.

TECHNICAL NOTES: 'standard too low' — 'prefer interesting solutions or observations from members rather than gee-whiz notes'.

IN GENERAL: 'The Bulletin should be larger to reflect the extent of activities throughout Australia' — 'informative, interesting and authoritative publication' — 'include small advertisement section for acoustical instruments and apparatus for sale or wanted' — 'invited editorials on significant topics' — 'we have to be an Acoustical Society and not a Noise Control Society' — '*People* should be dropped as it is a notorious avenue of free advertising for a few individuals' — 'I support the idea that the Bulletin should report gossip and rumours provided that only members are named'.

FINAL COMMENT from an appreciative member — 'I consider the current form of the Bulletin generally meets the requirements of the members. Very few attend Society organised technical meetings often because such meetings are foreign to their particular sphere of interest. The Bulletin serves to give them a feeling of belonging and a means of knowing what is occurring. Under no circumstances should consideration be given to downgrading this publication as the result can only mean a loss of members'.

—*H. F. Pollard,*
Chief Editor.

Quiet House Competition

This competition, sponsored by the State Pollution Control Commission, attracted 104 entries. The design submitted by Geoffrey Le Sueur was unanimously judged as the "most liveable and cost-effective design". Geoffrey Le Sueur is a graduate of the University of New South Wales where he now lectures. He has studied urban planning in the U.K. and Europe and has designed medium density dwellings in Paddington, Sydney and other inner suburbs.

Le Sueur's Quiet House design comprises a dwelling consisting of 16.6 squares — three bedrooms, a living/dining area, kitchen, bathroom/WC, family area, laundry, double garage (plus 40 m^2) and two enclosed courtyard areas at the front and opening off the living and bedroom areas on a site 900 metres square.

"I tackled the problem of noise pollution as though it were a privacy issue," said Geoffrey Le Sueur.

"The first step was to use masonry as a barrier against sound. The entire house therefore was set well back on a 900 metre square block. The nature strip takes on a wider than normal profile and is assimilated into the overall plan of the house.

"The courtyard is where the front wall of the house would normally be located. The idea here was to create the sensation of going through a zone, giving the psychological feeling of distance from the street to the house. To break sound patterns the front door was moved to the side."

Noise tolerance is dependent on activity. With that in mind Geoffrey reversed the normal layout of a house.

The laundry became the first room off the main hallway, in the Quiet House. With this planning criteria the zoning of rooms acts as an additional buffer.

Family and living areas face a second courtyard. "The centre courtyard is important for many reasons, most of all to break up the cellular pattern of the rooms," said Geoffrey.

"Roofs are conventionally a weak spot in noise abatement. To avoid a direct sound path we adopted a flat roof system, using metal decking. By taking away the eaves and adding parapets we further reduced the possibility of sound travelling."

Geoffrey added that the roof is to be insulated with Stramit acoustic boards pointing out most insulating materials used in a roof are usually for thermal effect, and do not really work at reducing noise.

The absence of windows opening on to the street is another major noise-reducing feature of the house. There were many reasons why Geoffrey avoided using double-glazed windows.

"While I agree they do limit noise, there are problems with double-glazed windows when it comes to opening and shutting them. For this purpose all the windows in the house open onto the centre courtyard".

Throughout the house the double-cavity brick walls will be hard at work — sealing off rooms, acting as barriers upon barriers, shielding against noise, both inside and out.

The bedrooms, tucked away at the rear of the house, receive the benefit of all these rooms acting as barriers to this most noise sensitive area. The hallway directly leading to the bedrooms is sealed off with a door, a skylight providing light to this section of the house. There will be another doorway further up the main hallway, isolating the frequently noisy family area.

There is also provision for a garden or additional courtyard to adjoin the sleeping areas.

—*(Extracted from Hometime magazine).*

Noise control — C.A.R.E.S. shows how

C.A.R.E.S. — Campaign Against the Royal Easter Show is campaigning against the noise and litter that local residents have to put up with at showtime. Their pamphlet explains "the worst thing for the Show is wet weather, and we all know that it always rains just after washing the car. You can participate in this innovative consumer action by washing your car on Friday 13th. Our rain-making consultants have advised that all car washing must be synchronised to the one day for maximum effectiveness. If you cannot wash your car on this day, C.A.R.E.S. will do it for you, free of charge. Just call the Careline on 267-1867 on Tuesday 10th between 9 a.m. and 9 p.m., giving your car's registration number and where it will be parked on Friday. Help wash out the Show!"

Council and the old silent rooster trick

The Ryde Council has ruled that a noisy rooster in Buffalo Road, Gladesville, must be moved to a perch closer to the roof of his fowlhouse, so he won't be able to stretch his neck so far. The theory is that he will hit his head if he tries to be too enthusiastic in his crowing.

This and the preceding item about C.A.R.E.S. were mentioned in the column "Stay In Touch" in the Sydney Morning Herald of Tuesday, 10th April, 1984.

Paul Bridge deserves special mention for joining the ranks of the very few who have sent us snippets of information for inclusion in this column; Paul having sent us a photocopy of the relevant page of the Sydney Morning Herald.

New Members

We have pleasure in welcoming the following new members of the Australian Acoustical Society, following grading by the Council Standing Committee on Membership . . .

Subscriber: Mr. M. Howells (S.A.).

Affiliate: Mr. D. O. Lane (N.S.W.).

Member: Mr C. E. Tickell (N.S.W.), Dr. K. C. Wan (W.A.), Dr. P. A. Wilkins (W.A.). Mr. A. I. Segal (N.S.W.)

Beta Audio Video

Two issues ago we invited **Denis Cale** to tell us what he was doing after he had left Bang & Olufsen. Not only has he told us but Denis is offering preferential treatment to fellow members of the Society. Denis has opened his own shop called Beta Audio Video and is selling the full range of Sony equipment plus Acoustic Research Loudspeakers, Sennheiser Headphones, Dynaudio Loudspeakers and B.A.S.F. products.

Brian Scrivener retires

Brian Scrivener, M.A.A.S., has retired from his position as Senior Acoustics Officer for BMI Limited, a position he has held for the past five and a half years.

However, just to keep his hand in, Brian is interested in doing some part time acoustical consulting as an "overload" sub-contractor for established consultancies.

He has specialised in blasting, both monitoring and the design of blast geometry to reduce the problems of ground vibration and airblast (see A.A.A. Bulletin, Vol. 11, Dec. 1983), and also in the production of Noise Impact Statements for environmentally sensitive projects including open-cut coal mines.

Brian can be contacted at 69 Devon Street, Epping, Sydney 2121 or by telephone (02) 869-2580.

James Madden Cooper Atkins shifts

James Madden Cooper Atkins Pty. Ltd., Consulting Acoustical and Vibration Engineers, have shifted to Suite 7, 9 Myrtle Street, Crows Nest, N.S.W. 2065. Their telephone number of 929-6378 remains unchanged.

New Zealand reciprocal visits

Following the visit of your Peoples Columnist (also Society Vice-President) to the beautiful country of New Zealand we have been pleased to have here in Australia **Dr. Philip Dickinson,** Associate Director of the Acoustics Institute at the University of Auckland. Dr. Philip has visited the C.S.I.R.O., the RMIT, our own office of Graeme Harding & Associates, and similar organisations in other States. Dr. Philip Dickinson is one of two Vice-Presidents of the New Zealand Acoustical Society; Cliff Stephenson formerly a member of the Australian Acoustical Society is the Vice-President in the South Island. Dr. Philip's visit did much to promote co-operation between the Australian and the New Zealand Societies. We also learnt with interest of some of the work being done in New Zealand particularly of original work being done regarding noise from rain on roofs.

Jim Menadue leaves RBK Acoustics

After many years in the continuing organisation known originally as the Australian Acoustical Laboratories, then Riley, Bardon & Kirkhope, then RBK Acoustics, **Jim Menadue** has had to leave because of the depressed conditions in their office. Needless to say, Jim will be interested to hear of any employment opportunities.

John Moffat recovering

Some members will know that **John Moffatt** has been seriously ill with leukemia and will be pleased to know that at last report he was back home again getting well and looking forward to returning to work.

Australian Metrosonics

JOHN VESTERGAARD *has been appointed as manager of the recently established Metrosonics Inc. (Aust.) located in Melbourne. Further details are given in the advertisement elsewhere in this issue.*

Society Archives

The Society Archivist, **Paul Dubout,** reports that certain issues of the Bulletin are missing from the archives. If any member would care to donate one of the following issues it would be gratefully received.

Copies missing: Vol. 4 No. 4; Vol. 5 Nos 3 and 4; Vol. 6 Nos 1, 2, 3, 4; Vol. 7 No. 1.

One copy only held: Vol. 1 Nos 1 and 2; Vol. 4 Nos 2 and 3; Vol. 5 Nos 1 and 2.

Please forward copies to **Paul Dubout,** CSIRO Division of Building Research, P.O. Box 56, HIGHETT, VIC. 3190.

Change of Address

We have been advised that **C. M. Steele & Associates** have moved their main office to Sydney. The new address is Suite 610, Mirvac Trust Building, 185 Elizabeth Street, Sydney, N.S.W. 2000. Tel. (02) 264 9401. (After hours: (02) 328 6510.)

Clients in the Wollongong area will still be able to arrange appointments with Mr. Steele by telephoning Miss Foskett on (042) 28 8294.

Pictures with news

Remember not only do we appeal for news from all divisions of the activities of people involved in acoustics, but also appeal for any pictures suitable for inclusion in this column. Please send all contributions to **Graeme Harding & Associates,** 22a Liddiard Street, Hawthorn, Vic. 3122.

Underwater Acoustics In Australia

Marshall Hall
Defence Science and Technology Organisation (RANRL)
P.O. Box 706, Darlinghurst N.S.W. 2010

ABSTRACT: In common with other branches of acoustics, Underwater Acoustics consists of "forward" acoustics and "inverse" acoustics. The former can be divided into physical underwater acoustics and acoustical oceanography. The different types of activity within each of these divisions are outlined and Australian contributions to them are reviewed. Australians have not made many "breakthroughs" in physics (although they have tidied up a number of loose ends); but they have made significant contributions to the acoustical oceanography of the oceans around Australia.

INTRODUCTION

Underwater, or marine, acoustics is a field of study that embraces two processes: the "forward" problem of predicting the sound field when the physical environment is specified; and the "inverse" problem of describing the environment on the basis of some acoustic measurements.

In "forward" acoustics, the types of sounds that we wish to be able to predict include both natural (ambient) sounds (due to animals or splashes for example) and artificial sounds caused by vessels or sound-projectors (e.g. echo-sounders, sonars, or explosive charges). The objective of studying "forward acoustics" is to develop models (algorithms) and acquire data in order that we can predict the properties of the sound field at any position and time, for any given configuration of sources within the ocean. The main application of this information is to be able to predict how well various sonar systems should perform in a given set of circumstances.

"Inverse underwater acoustics" (not backward acoustics!), or "acoustic sensing" as it is generally known, is the generic label for the various methods that use acoustic devices to obtain information relevant to any of the marine sciences. These methods make use of the dependence of the sound field on the compressibility and density of the medium. Examples of some methods, together with the disciplines that employ them, are as follows:

Discipline	Method of Sensing
Marine Geology & Geophysics	Seismology
Physical Oceanography	Acoustic Tomography
Bathymetry & Hydrography	Echo-Sounding
Marine Biology	Echo-Sounding

Since acoustic sensing is discussed in a companion paper by J. Penrose et al, this article will henceforth consider only "forward" acoustics. Within this topic, we can identify physical acoustics ("physics") and acoustical oceanography ("geography") as the two main types of activity.

1. PHYSICAL UNDERWATER ACOUSTICS

Physical acoustics is concerned with obtaining solutions to the wave equation for given boundary conditions. Examples in the marine environment are:

- the transmission of sound in a surface mixed-layer;
- transmission in the deep-ocean (including reflection by the bottom and refraction by features such as "eddies");
- scattering from the sea surface with a prescribed roughness spectrum;
- the effects of wind-generated bubbles near the surface on both reverberation and transmission; and
- the sounds produced by the motion of the sea surface.

To solve these problems the first step is to develop a mathematical model of those aspects of the environment that affect the compressibility and density. This model becomes the boundary condition for the wave equation, the solution of which yields the properties of the transmitted sound.

Physical underwater acoustics began in earnest in the 1940's. Most of the work on the subject has been carried out in the USA, with some important contributions from the USSR and further contributions from other nations. One ocean is similar to another in many ways and for this reason results obtained for other oceans are often applicable to the oceans around Australia (for example, physical processes such as sea-surface roughness or bubbles, for a given wind-speed). Similarly, algorithms for determining propagation that accept a variety of sound-speed profiles can be applied to oceans around Australia. One important difference in emphasis is that in general the oceans of interest to Australia (namely the eastern Indian Ocean and the western South Pacific Ocean) are warmer and shallower than those of interest to other developed nations. The significance of this is that it is important for us to know the acoustical properties of the sea floor in considerable detail.

Topics of a fundamental nature in physical underwater acoustics in which Australians have made useful contributions include:

- the effects of bubbles near multipole sources [1,2];
- target (or "scattering") strengths of marine organisms [3];
- noise generation by the motion of the sea surface [4]; and
- propagation in a random medium [5].

Except for the above-mentioned work, most Australian projects in physical underwater acoustics have been one of the following types of activity:

(a) modifying existing algorithms to improve their accuracy [e.g. 6-9];
(b) applying existing algorithms to new environmental scenarios [e.g. 10-16];
(c) clarifying the region of validity of an existing algorithm [e.g. 17-20]; and
(d) modifying an existing algorithm to improve its efficiency [e.g. 21].

An interesting question is: which of these types of activity are "research" and which are "development". Papers on all four activities are published by learned journals such as the Journal of the Acoustical Society of America or the Journal of Geophysical Research. On the other hand, the U.S. Office of Naval Research considers type (d) to be "development". It can also be argued that type (b) is applied science rather than research, since the person involved need not even understand the details of the algorithm (depending on how operator-dependent it is).

The topics mentioned so far have all been related to the "linear" wave equation that is valid for small amplitudes. Work has been done on non-linear acoustics as it relates to new types of acoustic sources, but none of this is being conducted in Australia.

An important problem that concerns users of acoustic equipment, although it is not related to the wave equation, is that of the background noise of a moving hydrophone. The background noise of a stationary hydrophone will be either internal electronic noise or ambient sea noise. A moving hydrophone will also be subject to "flow noise". The prediction of flow noise comes under the heading of "fluid dynamics" rather than "acoustics" however, because it is not composed of sound waves. The pressure fluctuations, which are caused by turbulence, are not governed by the wave equation. (Turbulence does also cause sound to radiate, but this type of sound, whose intensity is proportional to the sixth power of the Mach number, has never been detected in the ocean.)

2. ACOUSTICAL OCEANOGRAPHY

Acoustical oceanography (or descriptive underwater acoustics) comprises survey measurements of the properties of the sound signals that occur at particular places and times under certain conditions. The objective of this work is to compile an atlas or data-bank for each of a large number of acoustic parameters. This type of data is of considerable use to the Australian Navy and much effort has been devoted to obtaining it.

Most of the acoustical oceanography of the eastern Indian Ocean has been done by Australians, whereas in the western South Pacific, New Zealanders seem to have shown somewhat more interest than we have.

Several parameters have been surveyed to varying degrees, so we will consider them one by one.

• **Propagation Loss.** The measurement of this parameter involves the detonation of explosive charges (whose source spectrum covers a wide band of frequencies) at regular intervals along pre-set paths. The resulting spectra of propagation loss at various ranges from a fixed position in the ocean can then be stored for subsequent referral in the same way as an atlas. Results of various experiments are reported in [19, 22, 23]. Users of these data will probably assume that the results are also applicable to the region surrounding the original datum point. The boundaries of this region would be determined by the location of significant changes in the sound-speed profile or in the properties (e.g. the depth) of the sea-floor.

• **Ambient sea-noise** [e.g. 24-29]. The main findings have been (i) there is a wind-dependent component at low frequencies whose intensity is proportional to the fourth power of the wind-speed; and (ii) shallow-water areas become very noisy at audio-frequencies at certain times of the day (e.g. the "evening chorus" caused by marine animals eating and communicating with each other).

• **Volume backscattering** [8, 15, 30-32]. (i) In the equatorial and tropical regions, huge variations take place each day as the small deep-sea fishes migrate to the surface each evening; (ii) scattering layers of relatively large deep sea fishes at depths of several hundred metres are a prominent feature of the sub-tropical regions during daylight hours.

• **Bottom backscattering** [33]. This is a highly variable parameter that should be related to the roughness of the sea-floor. Results obtained from two surveys have indicated that the scattering at certain frequencies is correlated with the depth of the sea-floor (further surveys have also been conducted, but the results have not been published in the open literature).

• **Bottom reflectivity.** This is another highly variable parameter. Many results have been obtained for reflection at normal incidence (this is an easy measurement because only one platform is required). A more important parameter is the reflectivity at small grazing angles, and so far only a small number of measurements have been made.

• **Sound-speed profiles.** This term is taken to include both the water column and the interior of the sea floor (for completeness we also need to know the density profile and the shear-wave speed profile within the sea floor). Most of the sub-bottom results that are available have been obtained by the Bureau of Mineral Resources and the Geology or Geophysics departments of various universities (see references 34-36 as examples).

• **Shallow-water propagation.** This usually means propagation on the continental shelf. Although spot measurements have been made at various locations around Australia [e.g. 37], a systematic survey has yet to be conducted. Results obtained overseas show a strong seasonal dependence, with transmission in the winter being much stronger than in the summer. This effect is due to the seasonal variation in the thickness of the surface mixed-layer, which is a prominent feature in the southern Australian coastal regions.

3. CONCLUDING REMARKS

• **Why do we measure both reflectivity and sub-bottom profiles?** There is some redundancy in measuring these two parameters. Reflectivity is measured because it is the easier measurement and because the results can be immediately applied to ray theory transmission models. Such application does not make good sense however if the return of sound energy to the water takes place due to refraction within the sediment rather than reflection at the interface, since in this case focusing of the sound occurs at certain regions in the water and the bottom seems to "magnify" the sound. Application of the complete sound-speed profile to a transmission model, on the other hand, is the correct procedure and avoids the pretext that magnification sometimes occurs at the sea floor.

• **Why do we study acoustical oceanography as well as physical underwater acoustics?** Would not one of these be sufficient? The answer is that if the studies of oceanography, biology, and geology ever produce all of the information that is relevant to acoustics, then acoustical oceanography would be unnecessary. In many cases however the environmental data are unavailable, and the effort required to obtain them is greater than the effort required for the direct acoustical measurement. This situation applies especially to cases where the environment is complicated. Examples are the sea floor where the sediment is thin; layers of plankton; and schools of fish. The main disadvantage of acoustical oceanography is that you cannot measure everything (for example, cover the entire frequency band that will ever be of interest) and if the theory is not understood then we have no basis for extrapolating from known to unknown variables.

ACKNOWLEDGEMENT

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Monte Carlo Modelling of Scattering in Underwater Acoustics

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ABSTRACT: Active acoustic sensing techniques are now emerging which promise to yield considerably enhanced information about targets of interest in marine acoustics. This paper reports on two programs underway at the Western Australian Institute of Technology which illustrate features of the new techniques.

In the first of these, statistical treatment of an ensemble of echoes from biological targets is shown to yield information about both individual targets and their spatial density. A suite of assumptions underlines the statistical treatment involved; the present work uses a Monte Carlo simulation to test the sensitivity of the technique to relaxation of these assumptions and thus illustrates the applicability of the technique to realistic biological populations.

In the second program a Monte Carlo model of acoustic scattering from a rough seabed is used to model a set of experimental results gained from a test rig operated in a local harbour. This leads to discussion on the use of the model to relate reflected/scattered pulse shapes to seabed roughness in ocean-going applications.

1. INTRODUCTION

The term *remote sensing*, widely applied to airborne and satellite applications, is also applicable to active acoustic sounding in the sea. Widely used systems for echo sounding, sonar, side scan and sub-bottom profiling are beginning to benefit from the availability of economical and compact data processing units. The opportunity exists to significantly improve the quality of information received from active marine acoustic systems, in particular, regarding target description, by the use of on-line data processing devices and data analysis techniques based on an understanding of acoustic scattering and reflection processes.

Marine biota and the seabed have formed the two main targets of interest in non-military echo sounding and sonar. In recent years attention has also been given to the acoustic detection of density stratification in the water column, often in association with investigations of internal waves. Under suitable conditions detectable acoustic signatures may be obtained from density contrasts alone, using standard echo sounding equipment [Penrose and Beer (1981)]. More commonly, such layering aggregates planktonic and some larger biota, which is then responsible for the acoustic records observed.

Work at the Western Australian Institute of Technology for the past few years has been directed to the study of acoustic scattering from marine biota, including some smaller marine crustacea, and from the seabed, with particular attention being given to scattering mechanisms, and the development of usable data processing techniques.

2. ACOUSTIC SCATTERING FROM MARINE BIOTA

Conventional echo sounder practice in the fishing industry uses acoustic backscatter from marine biota essentially as a presence/absence indicator. When resource estimation is required, quantitative sounding is used in various forms. Ideally, this calls for both measures of the acoustic cross section of individual organisms, and of the numerical distribution of organisms in the water column. In order to place fisheries sounding on a quantitative basis, various techniques have been developed to estimate the acoustic cross section σ, or target strength, $T = 10 \log (\sigma/4\pi)$, of significant marine species. Some estimates have been made by direct measurement in laboratory tanks [see e.g., Sofoulis et al (1979)]. A more satisfactory result can be expected if measurements can be made in a more indirect fashion, on free-swimming organisms in the sea. Such measurements call for a calibrated sounder system, and some method of dealing with several unknown parameters associated with field operation, notably where a single fixed transducer is used.

Figure 1 represents the backscatter geometry associated with echo generation from a fish at range R from a circular

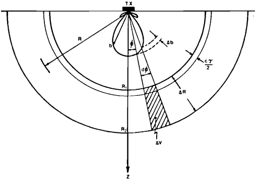

Figure 1: Geometry of backscattering measurements. Same transducer used to transmit and receive signals. (Redrawn from Petersen et al, 1976)

transducer with directional pressure sensitivity $b(\phi)$ and using wavelength λ and pulse length τ. The return signal pressure may be written

$$P_r = P_s (10^{-\alpha R/10}/R^2)\, b^2(\phi)\, (\sigma/4\pi)^{1/2} \qquad (1)$$

Here P_s is the source term, P_r the received pressure and α an absorption constant.

Two terms in (1) are subject to variability which renders an individual echo return of negligible value as a target descriptor in field operation. The value of ϕ is unknown and hence $b^2(\phi)$ is unspecified. Most targets of interest so far in fisheries resource estimation have lengths $L >> \lambda$. The choice of wavelength λ is dictated by various cost and engineering factors, and is commonly in the range (3cm — 0.75cm) (50kHz — 200kHz). Such targets are in the so-called "geometric" scattering region and have backscatter signatures which are critically dependent on target orientation in the sound beam.

An individual echo return is therefore of little value as a target descriptor. An ensemble of such returns, however, may provide useful information. A demonstration of this process has been provided by Peterson et al (1976). The authors have, by employing a set of assumptions, derived estimates of target acoustic strength and spatial density of fish in the water column. The assumptions are:

1. A single species of fish is present and all fish have the same average dorsal acoustic cross-section. This effectively requires that all targets should be the same length.
2. Only one fish is insonified at a time within the range shell $c\tau/2$. That is, the fish density is such that no echo overlap occurs at the sounder.
3. The variation in backscatter signal strength due to target orientation in the sound beam is represented by choosing the instantaneous value of the backscatter cross-section (in pressure terms) from within a Rayleigh distribution.
4. The transducer beam pattern is accurately known and realised.

Using these assumptions Peterson et al have developed a theoretical probability density function (PDF). This is fitted to an experimentally derived frequency-of-occurrence versus echo amplitude plot by varying two parameters describing the PDF. This process then yields two target descriptions, vis:

$\sigma/4\pi$ = the average dorsal backscatter cross-section for each target fish,

N_f = fish density (fish/m^3).

Figure 2 illustrates the results presented by Peterson et al. The field data is represented by the rectangular "amplitude cells", which are of varying shapes because of the need to sort the data into amplitude steps, each of which contains a significant number of counts. The selection of step widths represents an operational problem with this technique which requires more processing time than do later methods which have been developed.

In recent years, major advances in the interpretation of echo signals from marine biota have been made by workers at the University of Washington [see e.g. Ehrenberg (1981)]. A two transducer system has been developed to establish the value of $b^2(\phi)$ on an echo-by-echo basis, and a range of signal processing and statistical techniques developed for use with the more common single transducer configuration represented in Figure 1. By fitting data to the cumulative probability function rather than the PDF, Ehrenberg has removed several of the difficulties associated with the technique developed by Peterson et al. The cumulative probability function is, however, still generated using assumptions 1 to 4 above.

Working on the basis of Ehrenberg's method, Palumbo (1982) has developed the Ranked Array Method (RAM) in which

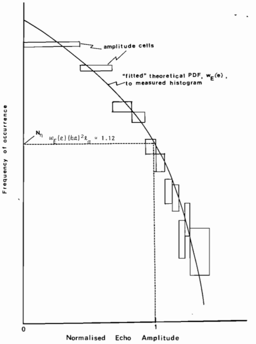

Figure 2: Theoretical probability density function of the envelope of echoes "fitted" to a measured echo amplitude distribution. The procedure is used to derive the acoustic target strength of fish and fish density in the water column. (Redrawn from Petersen et al, 1976)

incoming echoes are simply sorted in order of increasing pressure amplitude. When an adequate number of echoes have been accumulated (this may be as little as 50), the ranked values are summed and scaled to fit the theoretically derived cumulative probability function. As before, the scaling process yields values of $\sigma/4\pi$ and N_f. The $\sigma/4\pi$ value so obtained may be related to fish length for a number of important species using various empirically derived expressions [e.g. Love (1977)] and to describe other marine species with reduced accuracy [Penrose and Kaye (1979)].

The techniques described yield a considerable improvement in the information provided by most present sounding practice. Both methods are dependent, however, on the applicability of the assumptions noted above. Palumbo (1982) has used an extensive simulation computation and statistical techniques to test the Ranked Array Method for its sensitivity to relaxation of each of the assumptions. Such a test is essentially impossible to achieve in the field because of the difficulty of relating individual or small groups of echoes to the targets causing them. Palumbo used Monte Carlo simulated data from targets of specified Target Strength T and, after relaxing the assumptions noted above, processed the resultant "data" using the RAM to recompute T. An agreement to 1 dB was regarded as usable precision. Love (1971) reviewed laboratory target strength measurements from a number of researchers, collected from fish from up to 16 families, for which $0.015\text{m} < 1\text{m}$. Later, Love (1977) reduced his data to yield, for average target strength in the dorsal plane

$$T = 10 \log (0.042\, L^2/4\pi) \qquad (2)$$

TABLE 1. SIMULATION RESULTS.

ASSUMPTION	MODIFICATION OF ASSUMPTION	CONCLUSION
All fish have the same average dorsal cross section. (i.e. the same length)	Lengths distributed normally about mean L, and with standard deviation W	Target strength estimates remain within 1 dB of ideal, for variations in length of up to 30% of the average length.
Only one size class of fish is present.	Bimodal length - Frequency Distribution of targets. $L_{small} = 0.1056m$ $L_{large} = 0.264m$	For population ratio of large/small fish ≥ 15, TS. estimate corresponds to larger fish. For population ratio large/small $\leq 1/200 \rightarrow 1/1000$ TS. estimate corresponds to smaller fish.
Single target in the range shell at any one time.	Poisson distributed probability of several fish in range shell $P = \frac{(\lambda V)^T e^{-(\lambda V)}}{T!}$ $P \equiv$ probability that no. of fish in volume V is T. $\lambda \equiv$ average no. of fish/unit volume	TS. within 1 dB for $\lambda V = 0.6$ i.e. for $\frac{P(2)}{P(1)} = 30\%$ and $\frac{P(3)}{P(1)} = 6\%$
Target orientation factor described by Rayleigh Dist.	Distorted frequency distribution generated	TS. within 1 dB for significant distortions of the Rayleigh Distribution
Transducer Beam Pattern is known and well defined.	Various beam pattern deformations undertaken.	Mild variations in beam pattern acceptable

Using this formulation, a 1 dB increase in T corresponds to an increase in L of 12%.

Table 1 summarises some results of the simulation program.

Assumption 1 requires that all targets have the same acoustic cross section, i.e. the same length. Results for T within ± 1 dB can, however, be maintained for a Gaussian distribution of fish lengths with a standard deviation of up to approximately 30% of the mean length. Where mixed size classes are present, length estimates are dominated by the larger targets; smaller targets becoming apparent only when, for the examples given, small fish dominate by 200 times or more. Assumption 2 requires that no echo overlap from multiple targets occurs. If fish are distributed in the insonified volume randomly, the probability of the occurrence of x targets in the volume is given, agreeably, by a Poisson distribution and the effect on estimated target strengths of increasing the spatial density of targets may be computed. Results show that even when 30% of interactions are from two targets in the same pulse interval, target strength values within 1 dB are obtained.

The effect of these simulation results is to indicate that usable target strength estimations can be sustained for realistic departures from ideality in assumptions 1 and 2. This result is of significance for acoustic resource estimation of monospecific pelagic stocks which can be expected to approach, though not meet, assumptions 1 and 2. Assumption 3, which requires that backscatter pressure fluctuations arising from varying target attitudes to the sound beam i.e. the fish scattering PDF, be described by a Rayleigh distribution, has been the subject of considerable investigation, leading to the use of this description for $L/\lambda > 20$ (approx.) [Ehrenberg (1981)]. More recently Clay (1983) has examined the fish scattering PDF obtained after deconvolution of the beam pattern effect from an ensemble of Sonar echoes. Some evidence exists to show that differing target size classes may be discernible in the data. Clay and Heist (1984) have explored the possibility of identifying different species and behaviour from the fish scattering PDF, and have fitted their data to a two-parameter Rician PDF rather than the single parameter Rayleigh distribution.

Palumbo has tested the extent to which the application of the Rayleigh assumption to data sets which, in fact, differ in varying degree from the Rayleigh form, can still yield Target Strength values within 1 dB. The results suggest that the use of this simple one-parameter distribution may well be adequate for many field situations.

The signal processing outlined above may be implemented in real time by a simple processor and allows for the visual presentation on a VDU of spatial density, target strength and target length, provided the system has access to linearly amplified versions of the input signal. One commercial manufacturer now provides a related facility associated with a scientific sounder. The ability to compare such estimates with ground truth from periodic net hauls means that such systems can be tested and refined in the field and may in due course enable less dependence to be placed on time-consuming netting techniques for resource estimation of pelagic species.

3. ACOUSTIC SCATTERING FROM THE SEABED

Acoustic interaction with the predominantly sedimentary seabed has been modelled in a variety of ways. The simplest model treats the water-sediment interface as a perfectly flat boundary between two fluids. Despite the simple nature of this approach, some workers [e.g. McLeroy (1972)] have been able to relate acoustically determined reflection coefficients using this model with sediment properties, notably density and porosity. In general, factors such as mode conversion, absorption, sub-surface reflection and scattering due to surface roughness may influence acoustic returns. The significance of these various factors depends strongly on sediment properties and the acoustic wavelengths employed.

Investigation of small scale roughness usually involves concentration on short wavelength interactions where the acoustic energy is largely or totally scattered and reflected at the visually observable water-sediment interface. The use of wavelengths of the order of centimetres means that virtually all sea bottom surfaces must be considered as "rough", i.e., with roughness length scales at least comparable to the interacting wavelength. Seabed topographies exhibit roughnesses on a variety of length scales, from features kilometres in extent, often evidencing major geological processes, to roughnesses associated with individual sediment particles. At intermediate length scales, in the range centimetres to tens of metres, sediment roughnesses are attributable to near-bottom ocean currents, marine organisms and processes such as manganese nodule formation. Such features may be revealed by underwater photography or television, although the cost and logistics involved severely limit the seabed areas that can be covered by such means. Pace and Dyer (1979) have applied texture quantification to side scan sonar records in an endeavour to classify small scale roughness and Pace (1983) has reviewed a number of techniques for this purpose.

Conventional echo sounder usage can readily reveal many large scale features, but as the horizontal length scale of the bottom roughness considered approaches the magnitude of the intercepted sounder beam at the seabed, the echo sounder chart record no longer provides readily accessible information on seabed roughness.

The echo sounder beam may be viewed to first approximation as a simple cone which insonifies a circular area of diameter d in water of depth D. The angular width of the cone is such that the ratio d/D is commonly in the range (0.1 — 0.25). Thus, in water 100m deep, horizontal length scale fluctuations in the range up to (10m — 25m) do not appear as equivalent chart fluctuations. Roughness smaller than d will, however, have an effect on the return echo signal, contributing to the length of the return echo, the variability between successive returns, and also affecting the magnitude of the peak return echo. These second order scattering effects are not adequately revealed in the normal chart output of most sounders, although some sounder users have attempted to monitor the apparent length of the bottom echo record as an indicator of roughness. The work described below has been undertaken to evaluate the practicality of using data processing and graphics technology to provide information on seabed roughness from available echo sounding systems.

It should be noted that many echo sounders are provided with wide beam-width transducers in order to partly offset the effects of vessel roll and pitch. Stabilised systems are available, as, e.g., on HMAS *Cook* and the use of a towed subsurface "fish" containing the sounding transducer can also minimise angular fluctuations in the sound beam direction. Most vessels, however, are fitted with transducers fixed to the hull and therefore subject to inevitable roll and pitch excursions. Some measures are available to offset this effect, but for brevity in the present account, only vertically stabilised beams will be considered.

Parameterisation of rough surfaces has been undertaken in a variety of ways. In the sea, considerable attention has been focused on the roughness structures of both the sea bottom and on the sea surface. This interest has arisen in part because of the role of one or both surfaces in sound propagation. Eckart (1953) developed an analysis of the scattering of sound from the sea surface, and concluded in part that long wavelength interactions would yield more information about the surface than short wavelength interactions. Many investigators further developed the Eckart model, but the limitations of the formulation at short wavelengths remain [see e.g. Proud, Beyer and Tamarkin (1960)]. La Casce and Tamarkin (1957) utilised theories due to Rayleigh, Eckart and Brekhovskikh to interpret experimental results of underwater sound reflection from a corrugated surface. Here, where the surface was amenable to analytic expression, useful results were obtained for surfaces of both small and large slope. More recently Kinney, Clay and Sandness (1983) have successfully used calculations involving an ensemble of strip-like facets to model scattering from a sinusoidal water-air surface in a wave tank. Recent work on rough surfaces includes experimental and theoretical studies of scatter from roughened brass surfaces immersed in water [de Billy and Quentin (1982)]. The authors have successfully interpreted backscatter for incident angles up to 40° using a potential method for the solution of Helmholtz's equation for a wide range of wavelength to roughness-parameter ratios. Measured topographies on the test samples were fitted by a Gaussian height distribution and autocorrelation function.

These various results show that progress has been made in predicting backscatter behaviour from surfaces of known roughness. The inverse problem, to provide a surface description from backscatter measurements, is less tractable and may not always offer a unique solution. Some solution to this inverse problem is, however, required in remote sensing for seabed roughness.

3.1 Monte Carlo Computer Model of Echo Formation

The Western Australian Institute of Technology group has developed a Monte Carlo model of rough surface scattering which allows several pulse parameters to be modelled for surfaces of varying roughness. The intention is to establish whether rough surfaces characteristic of a range of seabed types can be distinguished on the basis of measurable pulse parameters.

The model employs a Huygens construction in which the seabed is made up of flat sourcelets of varying areas, arranged at varying slopes to the horizontal plane. In the scattering process, a pulse of acoustic energy is radiated from a transducer into the surrounding water. The pressure waves spread spherically and on encountering the seabed, are reflected and later detected by the transducer system, now in the monostatic listening mode. The received signal is recorded as return pressure as a function of time.

Many factors will influence the form of the return pressure signal in time, the most obvious being the position and orientation of the transducer relative to the seabed, the transducer directivity pattern, here calculated for a circular transducer, the duration of the sounding pulse, and the topography of the seabed.

Figure 3 shows the pulse of sound radiating outward from the transducer and being reflected from the seabed. If the

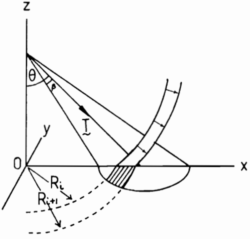

Figure 3: The sound has reached the reflection area and is being reflected by the shaded zone. T defines the transducer orientation. β is the beam halfwidth.

pulse duration is small, the case depicted, then only a "slice" of the elliptic response area will be re-radiating at any instant. This "slice" is the area bounded by a pair of concentric circles centred at 0 in the x,y plane, and the ellipse. The radii of the circles are simple functions of time. At any instant it is the sound reflected from the area within the ellipse bounded by the outward moving circles that constitutes the signal received at the transducer. The program computes this replying area at a set of times and evaluates the corresponding signal returned.

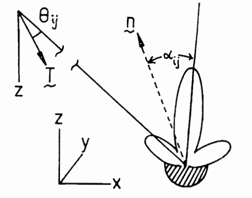

Figure 4: The j-th sourcelet in the i-th annulus. The reflection directivity is centred on the direction of specular reflection. **n** *is the sourcelet normal.*

The process by which sound is reflected from the seabed has been modelled as follows. The seabed is supposedly made up of an assembly of plane reflectors of varying size and orientation. The incident sound wave is reflected from the individual reflectors or sourcelets in the same manner as from a circular piston of equivalent area having its directivity pattern centered along the direction of specular reflection as shown in Figure 4. This is appropriate for a sourcelet of finite size. The seabed topography is represented in the model by distributions from which the sourcelet sizes and orientations are selected. By varying the parameters in these two distributions, the properties of echoes from different seabeds can be investigated. The program models the elliptic area involved in the reflection process by positioning sourcelets of size and orientation selected from the ditsribution at appropriate points in the x,y plane. The area is covered in a sequential manner, sourcelets being lain in concentric annuli centred on 0. Sourcelet areas are chosen randomly from within a Rayleigh distribution described by the modal parameter (AM), thus:

$$F(r) = (2r/AM)\exp(-r^2/AM), \quad 0 < r \leqslant \infty \qquad (3)$$

and $AM = 2M^2$, where M is the modal value of the sourcelet area. Sourcelet orientations are selected in various ways, according to the surface type under consideration.

As the sourcelets are in general treated as incoherent sources of reflected sound, the reflected intensity arising from each annulus is computed by adding the intensities of all the sourcelets belonging to that annulus. By grouping the effect of the sourcelets in this way, the total return signal at the transducer is obtained by combining the intensities of the annuli involved in the return signal at the required instant.

The process of forming a pressure return P(t) may thus be expressed by

$$P(t) = \Big[\sum_i \sum_j \big[\{ \exp(-2\alpha' r_i)/r_i^2 \} \, b^2(\theta_{ij}) \, A^{1/2}_{ij} \, b(2\alpha_{ij}) \big]^2 \Big]^{1/2} \qquad (4)$$

Here

i	=	annulus number
j	=	sourcelet number
α'	=	absorption coefficient of sound in water
r_i	=	slant range, transducer to annulus i
θ_{ij}	=	angle subtended at transducer axis by sourcelet ij
$b(\theta_{ij})$	=	pressure directivity function for transducer, evaluated at θ_{ij}
α_{ij}	=	angle between sourcelet normal and beam direction to sourcelet α_{ij}
A_{ij}	=	is selected from a Rayleigh distribution of sourcelet areas, with modal parameter AM

For the purpose of determining the θ dependence of backscatter, both the pressure source function and sediment reflectivities have been set to unity.

3.2 Tests of the Seabed Model

(i) Flat Surface

As a check on model performance, the return signal from a simulated flat surface, i.e. with zero slopes and uniform sourcelet area, was calculated for various values of θ, the incident angle. In this case the phase associated with each annulus return was specified according to the ray geometry involved, rather than randomised, as has been done for all rough surfaces modelled. For the flat surface, the return expected should be associated with a point directly below the transducer and the return pressure versus θ behaviour should take the form of $b^2(\phi)$.

Figure 5 shows the model results and a plot of $b^2(\phi)$. The model values have been estimated for each ϕ by forming an average of the results of five simulation runs.

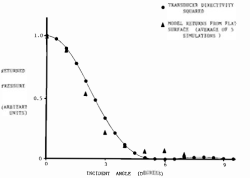

Figure 5: Plot of returned pressure and transducer directivity squared against angle for reflection from a flat surface.

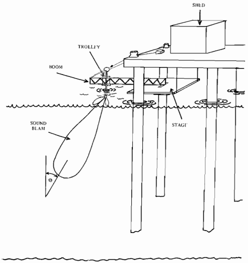

Figure 6: Fremantle jetty facility.

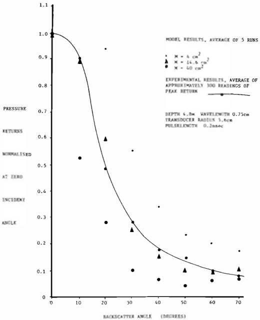

Figure 8: Experimental backscatter results from Fremantle site compared with model results for three values of modal parameter M.

(ii) The Fremantle Harbour Experiment

Figure 6 shows in outline form, an acoustic test facility which was established in the Fremantle Fishing Boat Harbour. The system was designed to investigate the acoustic backscatter at normal incidence and at incident angles θ in the range 0° to 75°. A number of measurements of sediment properties were made, and several representative sets of measurements of the topography of the seabed were made using diver-operated equipment. In this paper, attention is given to one suite of acoustic backscatter measurements, those taken using a 203kHz circular transducer, with a beam-width between first minima on either side of the main lobe, of 11.4°. A pulse length of 200μs was employed throughout. Bottom roughness measurements were made at 2cm intervals over 2m lengths. Figure 7 shows a representative result. No directional character was apparent in the bottom roughness.

The slopes associated with profile elements in Figure 7 will vary according to the averaging interval chosen. At 2cm scale intervals the ensemble of slopes may be represented approximately by a Gaussian distribution with standard deviation $\sigma_\theta = 25°$ (slope = 0.47). For larger intervals, slopes decrease. From a plot of slope-standard-deviation against element length x, measured along the surface, for 2cm $< x <$ 40cm, the slope of the graph was found to be given by

$$\text{Slope} = 0.85/x^{0.68} \qquad (5)$$

This variation of slope with element size is incorporated in the model results discussed below.

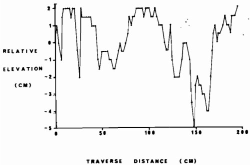

Figure 7: Sediment topography elevation vs traverse.

Figure 8 shows a set of experimental backscatter results together with three results from the model, for modal sourcelet areas M = 4cm², 14.6cm², and 40cm². In each case the sourcelet slopes have been drawn from Gaussian distributions with slope standard deviations found from eq. (5), where x now represents the sourcelet diameter. The model at this stage thus predicts that elements with this slope description and a modal area of approximately 15cm² will best fit the observed variation of backscatter with incident angle.

3.3 Modelling Seabed Returns

The model described requires further development to predict adequately other measured parameters of the Fremantle test site. In its present form it can usefully illustrate the effects of varying bottom roughness parameters on parts of the return pulse shape, a process which is strongly dependent on the variation of backscatter with incident angle.

In the period 1982-83 the FRV *Soela* was used by the CSIRO Division of Fisheries Research in an extensive survey of the North West Shelf area of Western Australia. As part of this program, attention was given to seabed type and roughness, and echo recordings were made using a Hewlett Packard 7964A Instrumentation Tape Recorder and Simrad EK 400 Scientific Sounder. Bottom photographs and television imagery were obtained also during part of the program. The Simrad Sounder operated at 120kHz with a 0.3ms pulse and water depths were in the range (38m — 124m) in five stations covering a range of bottom types ranging from near-flat surfaces (with moderate amounts of marine organisms) to isolated areas with marked sand ripples. The sea bottom model has been used as an aid in developing a signal processing strategy to evaluate the extent to which the echo returns can be used to establish roughness categories in the areas surveyed.

4 CONCLUSIONS

Acoustic remote sensing for fisheries resource estimation is an established technology which is now able to make use of new data processing and display technologies to provide rudimentary target descriptions. The analysis of seabed echo signals is less advanced, but information on seabed microtopography appears to be obtainable from high frequency sounder signals. Such information would be a useful adjunct to conventional sounder displays where seabed roughness reveals bottom dynamics or biological processes.

ACKNOWLEDGEMENTS

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An Appreciation of Jack Rose's Contribution to Acoustics

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It is hard to write something about somebody who is retiring without making it sound like an obituary. May I assure you at the outset that Jack Rose is very much alive and well and that his retirement is more a redeployment of his resources than a fading from the acoustic scene.

Most members of the Acoustical Society will be familiar with Jack's name but, if they are anything like me, they will be ignorant of what Jack has done for acoustics and the Society. When I asked Jack to talk about his involvement in acoustics he was not keen. He felt that other members of the Acoustical Society, like Gerald Riley, Ted Weston and Howard Pollard had retired and had not been given the same treatment, but he finally relented and agreed to an interview.

Jack was his characteristic, exuberant self. He started talking before I had time to turn on the tape recorder, and two and a half hours later, when I had run out of tape, I still hadn't asked most of my questions ... or had some of the ones I had asked, answered. I did have a wealth of information on the Acoustical Society's history and the National Acoustic Laboratory and, to a lesser extent, on Jack. I also had an assurance from Jack that my failure to dig up embarrassing stories about him could only have been because I hadn't asked the right people. As the right names were not proffered, I presume Jack does not need to supplement his pension with the proceeds of an action for libel.

Early days

How did Jack get involved in Acoustics? That is one question I didn't get to ask him, but I gather it was largely by accident or at least was not premeditated. Jack's background leading up to his work at NAL is interesting. He was born and brought up in Forest Lodge, near Sydney University. Early memories are of playing in the University grounds and sailing boats in the University duck pond. His schooling was at Forest Lodge Public School which celebrated its centenary last year and is even more celebrated for its motto, "We pull together".

After Forest Lodge, Jack went to Fort Street High School. He remembers his time at Fort Street as five years of slogging, but also as a highly enlightened education. There was no corporal punishment and the school was not run autocratically. Each student had to present lectures and take part in parliamentary and normal debating. Each student also took part in theatrical productions and there was compulsory team sport in either Summer or Winter, which probably accounts for Jack's interest in golf.

In 1938 Jack joined AWA and while working for AWA he completed two diplomas, and the bookwork for a third, at Sydney Tech. I got the impression that Jack was sorry he didn't take the opportunity that many of his contemporaries did, to convert those diplomas into degrees when the University of NSW was formed. That one's university involvement began and ended in a duck pond would be an embarrassment to some people, but Jack redeemed himself later by teaching part-time at Sydney University.

At the National Acoustic Laboratories

In 1948 Jack joined the variously named Commonwealth Acoustic Laboratory, Acoustic Research Laboratory, Acoustics Testing Laboratory and National Acoustic Laboratories (NAL from here on) as a draftsman, working on the design and development of early valve and transistor aids. He has seen NAL grow from ten people in 1948 to nearly 450 today. He is convinced that NAL is doing important work and tries to instil this conviction in his subordinates.

If hearing enhancement and hearing conservation have given Jack his raison d'être the excitement in his working life has been provided by the Army, Navy and Airforce. Jack looks back at tests done by NAL staff in the 1950s with mild incredulity. Service personnel were used to determine hearing damage caused by impulse sound. The "volunteers" were stood at different distances from an explosion. Afterwards their ears were inspected to see the distance up to which personnel had burst ear drums. This work gained NAL a worldwide reputation.

Other excitement that Jack was involved in was the phasing out of the Australian Airforce's Vampire Jets and the running aground of the Australian Navy's destroyer, HMAS Vendetta. Actually the Vendetta ran into the drydock gates at Williamtown Naval Dockyard in Melbourne because the communication (voice tube) between the bridge and the engine room was so bad and not because of what Jack was doing with a noisy gearbox. If the drydock gates had given way Jack estimates he would have ridden the largest wave of his surfing career half a kilometre inland.

The Acoustical Society

Jack was one of the early movers for creation of the Australian Acoustical Society, is a Foundation member and one of the ten subscribers to its registration. He also chaired the NSW Divisional Committee and the first meeting of the Council of the Society. His association with the Council has continued over many years, firstly as a member of the Membership Grading Committee, then later as Chairman of the Sub-Committee bidding for, and finally running the 10th International Congress on Acoustics.

Since 1978 he has represented the Society on the International Commission on Acoustics being the first (and hopefully not the last) Australian to achieve this recognition. While on the Commission, his task has been to promote acoustics in this region of the world. This resulted in the first Acoustical Conference of the Western Pacific Area in Singapore in 1982. He hopes that a second conference will take place in Hong Kong in 1985.

Thanks in part to Jack's active involvement in other clubs and societies, the Acoustical Society has a constitution which prevents individuals and cliques taking and maintaining control of the Society. Jack also ensured that the constitution allowed the Society to own property. He now thinks that the acquisition of secretarial and meeting rooms, possibly in collaboration with other societies, is what the Acoustical Society should be working towards, now that the earlier goal of holding an International Acoustics Congress in Australia has been attained. With the Society's finances as they are and the spread of its members, it may be better to invest in a mobile meeting room, a yacht, or in all seriousness, an aircraft or radio station, in order to keep the Society active and together.

Certainly, it seems important that the AAS be aiming for something ... and saving to pay for it. Considering the high quality of "The Bulletin" and the Society's Conferences and Technical Meetings, members pay surprisingly little for what they get. It would not seem unreasonable to double the subscriptions and for the extra income to be invested for future projects. This is no more preposterous than the thought of holding an ICA in Australia was in the '60s. Jack was one of the few with such foresight.

Main achievements

His most notable achievement on the work front Jack considers to be the 1969 ICAO Noise Meeting in Montreal. Here Australia's delegation of four were credited with the wording of two thirds of the resolutions passed which set the scene for

Jack Rose

quieter aircraft (and the collapse of Rolls Royce). Jack claims this was not because the Australian delegation had superior expertise, but because they could get answers to their questions overnight, whereas the European and North American delegates couldn't because their backup staff were off-duty.

In Montreal Jack survived an ordeal which, I suspect, greatly influenced his attitude to conferences. The ordeal was that the ICAL delegates were not given food or drink until they had finished their work. Thus dinner was often not served until 11 pm, after a day which began at 6 am. Meals, when they did come were a time to consult other delegates, with some of the barriers down, and to do the spadework for the compromises necessary to ensure one got fed the following day.

Other people think that Jack's greatest achievement was in the area of industrial hearing conservation. Whatever his achievements he feels he came into acoustics at the right time when the subject was blossoming and it was easier to make a contribution. Now the acoustics world has been subdivided many times, and with each subdivision it is harder to make a mark and it is harder to change anything because common usage dictates that methods and measurements remain unchanged until the next revolution, be it political or technological.

Playing the political game is very important to Jack. He used his political acumen and contacts to obtain the 10th ICA for Australia. Per Bruel dubbed Jack a "businessman and promoter", and Jack is happy with the description. It could be that his political and managerial skills have changed the world of acoustics more than most academically inclined acousticians could dream of doing. He believes that technology will continue to be ineffective unless it has political support. He also angrily observes that politics can be used to make substandard technology good business and cites parts of US industry as masters of the misuse of politics.

The culmination of Jack's career was to have been the commissioning of the new NAL Headquarters and research facilities at Chatswood. Unfortunately Jack's "baby" is late and he won't work in the new building.

The future

"Retires" is probably the wrong word. Jack will officially stop work at NAL in July, but he has never been a retiring sort of person and he has no intention of stopping doing things. Retiring from NAL will give him more time to concentrate on other things such as the Acoustical Society, consulting and golf. Retirement will not mean more time to read or watch television; he rarely reads a book and the only television he watches is the occasional comedy show. Jack is a "doer".

He and Ted Weston are already planning a conference to help the Australian motor industry and governmental authorities become more environmentally conscious. After that, who knows! Whatever it is it will be done with golf, gusto and flair. ("Not the notorious Jack Rose!" was the response Jack got from a person he introduced himself to recently. Jack was chuffed as he doesn't admire waxwork dummies.) Whatever happens you certainly haven't heard the last of Jack Rose. ☐

Some Effects of Correlation between Environmental Parameters on the Distribution of Acoustic Propagation Loss in the Ocean Surface-Duct

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ABSTRACT: If an acoustic variable (such as propagation loss) is a function of two environmental parameters, then the probability distribution of the variable depends on the joint probability distribution of the parameters, and therefore on the correlation between them. In the case of the oceanographic parameters sea-surface roughness, *(A), and* mixed-layer thickness, *(B), their effect on propagation loss is most marked for large A and small B, and propagation in the surface duct is most affected in the region of large propagation losses. In the region of low, and hence useful, propagation losses, the estimated effect of the correlation between A and B is typically to alter the propagation loss probability distribution by less than 10%.*

1. INTRODUCTION

The isothermal mixed layer, that is generally found near the surface of the sea, has a positive sound-speed gradient (with respect to depth) and is therefore an acoustic duct. The propagation "loss" at a given range from a source in the surface duct depends on a number of parameters, the three most important of which are frequency, surface roughness, and duct thickness. The probability distribution of propagation loss at a given range, and for a given frequency, may be determined from the joint probability distribution of surface roughness and duct thickness. Examples are presented in this paper that illustrate the effect on the distribution (of propagation loss) of treating the environmental parameters either as independent or (more correctly) as correlated.

2. THEORETICAL METHOD

(a) General Probability Distributions

The approach is as follows: we select the two parameters that have the most influence on variations in the propagation (call them A and B); and we ascertain the probability distributions (P.D.) of A and B.

In practice we will use discrete distributions, which we describe as

$$A = \{A_i \text{ with probability } \alpha_i\}, \text{ for } i = 1, 2, \ldots, n_a; \quad (1)$$

and

$$B = \{B_j \text{ with probability } \beta_j\}, \text{ for } j = 1, 2, \ldots, n_b. \quad (2)$$

Naturally,

$$\sum_i^{n_a} \alpha_i = 1 \quad (3)$$

and

$$\sum_j^{n_b} \beta_j = 1 \quad (4)$$

The mean values are

$$\bar{A} = \sum_i^{n_a} A_i \alpha_i \quad (5)$$

and

$$\bar{B} = \sum_j^{n_b} B_j \beta_j \quad (6)$$

and the standard deviations are

$$\sigma_A = [\sum_i^{n_a} (A_i - \bar{A})^2 \alpha_i]^{1/2} \quad (7)$$

and

$$\sigma_B = [\sum_i^{n_b} (B_i - \bar{B})^2 \beta_j]^{1/2} \quad (8)$$

The value taken by the propagation loss when $A = A_i$ and $B = B_j$ is denoted by PL_{ij}. If A and B are independent parameters, then the joint probability that $A = A_i$ and $B = B_j$ simultaneously is given by the product of their individual probabilities

$$p[A = A_i \text{ and } B = B_j] = \alpha_i \beta_j \quad \{A,B \text{ independent}\} \quad (9)$$

The P.D. of the propagation loss would therefore be

$$PL = \{PL_{ij} \text{ with probability } \alpha_i\beta_j\} \quad (10)$$
$$\text{for } i = 1, 2, \ldots n_a;\ j = 1, 2, \ldots n_b.$$

If A and B are dependent, however, then Eq. (9) is invalid. Instead we must ascertain the probabilities with which $A = A_i$ and $B = B_j$ together. Let us denote these by γ_{ij}. These γ_{ij} are related to the previously defined distributions as follows:

$$\sum_{i}^{n_a} \gamma_{ij} = \beta_j \qquad (11)$$

and

$$\sum_{j}^{n_b} \gamma_{ij} = \alpha_i \qquad (12)$$

Another equation that includes the γ_{ij} is the expression for the correlation coefficient (ϱ) between A and B:

$$\varrho = [\sum_{i}^{n_a} \sum_{j}^{n_b} A_i B_j \gamma_{ij} - \bar{A}\bar{B}] / \sigma_A \sigma_B \qquad (13)$$

The correlation coefficient may be known independently if the regression equation between A and B is known, since the standard form for a regression equation is

$$(B - \bar{B})/\sigma_B = \varrho(A - \bar{A})/\sigma_A \qquad (14)$$

The values γ_{ij} are not uniquely determined by Equations (11), (12), and (13) however, since we have $n_a \times n_b$ unknowns, whereas the number of equations is only $n_a + n_b$, if ϱ is unknown or $n_a + n_b + 1$, if ϱ is known. (The value of every γ_{ij} is non-negative, but this constraint does not qualify as an "equation"). A unique determination of the γ_{ij} is possible only if additional equations can be inferred from, for example, the physics of the relevant processes. For example, in the ocean it would be rare to find a thin surface mixed-layer in the presence of a high "sea-state" (i.e. very rough surface or high wind-speed). If the γ_{ij} can be determined, then the P.D. of the propagation loss is simply

$$PL = \{PL_{ij} \text{ with probability } \gamma_{ij}\} \qquad (15)$$

$$\text{for } i = 1, 2, \ldots n_a;\ j = 1, 2, \ldots n_b.$$

(b) Acoustic Model

As our acoustic example we consider propagation in an ocean surface duct, (or "mixed-layer") for which we find that the two most significant environmental parameters are the surface roughness, A, and mixed-layer thickness, B.

We will assume that propagation loss in a surface duct can be described by the formulas adapted from those presented in [1]:

$$PL = \begin{cases} 60 + 20 \log R + (C + D + E)R, \text{ if } R \leqslant 0.633\, B^{1/2} \\ \text{or} \\ 53.5 + 10 \log R + 5 \log B + (C + D + E)R, \\ \text{if } R > 0.633\, B^{1/2} \end{cases} \qquad (16)$$

where
- R is the horizontal range in kilometres
- B is the thickness of the duct in metres
- C is the coefficient of absorption (due to magnesium sulphate and boric acid in the ocean)
- D is the coefficient of leakage from the duct due to diffraction; and
- E is a coefficient that describes leakage from the duct that is related to surface roughness.

For the coefficient D we use an expression based on normal-mode theory [2]:

$$D = 1000\,(20 \log_{10} e)\,(\pi f g^2)^{1/3}\, I/V \qquad (17)$$

where
- f is the frequency in Hertz;
- g is the sound-speed gradient in the mixed layer (taken as $0.016\,s^{-1}$);
- I is the imaginary part of the eigenvalue for the first mode (to be discussed later); and
- V is the average sound-speed in the mixed-layer (taken as 1520 m/s).

The term I is a function of the "strength" (M) of the mixed-layer as a sound-channel, which can be expressed as [2]

$$M = (8\pi^2 f^2 g)^{1/3}\, B/V \qquad (18)$$

The variation of I with M, which depends on the sound-speed gradient below the mixed-layer, can only be expressed numerically. For typical conditions, the following expressions have been determined [3]:

$$\begin{array}{lll} \text{(i)} & M \leqslant 0.7: & I = 8.93 \exp(-3M^{6.5488}) \\ \text{(ii)} & 0.7 < M \leqslant 2.4: & I = 24.086 \exp(-1.9058M) \\ \text{(iii)} & 2.4 < M \leqslant 4.0: & I = 37.888 \exp(-2.036M) \\ \text{(iv)} & M > 4.0: & I = 0. \end{array} \qquad (19)$$

For the coefficient E we use the "AMOS" empirical expression [4]

$$E = 1.64\,(5\,h/\lambda)^{1/2} \text{ dB/limiting-ray skip distance} \qquad (20)$$

where
- h is the "characteristic" height of the surface waves: and
- λ is the acoustic wavelength.

According to [5] we have

$$h = 2.83\,A \qquad (21)$$

where A is the root-mean-square (R.M.S.) surface waveheight.

From [6] we have that the limiting-ray skip distance is given by

$$X = (8VB/g)^{1/2} \qquad (22)$$

On substituting Eqs. 21 and 22 into Eq. 20 we obtain

$$E = 7.1\,[A/(B\lambda)]^{1/2} \text{ dB/km} \qquad (23)$$

(c) Detailed Probability Distributions

We will consider 10 separate models for the joint-P.D. of A and B that, according to [3], are representative of the various ocean areas around Australia. The joint probability distributions

TABLE 1

Joint probability distributions (%) of surface-roughness (A) and layer-thickness (B) in 10 geographic areas around Australia

Area #	B_j(m) \ A_i(m)	.05	.3	1.5	β_j (%)	Area #	B_j(m) \ A_i(m)	.05	.3	1.5	β_j (%)
1	10	21	16	3	40	6	10	11	14	4	29
	30	0	7	3	10		30	0	2	6	8
	40	6	6	0	12		40	4	8	0	12
	60	11	18	9	38		60	9	19	23	51
2	10	11	16	4	31	7	10	5	12	12	29
	30	0	5	5	10		30	0	0	12	12
	40	6	10	0	16		40	2	5	0	7
	60	7	19	17	43		60	4	13	35	52
3	10	11	19	6	36	8	10	8	14	6	28
	30	0	1	8	9		30	0	0	6	6
	40	4	8	0	12		40	5	11	0	16
	60	7	16	20	43		60	8	19	23	50
4	10	6	12	13	31	9	10	8	14	6	28
	30	0	0	12	12		30	0	1	6	7
	40	2	6	0	8		40	6	11	0	17
	60	4	12	33	49		60	7	19	22	48
5	10	15	14	4	33	10	10	14	15	2	31
	30	0	2	6	8		30	0	6	5	11
	40	5	6	0	11		40	6	9	0	15
	60	12	17	19	48		60	8	23	12	43

are listed in Table 1. We see that $n_a = 3$ and $n_b = 4$. Also shown in Table 1 are the marginal probabilities β_1 to β_4. We see that the prevalence of thin layers (B ~ 10m) ranges from 28% (in areas 8 and 9) to 40% (area 1); and that the likelihood of thick layers (B ~ 60m) varies from 38% (area 1) to 52% (area 7).

The marginal probabilities α_1 to α_3 are listed in Table 2. The likelihood of calm seas (A ~ 0.05m) varies between 11% (area 7) and 38% (area 1); while the prevalence of rough seas (A ~ 1.5m) ranges from 15% (area 1) to 59% (area 7). Also shown in Table 2 for each area are the means and standard deviations of both the layer-thickness and the surface-roughness. The value of $\bar{A}$ varies from 0.39m (area 1) to 0.98m (area 7); and the value of $\bar{B}$ ranges from 35m (area 1) to 41m (areas 6 through 9). The correlation coefficients between A and B for the 10 areas are also listed in Table 2; these range from 0.18 (areas 4 and 7) to

TABLE 2

Marginal probabilities (%); means and standard deviations [of surface-roughness, A, and layer-thickness, B]; and correlation coefficient [between A and B], in each of the 10 geographic areas

Area #	α_i(%) 1	2	3	$\bar{A}$ (m)	σ_A (m)	$\bar{B}$ (m)	σ_B (m)	ϱ_{AB}
1	38	47	15	.39	.48	35	22	.21
2	24	50	26	.55	.57	38	21	.24
3	22	44	34	.65	.62	37	22	.24
4	12	30	58	.97	.63	39	22	.18
5	32	39	29	.57	.60	39	22	.24
6	24	43	33	.64	.61	41	22	.26
7	11	30	59	.98	.63	41	22	.18
8	21	44	35	.67	.62	41	21	.19
9	21	45	34	.66	.61	41	21	.19
10	28	53	19	.46	.52	38	21	.23

TABLE 3

Values of propagation loss (dB) for 1 kHz at 50km range

B_j \ A_i	.05	.3	1.5
10	1749	1779	1840
30	202	219	255
40	122	137	168
60	91	103	128

0.26 (area 6). (It is of interest that if we give equal weights to the 10 areas, then we can also calculate the correlation between the values of $\bar{A}$ and $\bar{B}$; the result is 0.57 which is much greater than any of the intra-area correlation coefficients.)

The joint probability distributions for A and B that would result if A and B were independent variables can be calculated from the marginal probabilities shown in Tables 1 and 2. The main effects of the correlation between A and B are to reduce the chances that B_1 (thin duct) occurs with A_3 (rough surface) and that B_4 (thick duct) occurs with A_1 (calm surface).

3. RESULTS AND DISCUSSION

We examine the significance of the correlation between A and B for two examples of acoustic propagation: a medium frquency (1kHz) at long range; and a high frequency (20kHz) at short range.

Medium Frequency at Long Range

Values of propagation loss (PL) have been calculated from Eq. 16 (for a frequency of 1kHz and a range of 50km) for each combination of A_i and B_j. The results are shown in Table 3. The cumulative probability distributions (C.P.D.) of propagation loss for the dependent case were obtained from Tables 1 and 3, and are listed in Table 4 (denoted by p_D). The C.P.D.'s for the independent case were obtained from Tables 1, 2 and 3, and are also listed in Table 4 (denoted by p_I). The C.P.D.'s for propagation losses greater than 130dB have not been computed because such losses have no practical significance.

TABLE 4

Cumulative Probability Distributions (%) of Propagation Loss for the dependent (p_D) and independent (p_I) cases; the medium frequency/long range example.

Area # \ X	90	100	110	120	130	Area # \ X	90	100	110	120	130
1						6					
$P_D(PL \leq X)$	0	11	29	29	44	$P_D(PL \leq X)$	0	9	28	28	55
$P_I(PL \leq X)$	0	14	32	32	43	$P_I(PL \leq X)$	0	12	35	35	54
2						7					
$P_D(PL \leq X)$	0	7	26	26	49	$P_D(PL \leq X)$	0	4	17	17	54
$P_I(PL \leq X)$	0	11	32	32	47	$P_I(PL \leq X)$	0	6	21	21	53
3						8					
$P_D(PL \leq X)$	0	7	23	23	47	$P_D(PL \leq X)$	0	8	27	27	55
$P_I(PL \leq X)$	0	9	28	28	46	$P_I(PL \leq X)$	0	11	33	33	53
4						9					
$P_D(PL \leq X)$	0	4	16	16	51	$P_D(PL \leq X)$	0	7	26	26	54
$P_I(PL \leq X)$	0	6	21	21	50	$P_I(PL \leq X)$	0	10	32	32	52
5						10					
$P_D(PL \leq X)$	0	12	29	29	53	$P_D(PL \leq X)$	0	8	31	31	49
$P_I(PL \leq X)$	0	15	34	34	52	$P_I(PL \leq X)$	0	12	35	35	47

We see from Table 4 that C.P.D.'s calculated on the assumption that A and B are independent are in error (for $X \leqslant 130$dB) by a few percent. The average and standard deviation of the errors for each listed value of X are as follows:

X (dB) :	90	100	110	120	130
Average error :	0	2.9	5.1	5.1	−1.4
S.D. of the error :	0	0.7	1.2	1.2	0.5

We can see from Table 3 that the errors for X = 110dB are due to differences in the values of $(\gamma_{14}+\gamma_{24})$. From Tables 1 and 2, the error in $\gamma_{14}+\gamma_{24}$ ranges between 3 and 7%. The correlation between A and B reduces slightly the likelihood that A_2 and B_4 will occur together. Similarly the errors for X = 100dB are due to differences in the values of γ_{14}, which range between 2 and 4%. (The correlation between A and B slightly reduces the chance that B_4 occurs with A_1.)

High Frequency at Short Range

Values of PL for a frequency of 20kHz and a range of 4km have been calculated from Eq. 16 for each combination of A_i and B_j. The results are shown in Table 5.

The C.P.D.'s of PL for the dependent and independent cases in each of the 10 areas are listed in Table 6.

The average and standard deviation of the errors for each listed value of X in Table 6 are as follows:

X (dB) :	80	85	90	95	100
Average error (%) :	2.0	0.0	1.2	0.0	−8.6
S.D. of the error (%) :	1.1	0.0	2.0	0.0	1.9

In this example the main errors occur for values of PL between 96 and 100dB; and from Table 5 we see that the corresponding elements in the joint probability distribution are γ_{32} and γ_{34}. From Tables 1 and 2, the sum of γ_{32} and γ_{34} is usually several percent less when A and B are independent than it is when A and B are (positively) correlated. The correlation increases the chance that A_3 will occur with either B_2 or B_4.

For X = 85 there is no error in the C.P.D. This result is due to the fact that the C.P.D. at X = 85 is determined by $\sum_{j=1}^{4} \gamma_{1j} = \alpha_1$ which is, of course, unaffected by any correlation.

This phenomenon occurs because at short ranges and small roughness, propagation loss at high frequencies is a slowly varying function of duct thickness (for the range of duct thicknesses considered in these examples).

4. CONCLUSION

The assumption that duct thickness and surface roughness are independent variables, when in fact they have a correlation coefficient of about 0.2, leads to typical errors of several percentage points in the cumulative probability distribution of propagation loss.

Acknowledgement

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TABLE 5

Values of propagation loss (dB) for 20 kHz at 4km range

B_j \ A_i	.05	.3	1.5
10	81	91	113
30	80	86	99
40	84	90	101
60	84	88	97

TABLE 6

Cumulative Probability Distributions (%) of Propagation Loss for the dependent and independent cases; the high frequency/short range example.

Area # \ X	80	85	90	95	100	Area # \ X	80	85	90	95	100
1						6					
$P_D(PL\leqslant X)$	0	38	69	85	97	$P_D(PL\leqslant X)$	0	24	53	67	96
$P_I(PL\leqslant X)$	4	38	66	85	93	$P_I(PL\leqslant X)$	2	24	55	67	86
2						7					
$P_D(PL\leqslant X)$	0	24	58	74	96	$P_D(PL\leqslant X)$	0	11	29	41	88
$P_I(PL\leqslant X)$	2	24	58	74	88	$P_I(PL\leqslant X)$	1	11	32	41	79
3						8					
$P_D(PL\leqslant X)$	0	22	47	66	94	$P_D(PL\leqslant X)$	0	21	51	65	94
$P_I(PL\leqslant X)$	2	22	50	66	84	$P_I(PL\leqslant X)$	1	21	53	65	84
4						9					
$P_D(PL\leqslant X)$	0	12	30	42	87	$P_D(PL\leqslant X)$	0	21	52	66	94
$P_I(PL\leqslant X)$	1	12	33	42	77	$P_I(PL\leqslant X)$	1	21	54	66	85
5						10					
$P_D(PL\leqslant X)$	0	32	57	71	96	$P_D(PL\leqslant X)$	0	28	66	81	98
$P_I(PL\leqslant X)$	3	32	58	71	87	$P_I(PL\leqslant X)$	3	28	65	81	91

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Traffic Flow and Noise Levels at One Site

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ABSTRACT: A series of measurements of traffic volumes and traffic noise levels at one site in Sydney show the range of values which can be obtained when short time samples are used, and highlight the need for careful monitoring to ensure that the values obtained are really representative. The comparison between the measured and predicted values for L_{10} show that large errors can be made if the prediction methods are used in situations which are outside their range of validity.

1. INTRODUCTION

Repeated measurements of traffic flow and traffic noise levels have been made at one site in Sydney over a period of 16 months. The primary purpose of these measurements was to determine the sound attenuating properties of various facades using traffic noise as the source. The data has been further analysed to examine the variation in noise levels and traffic flow that can occur at one site and to compare the measured values with those obtained from prediction methods.

2. THE SITE

All the measurements were made in the vicinity of an experimental building which has been constructed alongside a road in an industrial area of Sydney. The building was designed to enable investigations of acoustic performance of a range of facades, comprising various openable elements, to be made under field conditions [1]. The building is located on open ground, soon to be converted to parkland, and the surface between the footpath and the building is essentially level and covered in rough grass. There are no reflecting surfaces nearby and the buildings on the other side of the road are set well back. The roadside boundary is identified by a wire mesh security fence. The 12m wide road has four available lanes, of which the two central lanes are predominantly used.

3. MEASUREMENTS AND ANALYSIS

The main purpose of the measurements was to determine the traffic noise attenuation provided by various facades. Five or ten minute samples of traffic noise were measured at one position and simultaneously recorded at two or three other positions. All microphones were 1.2m above the ground; one was located at the wire mesh boundary fence and a second was located 1m from the building facade. For a direct measurement the signal from a condenser microphone was fed into a Bruel and Kjaer measuring amplifier, filter set, level recorder and statistical distribution analyser. Precision sound level meters were used for recording with Nagra tape recorders and the later analysis used the same analysing equipment as for the direct measurement.

For the duration of the traffic noise sample, the number of vehicles passing the site were manually counted and classified into six categories (motor bikes, cars, light commercial, medium, heavy and bus); these were later combined into two categories (cars and heavies) for use in the prediction methods. The traffic noise samples and traffic counts were synchronised with an acoustic cue.

4. RESULTS AND DISCUSSION

4.1 Traffic Flow

The recommendations [2] for the measurement of traffic flow for traffic engineering purposes are generally related to the determination of the daily, weekly or annual volumes, or in special cases the peak hour volumes. Short time samples are not recommended as even a two-hour sample is estimated to have a coefficient of variation of 15% as a basis for the daily flow estimation on an urban/commuter road [3]. However it is acknowledged [4] that for prediction "of a day's volume from an hour's volume the maximum consistency occurs between 9 am and 7 pm" and for most roads the pattern of hourly traffic volume shows a morning peak followed by a plateau and a broader afternoon peak.

All the measurements at the experimental building were made after 10 am on weekdays and were completed before mid-afternoon. Any unusual flow, such as that resulting from an accident, was avoided. The histograms, showing the range of values obtained for the total vehicles per hour and the pecentage of heavy vehicles, calculated from the data obtained during the five or ten minute samples on 114 occasions, are shown in Figure 1. The average values and standard deviations were:

Total vehicles per hour	average 485	standard deviation 71.7
Percentage of heavies	average 29.7	standard deviation 7.7

It is clear that even though maximum consistency in traffic volume may be considered to apply during the measurement times, the use of short time samples can produce a wide range in the values for the traffic parameters.

The estimates of accuracy and required sample times for measurements of road traffic noise to be representative of the

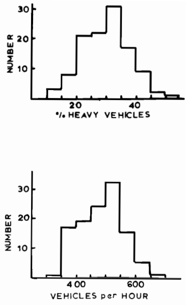

Figure 1: Range of traffic volumes for 114 samples at one site.

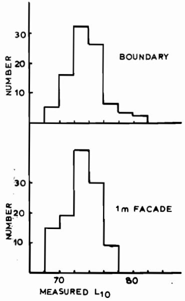

Figure 2: Range of traffic noise levels, in terms of L_{10}dB(A), for repeated measurements at two positions at one site.

traffic noise in the area are based on knowledge of the traffic volumes. The sampling error $\triangle L_{eq}$ has been estimated by Fisk [5] to be

$$\triangle L_{eq} = 7.4/(m)^{1/2}$$

where m = number of vehicles passing during the sample time

For the upper and lower ends of the range of traffic volumes at this site the sampling errors are:

Sample Time	350 vehicles/hr	650 vehicles/hr
5 min	1.4	1.0
10 min	1.0	0.7

While these sampling errors are not great, the error introduced by using the shorter sample time when the traffic volume was at its lower limit was twice that obtained for a longer sample when the traffic volume was at its upper limit.

The UK publication for the Calculation of Road Traffic Noise [6] gives a recommendation for the minimum sampling time, t_{min}, based on the traffic volume, q, and the register rate for the noise analysis, r:

$$t_{min} = 4000/q + 120/r$$

so when q = 350 veh/hr, t_{min} = 11.4 + 120/r
and q = 650 veh/hr, t_{min} = 6.2 + 120/r

Thus the recommended sample time for the lower traffic volume is approximately twice that for the upper limit of the traffic volume at this site.

Short time samples of the traffic flow along a road can lead to inaccurate recommendations for the required sample time for noise measurements to be representative of the traffic noise in the area.

4.2 Traffic Noise Levels — Measurement and Prediction

The L_{10} (the level exceeded for 10% of the time period) in dB(A), was determined for each sample of traffic noise [7]. The range of values for 90 measurements on the boundary and 114 measurements at 1 m from the facade are shown in the form of histograms in Figure 2. The range is in excess of 10 dB(A) and shows the errors which can be introduced if short samples of road traffic noise are taken to be representative of the traffic noise from a road.

As the noise measurements and traffic flow counts were made simultaneously, this data can be used in the prediction methods to obtain a comparison between the measured and predicted values for L_{10}. Two prediction methods were used. One is that published by the UK Department of Environment (DOE) [6] and the second is a modification by Burgess (BUR) of an earlier UK prediction method following measurements in the Sydney Metropolitan Area. The traffic flow data was used in conjunction with the appropriate vehicle speeds and distances. The allowance of 2.5 dB(A) for the reflection from the facade as specified in the DOE method, was also applied to the BUR method. The following equations for the regression between the measured and each set of predicted values for L_{10} were obtained:

		Standard error
Boundary	$L_{10}(DOE) = 0.31\, L_{10}(Meas) + 46.25$	1.22
	$L_{10}(BUR) = 0.47\, L_{10}(Meas) + 41.48$	2.18
Facade	$L_{10}(DOE) = 0.34\, L_{10}(Meas) + 44.14$	1.22
	$L_{10}(BUR) = 0.67\, L_{10}(Meas) + 25.51$	2.19
Combination	$L_{10}(DOE) = 0.31\, L_{10}(Meas) + 46.38$	1.24
	$L_{10}(BUR) = 0.60\, L_{10}(Meas) + 31.51$	2.22

The regression lines for the boundary and facade values are shown on Figure 3, along with the line representing equality between the measured and predicted values. While the traffic at the site was freely flowing, in an urban context, the DOE method is more applicable for freely flowing highway traffic. The standard error for the regression line was only 1.2dB(A), however the predicted values for L_{10} were substantially less than the measured values at the higher noise levels. The tendency of the DOE method to underpredict the noise levels has been noted in other studies alongside suburban roads in the Sydney area [8]. Conversely, the BUR method overpredicts the lower noise levels. This is probably because the proportion of heavy vehicles at the site is above the range of validity for the BUR method.

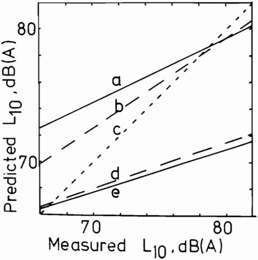

Figure 3: Regression lines between the measured and predicted values for L_{10} ; (a) BUR prediction for 1m from facade, (b) BUR prediction for the boundary, (c) representation of equality between the measured and predicted levels, (d) DOE prediction for 1m from facade, (e) DOE prediction for the boundary.

5. CONCLUSION

Repeated measurements of the traffic flow and the noise levels at one site have shown the variations that can occur when short time samples are used.

In many situations prediction methods are used outside their range of validity because more accurate methods are not available. At this site it has been found that the DOE prediction method can substantially underpredict the noise levels. As the reason for the prediction of noise levels is usually to determine the noise reducing procedures which should be applied or to assess the compensation entitlement, such underprediction is undesirable. The BUR method was found to overpredict the lower noise levels at this site, however better agreement was obtained as the noise level increased. These findings highlight the need to exercise caution when using the results of prediction methods.

6. ACKNOWLEDGEMENTS

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ULTRASONIC EYE SCANNER: An advanced ultrasonic data imaging, processing and recording system has been developed at Harwell for the ultrasonic eye scanner at the Moorfields Eye Hospital. Ultrasonic images of the eye are displayed directly on a standard TV screen, enabling them to be recorded using a standard video cassette recorder. These recordings can then be stored for later analysis, used as a guide during surgery and also as a teaching aid.

In the operation of the eye scanner, a low energy pulsed beam of ultrasound is scanned across the eye and from the reflected signals, which are digitised and processed, an image of the internal structure of the eye can be built up. This is presented as a cross sectional image along a selected plane, allowing detection of, for example, retinal or vitreous detachments or tumours.

The image processing system uses a dual memory unit in which the digitised ultrasonic data are continually captured and transferred to a temporary store. Subsequent processing involves coordinate plotting and transfer of the data to a picture store for display and manipulation. Harwell has developed video synchronisation techniques which ensure that the processed data emerge as a genuine video signal, compatible with any standard unmodified VCR. This convenient method of recording ultrasonic data overcomes one of the most frequently cited limitations to the use of ultrasonic inspection techniques.

(Physics Bulletin, April 1984)

Current R.A.N.R.L. Research on Noise from Wind and Wave Action at the Sea Surface

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Sound has long been the most commonly used means of transmitting information through the ocean and is now widely used in many applications. Its use is due mainly to the fact that electromagnetic radiation in water is highly attenuated whereas acoustic radiation is not. In fact, for the same absorption attenuation, sound propagates in the ocean to distances two orders of magnitude greater than in air. Such good propagation results in high background noise levels from the many sources in the ocean and this is one of the limitations on the effectiveness of our use of sound (SONAR) in the ocean. It is important, therefore, to quantify this background noise both to optimise the use of existing sonars and in the development of sonars.

There are many sources contributing to the **ambient noise in the ocean** but the major component, evident from frequencies of less than one Hertz to tens of kilohertz is that due to wind and wave action at the sea surface. This component varies in a complicated manner over a range of more than 30 dB as conditions vary. Its effect on sonar performance has led to considerable research over the last forty years but the phenomena involved in noise generation are still not well understood and our ability to predict noise levels leaves much to be desired. No theory can be said to be well supported by measurements, and although empirical methods are useful under certain conditions or in particular locations, none is universally applicable. Part of the problem is the complex nature of sea surface dynamics from which arise a number of possible mechanisms of noise generation. Also there are difficulties in obtaining unambiguous measurements of surface generated noise especially at lower frequencies because of the difficulties in sorting out contributions from other sources such as ocean traffic noise and flow noise about the hydrophone, and allowing for environmental effects like propagation.

It seems likely that there are a number of **mechanisms of noise generation by wind and wave action,** applying over different frequency ranges (see my article in Vol. 6 of the Bulletin, March-June, 1978 for details). There have been attempts to model some of these theoretically with limited success. In the theory that we have developed over the last few years we have taken a rather different approach by applying to the sea surface Lighthill's theory of noise generation (originally developed for aerodynamic noise: Lighthill, 1952 Proc. Roy. Soc., Lon., A-211, 564-587). Lighthill's theory in effect identifies the fluid processes inherent in sound generation by whatever means. Applying this to noise in the ocean requires the effect to be integrated over the surface of the ocean and also over the body of the ocean if, as in our model, noise from sources below the surface (such as water turbulence) are to be included.

The main result of our theory is an expression in which the spectrum of the noise received at some depth in the ocean is given in terms of the spectra of the fluid processes inherent in sound generation. The result is general in that it applies to all mechanisms of noise generation and has been derived without approximations. Other theories can be shown to be subsets of this theory, although they are somewhat different in form and include approximations. In order to determine actual noise levels, the spectra of the appropriate fluid processes must be known. While they are intrinsically capable of being measured or modelled there are difficulties in obtaining reliable measurements at sea and theoretical modelling is somewhat limited by our limited understanding of the fluid dynamics of sea surface motion. Any theory of noise generation by sea surface motion does, of course, have to address these problems.

So far **we have applied the theory to noise at frequencies of a few Hertz and below** by modelling partly empirically and partly theoretically the spectra of the fluid processes involved in surface wave interaction. The theory has been compared with measurements in a carefully controlled experiment in Woronora Dam and the results were in good agreement. This is the first time a theory of noise generation by wind and wave action has predicted noise levels in agreement with measurement. (The results of this work were presented at the 11 ICA in Paris). Woronora Dam was chosen as the site for the first set of measurements as it allows much more experimental control than at sea, and avoids the problem of sorting out the relative contributions of surface noise and distant shipping noise.

We hope to extend the experimental work to **measurements at sea.** This requires the development of a special self-contained recording system which can be fixed on the bottom and left to sample noise spectra, and is free of any cables or moorings which might induce flow noise. It would be used in an environment where shipping noise is low. It would be recovered by transmitting an acoustic signal which would trigger a release mechanism allowing the system to float to the surface.

Future work on the theory will involve extension to the determination of noise in the frequency range of a few Hertz to a few hundred Hertz.

Underwater Acoustics Research in the Marine Studies Composite

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INTRODUCTION

Since its inception in 1974 the Marine Studies Composite (MSC) at the Defence Research Centre Salisbury has been active in underwater acoustics. The Composite was formed to undertake the expanded activities of an earlier Underwater Detection Systems Group which, led by H.A. d'Assumpcao, had conceived and proved the concept of the advanced Barra sonobuoy currently in use with the RAF and RAAF. The Composite presently includes groups involved in underwater detection systems, experimental support and signal processing and classification studies. An oceanographic research section was also active until 1980 when the work was transferred to the RAN Research Laboratory in Sydney.

Currently the MSC is involved in research on a number of passive systems for the detection of underwater acoustic signals in the presence of background noise. Once detected these signals require classification as to their origin. A useful method of understanding some of the factors involved is to investigate the various terms in the passive sonar equation, expressed in logarithmic form as

$$SE = SL - PL - NL + AG - DT$$

where

- SE is the signal excess in dB (for a 1 Hz band) relative to that required for detection,
- SL is the sound source level of the target of interest, expressed in dB relative to 1 μPa^2 at 1 metre,
- PL is the signal loss in dB at 1 metre due to propagation from source to receiver,
- NL is the background noise level in dB relative to 1 $\mu Pa^2/Hz$,
- AG is the gain enhancement in dB of the listening system, and
- DT is the detection threshold of the processing and display system, i.e. the ratio of processed signal power to noise power required for detection, expressed in dB for a 1 Hz band.

When SE = 0 dB the target is just being detected.

This report will present aspects of acoustics research undertaken in the MSC relevant to evaluating the values of PL, NL and AG.

ACOUSTIC PROPAGATION

One of the basic problems in underwater acoustics is to determine the propagation loss of a given signal through the ocean, possibly reflecting off the sea surface and bottom, out to ranges of hundreds of kilometres. The ocean is in reality a stochastic medium; its acoustic properties fluctuate in space and time. As a first approximation it can be modelled on the assumption that it has either constant or gradually varying properties. The resulting cylindrically symmetric Helmholtz equation for underwater acoustic propagation can be solved directly or simplified for normal mode, parabolic equation or ray approximations. A summary of models is given in [1].

Models of various types are currently in use by the MSC. Recently developed models are a ray trace model [2] and a split-step parabolic equation model [3]. These have been used to provide predictions of PL in a variety of scenarios with the latter model being useful for both deep and shallow water applications. A theoretical study [4] of surface duct leakage was undertaken using the parabolic equation method.

An investigation of the differences between the split-step Fast Fourier Tranform (FFT) [3] and the Implicit Finite Difference (IFD) [5] methods for solving the parabolic equation has shown [6] the effects of starting fields and that the FFT method was superior for deep water problems. For shallow water cases IFD was found to be better.

To obtain data for model validation, experiments are usually conducted with either a continuous underwater sound projector or air-deployed SUS (Source Underwater Sound) charges with receivers either being vessel-mounted or air-deployed sonobuoys.

AMBIENT NOISE DIRECTIONALITY

The gain enhancement term, AG, in the passive sonar equation is defined as 0 dB if a single omnidirectional sensor is used. To increase this value the receiver usually consists of an array of hydrophones, whose outputs are combined together to provide directivity simultaneously in many directions. If the ambient noise is isotropic then the value of AG is 10 log (N), when N sensors are used.

The MSC has conducted experiments with arrays having horizontal and vertical apertures. Using a vertical linear array (VLA), the ambient noise vertical directionality around Australia has been studied. Some examples from the South Fiji Basin have been presented [7,8]. It was found that the shape of these directionalities was not isotropic and varied from an S-shape at high frequencies (e.g. 560 Hz) to a "hump" shape centred at near horizontal angles for low frequencies (e.g. 70 Hz).

When there are signals present in the noise various techniques [9-13] have been developed by the MSC which can be used to investigate them.

Utilising the ability of the VLA to discriminate between vertical angles it was found possible to eliminate sources of sound not locally generated and to calculate the effective local omnidirectional ambient noise. This method was used to produce the results discussed in the next section.

WIND-GENERATED NOISE

Recently vertical directionality data have been used to determine the dependence of ambient sea noise on local wind. Correlations of wind speed with measured and local omnidirectional ambient noise were found to be much improved for the latter case at low frequencies [7,8]. These results supported the earlier work by Cato at the RAN Research Laboratory [14,15] which highlighted the effects of wind at low frequencies which are usually obscured by shipping noise in northern hemisphere data. By removing the local site dependence using the VLA, the surface source levels for wind-generated noise were obtained from the South Pacific data [8]. By including measurements obtained in the Eastern Indian Ocean, further refinement of these source levels has been made [16]. Using these source levels and the appropriate bottom reflection data, estimates of ambient noise due to winds can be made for different locations.

FLOW-GENERATED NOISE

If a hydrophone has a water flow over it then there will be noise generated by hydrodynamic pressure fluctuations. Some work on this topic has been undertaken [17].

SUMMARY

These notes describe briefly some of the activities of the Marine Studies Composite in the field of underwater acoustics covering both experimental and theoretical topics aimed at improving underwater detection systems for the Australian Defence Forces.

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(Received 17 April 1984)

A VERSATILE METHOD FOR ASSESSING THE NOISE IMPACT OF NEW TRAFFIC SCHEMES

One of the tasks dealt with by local authorities is to assess the impact upon the population of noise from proposed new traffic management measures, such as one-way systems, bypasses, flyovers, etc. The usual approach is to calculate noise levels for selected locations, such as the facade of residential properties, on the basis of projected traffic flow data and a detailed knowledge of the layout of the area in question. Although the method of calculation is well-tried, it can still be a lengthy task to work out noise levels at a large number of locations, especially where there may be complicating factors such as intervening buildings or undulations in the level of the surrounding land. In addition, and particularly where the scheme goes to a Public Inquiry, more detailed information may sometimes be requested on particular aspects, or alternative traffic flow data proposed, necessitating the calculations to be repeated.

To overcome this difficulty a new system based on modern computer technology, and which may be the most advanced of its kind in Britain today, has been developed by Applied Research of Cambridge in conjunction with the Scientific Services Branch, and is now in use by the Council. The system, known as M-Way, stores a map of the proposed scheme in its memory, along with traffic flow data, and carries out the noise calculations according to standard methods (Calculation of Road Traffic Noise, Department of the Environment, 1975) which are also applicable for evaluating mandatory road schemes under the Land Compensation Act (1973) requirements. The calculations themselves are performed on the computer's central processor within minutes, and it is a simple task to re-run the program should this be necessary.

The map of the road system under investigation is introduced into the computer memory bank by means of a "digitising table". A large scale map is taped to the table and the corners of relevant buildings and road segments traced with an electronic pointer connected directly to the computer. The heights of roads, buildings and any barriers to sound propagation are also typed in. This information can be displayed on a visual display unit, or plotted by the computer on a flat bed plotter to the same scale as the original map, allowing the accuracy of the digitisation to be checked.

Besides the accuracy and consistency implicit in the method, in which all roads and buildings are considered in every noise calculation, the database becomes a permanent record of the road scheme which can easily be re-checked or modified for, say, different traffic flows or changes to sound barriers at some later date. The program can further be used for comparing alternative road schemes or, perhaps, for studying the effects of different configurations of noise barriers. Changes to a section of a road, by placing it in a cutting or at elevation, requires but a minor modification to the data.

In due course it should be possible, by using similar techniques on some of the existing data produced from the noise studies, to predict air pollution concentrations from traffic or even disturbance from road construction.

The GLC's Noise Group has now substantial experience with the system, having used it for traffic noise calculations for the North-South Route, Catford Town Centre, Vauxhall Bridge Road, the Hayes By-Pass and the M11 link to name but a few. The Pollution Monitoring Group provides a service, using this system, to any London local authority.

R. Freedman,
Scientific Services Branch, Greater London Council,
in *London Environmental Bulletin*, Vol. 1, No. 2, Autumn 1983.

Acoustic Deep Ocean Bottom Experiment

Martin W. Lawrence
Royal Australian Navy Research Laboratory
Rushcutters Bay, Sydney, 2011

Ocean Bottom Interaction of Acoustic Waves

Acoustic waves propagating through the ocean experience loss and scattering in the water, at the ocean surface, and at the ocean bottom. It is an investigation of acoustic wave interaction with the ocean bottom that is being reported here.

The water-bottom interface (i.e. the sea floor) is, over large areas, flat and underlain by sediments hundreds of metres in thickness. Acoustic energy incident on this interface (with arbitrary angle of incidence) will be partially reflected at this interface, and at other interfaces within the sediment pile. Furthermore, there is usually a gradient in sound speed with depth in the sediment, which results in energy being returned to the water column by refraction. There are potentially many other effects which will be present in various circumstances, and which include effects due to shear waves, lateral waves, and interface roughness.

A variety of techniques have been used previously in order to investigate acoustic bottom interaction. Recently, RANRL has been involved with use of a new technique, which was developed at the Woods Hole Oceanographic Institution (WHOI) of Woods Hole, Massachusetts [1]. This technique uses source and receiver within a few tens to hundreds of metres of the sea floor in the deep ocean (water depth from 2000 to 6000 m); the horizontal separation of source and receiver is gradually increased from 0 m to about 10 km. The acoustic source produces a pulsed harmonic signal of a few hundred Hertz (the signal is pulsed so that energy reflected from the sea surface may be gated out). Both the magnitude and phase of the acoustic signal are recorded for analysis.

Experiment

In April 1983 RANRL and WHOI combined with the Defence Scientific Establishment of New Zealand to conduct an experiment in the New Caledonia Basin, which is located in the Tasman Sea about half way between Australia and New Zealand. The ship used in the experiment was the HMNZS Tui. The New Caledonia Basin has very flat calcareous sediments at a depth of 3200 m. For the first time this experiment was conducted with the source located on the sea floor.

Geoacoustic Models

A geoacoustic model describes the ocean bottom, specifying such properties as sound speed, density, and absorption as a function of depth. A geoacoustic model can be determined by iteration of forward models, i.e. the repeated calculation of pressure fields from assumed geoacoustic models. An alternative method of determining a geoacoustic model from the measured pressure field is to directly invert the data using an appropriate algorithm. At this stage of development of such direct inverse techniques, the iteration of forward models remains a very useful approach.

Various acoustic theories have been employed to implement forward models. Currently, the geometric acoustics approach is being developed for this purpose. One advantage of this approach is the insight it can give on the effect that various parameters have on the total field. Straightforward geometric acoustics has some limitations in this context, and various corrections are being incorporated to allow for such effects as diffraction at caustics and beam displacement on reflection.

Caustics are regions of focused acoustic energy, in which geometrical acoustics predicts infinite intensities; diffraction corrections using Airy functions are normally applied. For the type of environmental model considered here, the caustics are more complex than usual, because of (i) phase effects at interfaces (in particular variation of phase shift with ray angle) and (ii) cut-off of a ray family by an interface. Beam displacement effects occur when a beam (or a ray) are totally reflected by an interface, i.e. incident angle is beyond critical. The beam is, in essence, displaced sideways along the interface. As for the caustic correction, due to the demanding nature of the current data set, beam displacement needs to be incorporated in a more thorough way than has been done previously. The beam displacement treatement being developed inherently incorporates the lateral wave (the lateral wave has the property of travelling along an interface while continually radiating energy away from the interface in a direction that makes the critical angle with the interface).

Steady progress is being made in matching geoacoustic models to the data from the New Caledonia Basin, and also in matching the geometric acoustics results with those from full wave theories (which inherently include many effects outside simple geometric acoustics, but which do not give the same insight into the physics of the situation).

Plane Wave Reflection Coefficient

The results of this type of experiment can be analysed to give (in principle) the plane wave reflection coefficient of the ocean bottom. The plane wave reflection coefficient (as a function of incident angle) is an important geometry-independent parameter which specifies the response of horizontally stratified bottoms. It is a waypoint in the direct inversion of measured acoustic fields in order to obtain a geoacoustic model of the bottom. Further, it can be used directly as input to acoustic propagation models.

Somewhat surprisingly, it is not easy to determine the plane wave reflection coefficient. The problem results from the fact that any real acoustic source produces a spherical wave, not a plane wave. This has caused considerable problems in analysis of experiments using earlier techniques. In the experiment described here the total acoustic field at the receiver is the sum of the direct field plus the field returned from the bottom (i.e. the "reflected" field). The reflected field can be written as the Hankel Transform of the depth-dependent Green's Function, where the transform converts from the horizontal wavenumber domain of the Green's Function to the horizontal range domain of the pressure field. Thus by measuring the total acoustic field and subtracting the direct field contribution, the depth-dependent Green's Function may be found, leading to the plane wave reflection coefficient. Techniques for efficiently performing this operation are being investigated by WHOI reseachers.

Concluding Remarks

The author is currently on twelve months exchange at WHOI, working with George V. Frisk and Earl E. Hays on analysing the results of the Tasman Sea experiment. Previously, Earl Hays was stationed at RANRL (during the period encompassing the experiment). The current work includes developing new techniques in order to handle the unique characteristics of the data collected here.

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(Received 17 April 1984)

Theses

THE ROLES OF FREQUENCY AND REVERBERATION IN AUDITORY DISTANCE PERCEPTION

Kristin Young

A thesis submitted in partial fulfilment of the requirements for the Degree of Bachelor of Arts (Honours), Department of Psychology, University of Sydney.

SUMMARY

There are a number of possible factors in auditory distance perception. The ratio of direct to reflected sound has been shown to be a factor in absolute auditory distance perception. Absolute distance judgments of sounds of different frequencies, having different amounts of reflected content in different environments, would be determined by the ratio of direct to reflected sound. Normally, for absolute distance judgments to be made, the sound source must be familiar. When the reverberation cue is available, it is likely that familiarity with the sounds' environment is important.

Certain methodological issues are important in the study of auditory distance perception. Response indicators and instructions can produce cognitive biases in the observers' judgments. The experimental design must be appropriate to the study of absolute or relative distance. Cognitive biases associated with certain designs must be recognised.

An experiment was conducted to examine the roles of frequency and reverberation in auditory distance perception. It was hypothesised that the ratio of direct to reflected sound would determine the judged absolute distance of sounds recorded on a dummy head and presented over headphones.

It was found that the frequency of the sound determined the distance judgments. The pattern of judgments reflected the way in which familiar sounds are judged, according to knowledge of how frequency varies over distance. There was no significant effect of reverberation.

The results indicated the importance of prior experience with and the current context of sounds for auditory distance perception.

New Publications

Journals Received

Canadian Acoustics

Vol. 12, No. 2, April 1984.
Contents . . . Lateral differences in hearing sensitivity (D. Y. Chung) — The accuracy of highway traffic noise predictions (J. J. Hajek and R. Krawczyniuk) — Improving sound absorption properties of porous concrete materials (J. J. Hajek) — Sound fields near building facades (J. D. Quirt).

The Australian Journal of Audiology
Vol. 6, No. 1, May 1984.

Revue d'acoustique

Vol. 16, No. 67, 1983.

Journal of Technical Physics

(Polish Academy of Sciences)
Vol. 24, No. 1, 1983.

Archives of Acoustics (in English)

Polish Acoustical Society
Vol. 8, No. 2, 1983.
Contents include . . . Prediction of octave noise spectra in accommodations in the superstructure of a ship (E. Szczerbicki and A. Szuwarzynski) — Detection of low intensity auditory evoked responses (F. Grandori) — Evaluation of electroaucoustic devices by the equivalent scale methods (T. Letowski and J. Smurzynski).

Vol. 8, No. 3, 1983.

Contents include a number of papers on ultrasonic techniques plus a paper on optical generation of acoustic waves.

Acta Acustica (Acoustical Society of China)

Vol. 9, No. 2, March 1984.

Anales Otorrinolaringologicos Ibero-Americanos (Barcelona)

Vol. 11, No. 1, 1984.

Reports Received

Proceedings of Internoise 83 (Two volumes)

CSIRO Division of Energy Technology
Research Review 1982-1983.

Includes reports on . . . Sound and vibration in pipes (A. Cabelli and I. G. Pearson) — Active attenuation of sound in ducts (I. C. Shepherd and R. F. La Fontaine).

Institute of Sound and Vibration Research, Southampton
Annual report for year ending March 1984.

Royal Institute of Technology, Stockholm

Dept. of Speech Communication and Music Acoustics.
Quarterly progress and status report, January 1984.
Speech research — summary report for 1983.

Standards

Recently released Australian standards include the following:

Portable Equipment for Integration of Sound Signals — AS 2659, Part 2

The purpose of Standard AS 2659.2 is to provide guidance in the use of integrating instruments such as integrating (or averaging) sound level meters and sound exposure meters (or noise dosemeters), which are being used extensively for making sound measurements.
Copies of AS 2659, Part 2 can be purchased from any SAA office at a cost of $9.20 plus $1.50 postage and handling charge.

Measurement and Evaluation of Human Exposure to Whole Body Vibration — AS 2670

AS 2670 will enable persons involved in the measurement and evaluation of human exposure to whole body vibration to use a method which will produce consistent results when measured in accordance with the procedure specified herein and evaluated under similar conditions.
Cost: $11.40 plus $2.50 postage and handling charge.

Measurement Procedures for Ducted Silencers — AS 1277

AS 1277 deals with the objective measurement and determination of the performance of unit silencers and silencing elements for ducted ventilating and air-conditioning systems.
Cost: $13.40 plus $2.50 postage and handling charge.

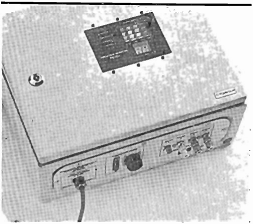
Tape Recording Equipment for Acoustical Measurement Systems — AS 2680

The Standards Association of Australia has published a new standard dealing with the performance requirements of tape recorders for acoustical measurement use.
Cost: $5.00 plus $1.25 postage and handling charge.

Measurement of Road Traffic Noise — AS 2702

The Standards Association of Australia has published a new standard dealing with methods for the measurement of road traffic noise and for the collection of associated data.
Cost: $9.80 plus $1.50 postage and handling charge.

New Products



Machine Vibration Monitor-World premiere

An Australian designed, New Zealand made (Fountain Corporation) microprocessor based machine monitor, for continuous machinery health monitoring, was given its world premiere display to industry in Melbourne recently.

Describing the functions of "Plant Bug", Fountain's Engineering Manager, **Ken Tribble,** said "Plant Bug" runs on an 8085 microprocessor and continuously performs 64 line FFT spectral processing. A three-stage alarm at 6, 12 and 18 dB deviations from the learned reference may be changed by software.

Four channels are automatically scanned and front panel LED or remote terminal display via standard RS 232-C or optional 20 mA current loop is provided. The mid and high alarms operate two relays. A numerical panel display indicates the relative RMS level of each channel during scanning.

In addition, the "Plant Bug" self-tests each 256 cycles, ensuring maximum reliability of protection.

The "Plant Bug", reliably guarding machinery and continuously performing FFT spectral analysis can provide ample warning of machine deterioration whilst pinpointing its source. Confident extension of maintenance periods and reduced downtime and costs can quickly recoup its installation cost.

For information about "Plant Bug" contact **Vipac Instruments:**

Melbourne, Mr. Malcolm Mulcare (03) 240 8731 — Sydney, Mr. Dirk Bout (02) 736 3011 or Vipac offices in Brisbane (07) 371 8100—Adelaide (08) 46 5991—Perth (09) 361 7311.

Hand Held Spectrum Analyzer

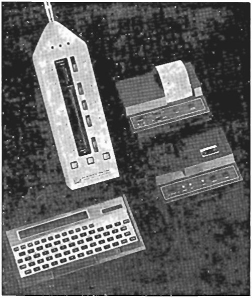
The widest display range of any available sound level meter/acoustic analyzer is one feature that will be appreciated by users of the Larson-Davis model 800 acoustic analyzer just released in Australia by **Vipac Instruments Pty. Ltd.**

Manually operated or auto-functioning under the control of a programmable calculator, the LD800 provides more measurement power than ever before in a hand held instrument.

Features include 60 dB span linear LED display and 10-150 dB measuring range plus in-built 1/1 and 1/3 octave band analysis. A very extensive array of peripherals consisting of calculators, software, printers, plotters and data storage devices are available from Vipac.

Accessories include Model 801 signal processor with four computer-selected microphone inputs, internal white or pink noise generators, programmable signal output levels and peripheral equipment switch channels for rotatable booms or floor tappers.

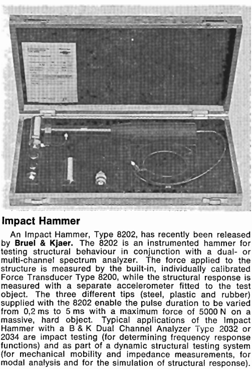
The Model 802 accelerometer pre-amplifier enables inputs from two tri-axial accelerometers (6 channel total). It has programmable input sensitivities and provision for high and low impedance accelerometers with electronic integration



for the measurement of displacement, velocity and acceleration.

The Larson-Davis system from Vipac Instruments provides new micro-processor generation noise and vibration measurement at an affordable price.

Further information from Vipac Instruments:
Melbourne, Mr. Malcolm Mulcare (03) 240 8471 — Sydney, Mr. Dirk Bout (02) 736 3011 or Vipac offices in Brisbane (07) 371 8100—Adelaide (08) 46 5991—Perth (09) 361 7311.



Impact Hammer

An Impact Hammer, Type 8202, has recently been released by **Bruel & Kjaer.** The 8202 is an instrumented hammer for testing structural behaviour in conjunction with a dual- or multi-channel spectrum analyzer. The force applied to the structure is measured by the built-in, individually calibrated Force Transducer Type 8200, while the structural response is measured with a separate accelerometer fitted to the test object. The three different tips (steel, plastic and rubber) supplied with the 8202 enable the pulse duration to be varied from 0,2 ms to 5 ms with a maximum force of 5000 N on a massive, hard object. Typical applications of the Impact Hammer with a B & K Dual Channel Analyzer Type 2032 or 2034 are impact testing (for determining frequency response functions) and as part of a dynamic structural testing system (for mechanical mobility and impedance measurements, for modal analysis and for the simulation of structural response).

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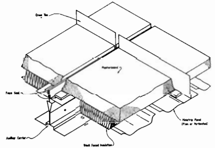

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INTERNATIONAL NEWS

Institute of Acoustics Spring Conference 1984

The Institute of Acoustics Spring Conference, entitled Acoustics '84 was held at the University College of Swansea in Wales from Monday, 9th April to Thursday, 12th April and was attended by over 100 delegates. An international conference on Condition Monitoring was held at the same time and the joint Trade Exhibition enabled the manufacturers to dispay a wider range of instrumentation than is normally shown at Acoustics Conferences.

The sixty-one contributed papers were presented in three parallel sessions covering the following **subject areas** — Musical Acoustics 19 papers, Building Acoustics 14, Transportation Noise 13, Biological Acoustics 10 and Spectrum Analysis and Speech 5. There were some intriguing titles for the papers in the Biological Acoustics Sessions, for example "The Tuned Singing Burrow of Mole Crickets" and "Frog Vocalization and Sexual Selection". Unfortunately there were some interesting papers (with more mundane titles) in the parallel sessions within my subject area so I don't know if the papers were accompanied by live demonstrations.

In addition to the contributed papers there was an **invited lecture by Professor Taylor** on "Demonstrations in Aural Perception" which aptly demonstrated Prof. Taylor's abilities to handle a multimedia presentation. Both the 1983 and 1984 Rayleigh Medal Presentation Lectures were given during the conference. The former by Professor Skudrzyk from the U.S.A. on "Understanding the Dynamic Behaviour of Complex Vibrators" and the latter by Professor Ffowcs Williams on "Sources of Sound". The final session of the conference was the R. W. B. Stephens Lecture given by E. Shaw from Canada and entitled "Recent Advances in Hearing Research".

The **Technical Visits** were programmed for the Wednesday afternoon and included a visit to a Harp maker and to a Welsh Folk Museum; the industrial action by coal miners led to the cancellation of the visit to a mine. However many took the opportunity to analyse the sounds of the sea and enjoy the Welsh coastal scenery.

The **Social Programme** commenced with a buffet supper on the Monday evening. A "Welsh Night" on Tuesday comprised a traditional meal with entertainment from a group of singers and a clog dancer. A Male Voice Choir and Brass Band Ensemble provided the entertainment for the Conference Dinner on the Wednesday.

Overall the conference was well organised and although the programme was very full there was still time for colleagues and friends to meet and discuss matters of mutual interest.

—Marion Burgess.

* * *

Night Lorry Ban

A night and weekend ban on all heavy goods vehicles of more than 16.26 metric tonnes gross weight in Greater London has been agreed in principle by the GLC's transport committee.

Suggested times of operation are between 9 p.m. and 7 a.m., but further consultations on this and other matters will be held over the next few months with the freight industry and others.

Items to be considered further include:

- Possible exclusion of Saturday mornings from the ban.
- Measures to control the noisiest vehicles between 7.5 and 16.26 metric tonnes.
- Extending the ban to certain areas outside Greater London — to the M25.
- Possible exclusion of certain environmentally suitable roads to give access to industrial or commercial sites.
- Inclusion in the ban of certain lengths of trunk road to avoid through movements and also sections of sensitive trunk routes.
- A plan to exempt vehicles designed or modified to meet stringent but practicable noise limits.

SLEEP

Dave Wetzel, who chairs the committee, said: "The GLC is in no doubt about the essential role that lorries play in the economic life of London.

"But unrestricted use of big lorries creates serious environmental problems, including enough noise to prevent 250,000 Londoners from getting a decent night's sleep."

So as not to damage the financial or operational viability of any firm in London, or reduce service levels or employment, the GLC has contacted 200 firms that have been identified in co-operation with the Freight Transport Association, the Road Haulage Association, the London Chamber of Commerce and Industry and others.

—(The Londoner, March 1984)

* * *

12th International Congress in Acoustics Toronto, Canada

July 24 to August 1, 1986

The 12th International Congress on Acoustics will be held in Toronto, Canada, from July 24 to August 1, 1986. In keeping with tradition, the Congress will provide an open scientific forum in all fields of acoustics. As part of the Congress, it is planned to hold **three Symposia** on specific topics immediately before or after the Toronto meeting. The present status of these Symposia is:

- *Speech Communication* (specific topic to be selected), in Montreal, Quebec, on July 21-22.
- *Underwater and Imaging Acoustics*, in Halifax, Novia Scotia.
- *Acoustics and Theatre Planning for the Performing Arts*, in Vancouver, British Columbia.

INTERNOISE—86 is to be held in the eastern United States immediately before the Congress (July 21-23). Congress participants may also be interested in TRANSPO '86, a second category international exposition, to be held in Vancouver, British Columbia, May-October, 1986. Other associated meetings will be announced as they are organized.

To receive further information circulars and final registration forms, you must ensure that you are on the Congress mailing list **before September 1, 1984.** For free listing, please write to:

12th International Congress on Acoustics
Secretariat
Box 123, Station 'Q'
Toronto, Canada
M4T 2L7.

* * *

POLMET '85

Asia and Pacific Regional Conference

"Pollution in the Urban Environment"

Hong Kong, 2-6 December, 1985

Call for Papers

Contributed papers are invited for the sessions dealing with Noise in the areas of:

- Noise sources, surveys and assessment
- Environmental noise control strategies
- Planning against noise
- Noise control in practice

Intending authors should submit an **abstract** of 200-300 words (three copies) to the Secretariat, to arrive before the **31st August, 1984.**

The official address for all correspondence is:

The Secretariat
"Pollution in the Urban Environment" Conference,
57 Wyndham Street, 1st Floor,
Central,
Hong Kong.

Future Events

AUSTRALIA

1984

August 27-31, HOBART

12th Conference, Australian Road Research Board
Over 100 papers, 3 simultaneous sessions covering all aspects of roads and road transportation.

Details: Australian Road Research Board, P.O. Box 156 (Bag 4), Nunawading, Vic. 3131.

September 19, MELBOURNE

Victoria Division AGM 6-10 p.m.
World Trade Centre
An open forum on the future of the Acoustics profession.

Details: Victoria Division, National Science Centre, 191 Royal Parade, Parkville 3052.

October 9, MELBOURNE

Victoria Division technical visit to Aeronautical Research Labs.
Details: See Sept. 19 item.

October 30-November 2, SYDNEY

7th International Conference on Computer Communication.
Conference theme: "The New World of the Information Society".
Details: Conference Secretary, G.P.O. Box 2367, Sydney 2001.

November 1-2, PERTH

Australian Acoustical Society 1984 Conference.
"Noise and Vibration Legislation in Australia".

Details: F. R. Jamieson, Acting Secretary, W.A. Division, A.A.S., 2 Beryl Ave., Shelley, W.A. 6155. (Also see page 6 this issue).

December 3-7, MELBOURNE

Australian Institute of Physics.
3rd Applied Physics Conference: "Physics and Australia's Resources". Royal Melbourne Institute of Technology.
Details: Ken Cook, Conference Secretary, Dept. of Applied Physics, RMIT, G.P.O. Box 2476V, Melbourne 3001.

December 4-6, SYDNEY

International Conference on Underwater Acoustics
Special sessions: (1) Interactions with the sea floor, (2) Shallow water propagation, (3) Acoustic fluctuations.

Details: Marshall Hall, Navy Research Laboratory, P.O. Box 706, Darlinghurst, N.S.W. 2010.

1985

February 3-8, MELBOURNE

Australian Association of Speech and Hearing Annual Conference. The programme aims to highlight topical areas of therapeutic intervention, clinic and staff administration and professional development.
Details: ASSH Conference Secretariat, P.O. Box 29, Parkville, Vic. 3052.

INTERNATIONAL

1984

August 21-24, SANDEFJORD, NORWAY

FASE 84 — 4th Congress of the Federation of Acoustical Societies of Europe.
Secretariat: FASE 84, Secr. Gen. J. Tro, ELAB, N-7034 TRONDHEIM-NTH, NORWAY.

September 6-7, MERKSEM, BELGIUM

5th JAN PALFIJN Symposium European Conference on Echography. "Fetal abnormalities as detected by ultrasound".
Details: Mrs. H. Heye-De Decker, Gebr. Van Raemdonckstraat 46, 2060 Antwerp, Belgium.

October 2-4, CESKE BUDEJOVICE, CZECHOSLOVAKIA

23rd Acoustic Conference on Physiological and Psychological Acoustics, Acoustics of Speech and Music.
Organising Secretary: Mrs. Eva Dostalova, House of Technology, Gorkeho namesti 23, 112 82 Prague 1.

October 8-12, MINNEAPOLIS

Meeting of the Acoustical Society of America.
Chairman: W. Dixon Ward, Hearing Research Laboratory, University of Minnesota, 2630 University Ave., S.E. MINNEAPOLIS, MINNESOTA 55414.

December 3-5, HONOLULU

INTER-NOISE 84
Organised by INCE/U.S.A. in co-operation with INCE/Japan. Secretariat: P.O. Box 3469, Arlington Branch, Poughkeepsie, N.Y. 12603, U.S.A.

1985

April 8-12, AUSTIN, TEXAS

Meeting of the Acoustical Society of America.
Chairman: Professor David T. Blackstock, University of Texas, P.O. Box 8029, AUSTIN, TX 78712.

May 6-8, HELSINKI

Fourth International Symposium on Hand-Arm Vibration.
Details: Dr. I. Pyykko, Institute of Occupational Health, Department of Physiology, Laajaniityntie 1, SF-01620 Vantaa 62, FINLAND.

June 2-5, U.S.A.

NOISE-CON '85
INCE/USA National Conference on Noise Control Engineering.
Details: Prof. R. Singh, Mech. Eng. Dept., Ohio State University, 206 West 18th St., COLUMBUS, OH. 43210. Correction

August 4-9, MANCHESTER

International Congress on Education of the Deaf.
Details: Prof. Taylor, Dept. of Audiology and Education of the Deaf. The University of Manchester.

September 18-20, MUNCHEN, GERMANY

Enterprise 85. Organised by VDI, MUNCHEN.
Details from: Prof. E. Zwicker, Institut fur Elektroakustik der Techischen Universitat Munchen Arcisstr. 21, 8 Munchen 2.

June or September, DELPHI, GREECE

5th FASE Symposium on "Integrated Acoustical Environment Design".
Organised by the Hellenic Acoustical Society jointly with the Acoustical Society of Yugoslavia.
Details from: E. Tzekakis (5-FASE-85) 5, Agiou Seraphim Str. Thessaloniki.

October 1985, HIGH TATRA, CZECHOSLOVAKIA

24th Acoustical Conference on "Building and Room Acoustics".
Secretariat: House of Technology, Ing. L. Goralikova, Skultetyho ul., 881 30 Bratislava.

November 4-8
NASHVILLE, TENNESSEE

Meeting of the Acoustical Society of America.
Chairman: Robert W. Benson, Bonitron Inc., 2970 Sidco Drive, NASHVILLE, TN 37204.

December 2-6, HONG KONG

POLMET '85, Asia & Pacific Regional Conference
"Pollution in the Urban Environment".
Details: The Secretariat, POLMET '85, 57 Wyndham St., First Floor, Central, HONG KONG.

1986

TORONTO, CANADA

12th ICA Congress (International Commission on Acoustics).
Secretariat: 12 ICA, 5007-44 Charles Street West, Toronto, Ontario, Canada M4Y 1R8.

May 12-16, CLEVELAND, U.S.A.

Meeting of the Acoustical Society of America.
Chairman: Arthur Benade, Case Western Reserve University, Physics Department, Cleveland, Ohio 44106.

May 1986, WIEZYCA, POLAND

3rd International Spring School on Acoustoopics and Applications.
Organised by the University of Gdansk.
Details from: Prof. A. Sliwinski, Uniwersytet Gdanski, Instytut fizyki Dosw. ul. Wita Stwosza 57, 80-952 Gdansk.

July 8-11, GYOR, HUNGARY

6th FASE-Symposium on "Subjective Evaluation of Objective Acoustical Phenomena".
Secretariat to be announced.

Goodbye book, hello disc

For the 1982 Christmas Lecture, the South Central Branch of The Institute of Physics decided to mark the completion of Information Technology Year (IT '82) by inviting Dr. N. K. Bridge, Managing Director of PIRA, Leatherhead, to speak on the theme of electronic publishing.

Printing as we know it was invented in the 15th century in Germany, and it provided the first big industrial process and the means to educate and entertain everyone. It still holds an important place in the modern world despite competition from radio and films in the 1920s and television in more recent years. Until three years ago the number of books and periodicals continued to grow. The printed word is so valuable because it can be replicated; it does not need a complicated infrastructure; it is easily stored and retrieved; it can be distributed; it is easily usable and is attractive; and it is relatively cheap and portable. Its disadvantages are that production is a slow process; updating is a slow process; storage volume is high; and physical distribution is required.

Over the last few years new processes have been developed which allow text to be generated electronically by computers (e.g., word processors) and which allow graphics and pictures to be produced by electronic scanners. New technology has contributed to the production of the printed word. For example, "intelligent" photocopiers will take information directly from computers and ink-jet printers no longer use traditional techniques but work on a principle similar to that of the cathode ray tube.

Totally electronic publishing methods such as Videotex, videodisc and viewdata offer an exciting new potential. For example, videodisc has the capacity for very high quality moving pictures, individual pictures, hi-fi sound and interactive response which can be exploited in a totally different way from traditional books. Do-it-yourself car maintenance would be far easier with a videodisc than a traditional manual.

In the future we are likely to see developments and new products in teletext for information and shopping; computer assisted learning; electronic document storage and delivery (which could collect a royalty for every copy); electronic journals; on demand publishing and on-line databases; abstracts; and bibliographies. Distribution by satellite, cable and optical fibre will make the processes rapidly and readily available.

These electronic publishing developments will not have the weaknesses of the traditional printed word because they are quicker processes, with readily available updating, low volume storage capacity and no requirement for physical distribution.

The valuable properties of replication and easy storage and retrieval are retained, but there is a need for a complex infrastructure and the product will not be so easily used or be as aesthetically appealing as a book. Portability of ancillary "reading" equipment has not yet been achieved but will inevitably be developed in time.

Dr. Bridge forecast that over the next decade electronic publishing would be likely for "hot" news, encyclopedias, directories, timetables, educational and training material, catalogues and specialist technical journals. It would be unlikely for general books, magazines and newspapers. In 30 years' time it will be possible to say "goodbye book" — no longer will there be a technical need for them — but we will still retain some books because we like them.

(Colin Greaves in Physics Bulletin, May 1983)

AUSTRALIAN ACOUSTICAL SOCIETY 1984 CONFERENCE

"Noise and Vibration Legislation in Australia"
University of Western Australia, Perth

1-2 November 1984

The W.A. Division of the Australian Acoustical Society invites submission of papers for presentation at the above Conference. Papers shall be in the following areas:

1. Environmental and occupational acoustic legislation;
2. Review or criticism of existing legislation or proposals for future improved legislation;
3. Experience or problems with the application of existing legislation.

Abstracts of not more than 200 words should be forwarded by 31 May, 1984, to F. R. Jamieson, Acting Secretary, W.A. Division, Australian Acoustical Society, 2 Beryl Avenue, Shelley, W.A. 6155.

Complete papers not exceeding 2,000 words must be received no later than 31 August, 1984. Details of the required format will be provided at the time of notification of acceptance of papers.

● International Conference on "Developments in Marine Acoustics"

4-6 December, 1984—University of N.S.W., Sydney.

The topics to be covered in the programme are —

(1) Sea-floor acoustics;
(2) Propagation;
(3) Acoustic scattering and sensing;
(4) Sea noise; and
(5) Signal processing.

Programme

The programme will include —

(1) Plenary sessions addressed by eminent international invited speakers;
(2) Contributed paper sessions; and
(3) A conference banquet.

Contributed Papers

Anyone likely to attend and present a lecture is requested to submit complete papers (between 2 and 6 pages) to the Technical Programmer by the 2nd October, 1984.

Technical Programmer

Dr. M. Hall
RAN Research Laboratory
P.O. Box 706,
Darlinghurst, N.S.W. 2010
Telex: AA27142

Conference Secretary

Dr. J. I. Dunlop
School of Physics
University of New South Wales,
Kensington, N.S.W. 2033
Telex: AA26054

Victoria Division

Site Visit to Government Aircraft Factories

A site visit was organised on 14th June, 1984, to the Design and Development Laboratory of the Government Aircraft Factories, Department of Defence Support. The D & D Laboratory is responsible for the Vibration and Structural Dynamic testing of aircraft.

Members who attended were fortunate to see the following demonstrations:

- (a) Use of a 70 kN (20,000 lb force vector) dynamic shaker table to demonstrate the effect on equipment in a sinusoidal environment condition.
  (b) Random testing on air missile environments by the use of spectrum shaping equalisers, etc. The control is achieved by using HP 1000 random vibration control.
- Structural dynamic modal analysis of machine work using photographic methods, etc. This room is the heart of the laboratory, it includes data processing and storage, laboratory testing and field testing, signal analysis and FFT logarithmic analysis.
- Climatic simulation of environmental conditions which include high altitude temperature and control chamber and humidity control chamber.

—H. SIN CHAN.

AAS Representatives on SAA Committees

Following is a list of Society representatives on SAA committees who may be contacted for information relating to acoustics standards or drafts.

Committee: AK/12
Measurement Noise — Household and Small Appliances — MRS. V. BRAY, N.S.W.

Committee: AK/2
Techniques for Measurement — MR. R. C. WILKINSON, N.S.W.

Committee: AK/4
Architectural Acoustics — MR. E. T. WESTON, N.S.W.

Committee: AK/5
Community Noise — MR. P. R. KNOWLAND, N.S.W.
MR. R. J. CARR, VIC.

Committee: AK/9
Noise from Pneumatic Tools and Machines — MR. L. KENNA, N.S.W.

Committee: AK/-
Acoustics Standards Committee — MR. G. E. HARDING, VIC.
MR. G. A. RILEY, VIC.
MR. P. R. KNOWLAND, N.S.W.

The Acoustics of Stringed Musical Instruments

Proceedings of the Wollongong Co-operative Workshop, 5-8 July, 1980.

Published by the University of Wollongong, 1982, 289 pp. A$15.00. Edited by Abe Segal.

The book contains 16 papers on a variety of topics relating to the violin, guitar, clavichord, etc., by authors from eight different countries.

Copies may be obtained from:

Department of Physics, University of Wollongong, P.O. Box 1144, WOLLONGONG, NSW 2500.

Payment should be made to "Wollongong String Workshop".

Review of the Experimental Building Station

The Minister for Housing and Construction, the Hon. Chris Hurford M.P., recently released the Report of the Review Committee for the Experimental Building Station, Sydney (Ryan Committee). The report has now been printed and will be available, free of charge, to key groups and individuals associated with the building industry, who have contributed information to the Review or have an interest in the future of the Building Station.

The Australian Acoustical Society made a submission to the committee.