ACOUSTICS 2025
JOONDALUP
SOUNDS OF THE SUNSET COAST

Underwater acoustics in Australia in 2025 – Where has it been, where is it at, and where is it going?

Alec J Duncan

Centre for Marine Science and Technology, School of Earth and Planetary Science, Curtin University, Perth, Australia

ABSTRACT
This paper considers how underwater acoustics as a discipline has evolved over the last several decades and how it is likely to evolve in the future. The focus is on the Australian context, as that is where the bulk of the author's experience lies, but many of the influences and issues are global. This paper is intended to promote discussion, particularly with regard to the future evolution of the field.

1 INTRODUCTION
Acoustics 2025 is being held at the same venue as the 2000 edition of the Australian Acoustical Society's (AAS's) national conference, Acoustics 2000. It therefore seems timely to reflect on how the field of underwater acoustics has evolved over the intervening quarter of a century, and to consider how it may evolve in the future.

Acoustics 2000 was a watershed for underwater acoustics within the AAS. The AAS had sponsored the International Conference on Underwater Acoustics, held at the University of New South Wales in December 1994 (AAS 1994), but there had been no meeting of the Australian underwater acoustics community since then. The Acoustics 2000 organizing committee decided to strongly encourage the submission of papers on underwater acoustics and invited W. A. (Bill) Kuperman from the Marine Physical Laboratory at Scripps Institution of Oceanography, a world expert in the field, to attend as a plenary speaker. As a result, underwater acoustics went from being a very minor component of AAS national conferences, to contributing 34 of the 50 papers presented at Acoustics 2000.

The AAS has continued to encourage the participation of underwater acousticians, and the discipline has been well represented at all subsequent conferences, although not dominating to the extent it did in 2000. This year's conference is typical, with 31 papers being presented on various aspects of underwater acoustics, making up just under 25% of the total of 128 papers.

This paper starts with a brief outline of the state of underwater acoustics in Western Australia, and Australia as a whole, in 2000. It then compares the fields of application and topics of the papers being presented at the current conference with those presented in 2000 and then discusses the reasons for the changes. Finally, it considers how things are likely to change in the future.

2 Setting the Scene
Underwater acoustics was alive and well in Western Australia in 2000. At Curtin University, the Centre for Marine Science and Technology (CMST), originally established by John Penrose in 1985, had become a strong research group with considerable expertise in physical and biological aspects of underwater sound, hydrodynamics and subsea imaging.

The Australian built Collins class submarine fleet, which ultimately consisted of six vessels commissioned between 1996 and 2003, was based at the HMAS Stirling naval base south of Perth and in 1996 the Defence Science and Technology Organisation, DSTO, (now the Defence Science and Technology Group, DSTG), established a research facility on the naval base to support the fleet. By 2000, a number of DSTO scientists with expertise in underwater acoustics had moved from other states to work there and DSTO had also recruited local graduates, several of whom were ex CMST students.

In the commercial arena, the Fremantle based company that was set up as Nautronix in the 1980s to develop a novel acoustic subsea navigation system for the offshore oil and gas industry, had undergone various corporate rearrangements, and had expanded its activities into underwater acoustic communications, particularly for defence. (The corporate rearrangements have continued but the entity that traces its origins back to Nautronix - L3Harris Technologies – is still based in Fremantle.)

In the broader Australian context, the vast majority of research in underwater acoustics was defence related and was being carried out at DSTO's facilities in South Australia, Victoria and New South Wales. The largest commercial player was Thomson Marconi Sonar (Now Thales Underwater Systems), based in Rydalmere, NSW which had a long history of developing underwater acoustic technology for the Australian Navy, often in conjunction with DSTO, and provided the sonar systems for the Collins Class Submarines. In academia, Sydney University was the most significant player outside of CMST, largely due to the efforts of Doug Cato, from DSTO who had (and still has) an honorary position there.

By 2000, concern was growing about the potential impacts of human generated underwater sound on marine fauna, particularly marine mammals, but knowledge about the acoustic environment in which these animals lived, how they used sound themselves, and the impacts of human generated underwater sound on them, was in its infancy. This lack of knowledge was in large part due to the high cost of making long-term acoustic measurements in the ocean, which at that time required extremely expensive hydrophone systems, cabled to shore. However, as will be described later, that was about to change.

In Australia, the concern about underwater sound impacts had just been given legislative teeth by the passing into law of the Environment Protection and Biodiversity Conservation Act (EPBCA, 1999), which made it an offence to "take" migratory and endangered species, which specifically included many marine mammal species. The definition of "take" was sufficiently broad to include detrimental exposure to human generated sound, so this legislation had the potential to affect such activities as offshore seismic surveys, pile driving and even the use of high-powered naval sonar.

Another development was the impending installation of the Comprehensive Nuclear Test Ban Treaty Organisation's three-hydrophone hydroacoustic station off the southwest corner of Western Australia, which became operational in 2001 (CTBTO, 2008). Although set up to detect clandestine nuclear tests in the Indian Ocean, delayed data from this station was expected to be available for research purposes, opening up a wide range of research possibilities in underwater acoustics at frequencies up to the station's bandwidth limit of 100 Hz.

3 Comparisons between Acoustics 2020 and Acoustics 2025

Table 1 and Figure 1 compare the fields of application of the underwater acoustics papers being presented at Acoustics 2025 (31 papers) with those presented in 2000 (34 papers). There is a dramatic shift between a conference dominated by defence applications in 2000 to one dominated by environmental applications in 2025. The breakdown by paper topic shown in Table 2 and Figure 2 show a corresponding shift from papers related to acoustic propagation, scattering, sonars and signal processing to those on anthropogenic and biological sound source characterisation, soundscape characterisation, passive acoustic monitoring of marine animals and the impacts of sound on marine animals.

Table 1: Underwater acoustics paper percentages by field of application at the 2000 and 2025 Australian Acoustical Society national conferences. 34 underwater acoustics papers were presented in 2000, and 31 in 2025.

Year	2000	2025
Environmental	23.5%	82.3%
Defence	73.5%	16.1%
Offshore oil and gas	2.9%	1.6%

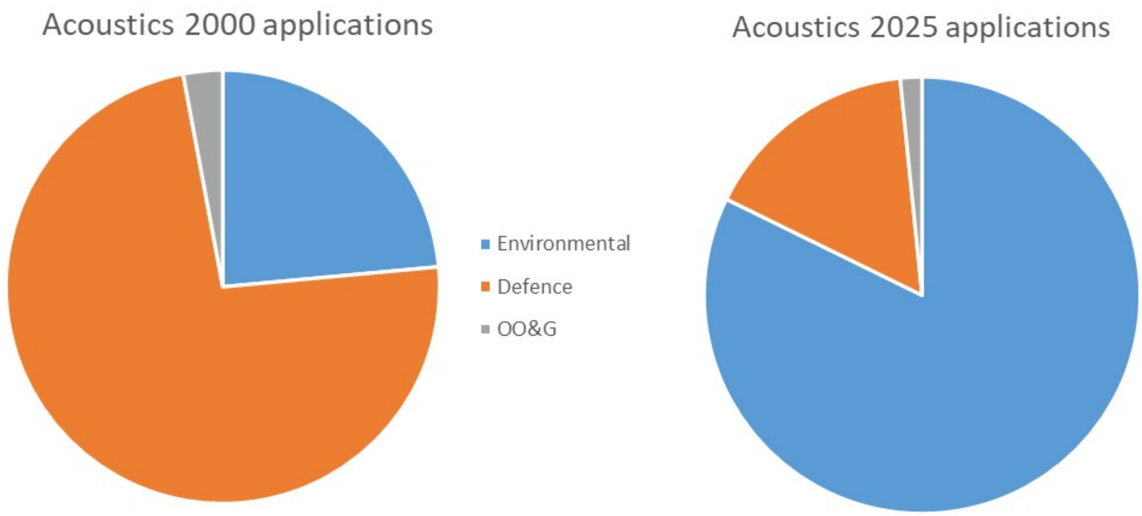

Figure 1: Pie charts showing proportions of underwater acoustics papers by field of application at the 2000 and 2025 Australian Acoustical Society national conferences.

Table 2: Underwater acoustics paper percentages by topic at the 2000 and 2025 Australian Acoustical Society national conferences. 34 underwater acoustics papers were presented in 2000, and 31 in 2025.

Year	2000	2025
Anthropogenic source characterisation	5.9%	12.9%
Biological source characterisation / Passive acoustic monitoring (PAM)	2.9%	27.4%
Noise / Soundscape characterisation / impacts on marine fauna	2.9%	27.4%
Propagation modelling and geoacoustic inversion	23.5%	8.1%
Scattering, reflection & transmission	8.8%	0.0%
Sonars, receiving sensors and arrays	32.4%	1.6%
Signal design and processing	17.6%	6.5%
Underwater communications	2.9%	3.2%
Management / systems / policy	0.0%	3.2%
Other	2.9%	9.7%

The large shift in emphasis from defence to environmental aspects of underwater acoustics demonstrated by these statistics will come as no surprise to anyone who has been active in underwater acoustics over the last few decades. The defence work is still going on but has become more focussed on the immediate needs of the Navy and therefore less likely to be in the public domain. The big changes have been the huge increase in concern about the effects of human generated underwater sound on marine fauna that occurred around the time of the 2000 conference, and also the technological changes that have allowed acoustics to become a standard tool for studying the marine environment, particularly its fauna.

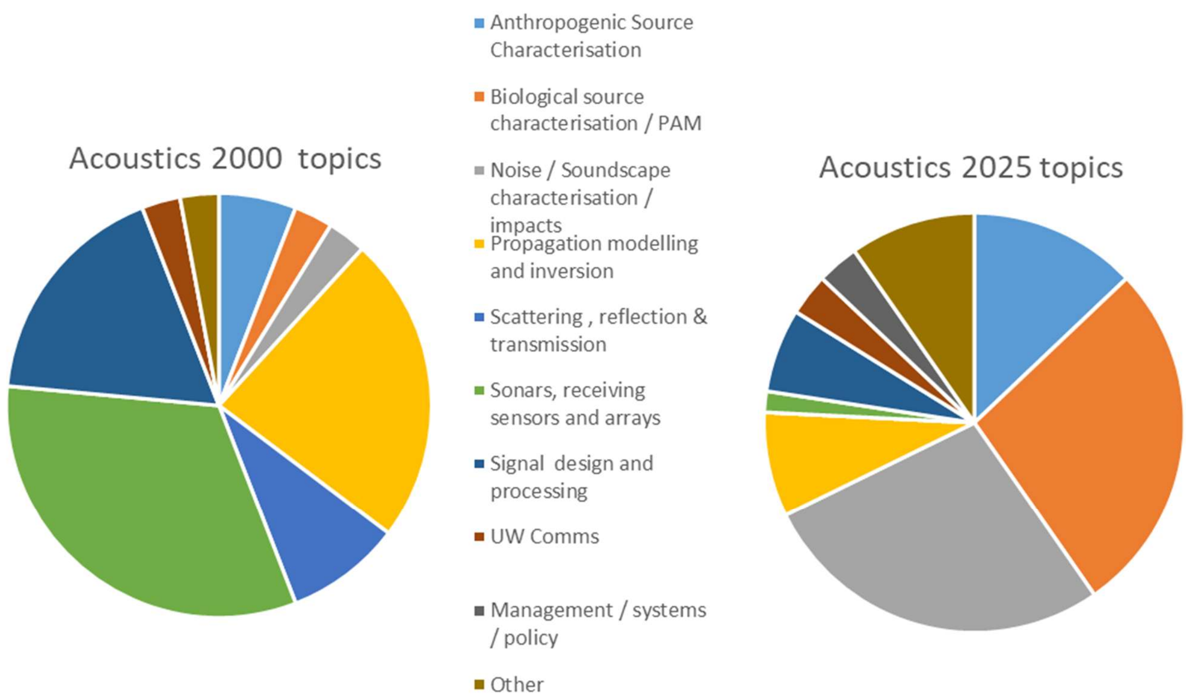

Figure 2: Pie charts showing proportions of underwater acoustics papers by topic at the 2000 and 2025 Australian Acoustical Society national conferences.

4 What has happened since 2000?

4.1 Autonomous recording systems

At the time of the 2000 conference CMST engineer Frank Thomas, with funding from Doug Cato at DSTO, was in the process of developing one of the first hard disk based autonomous underwater sound recorders. The first of these became operational in 2001 and had a 22 kHz sample rate and an 8 GByte hard drive – tiny by today's standards. However, the resulting 50 hours of recording (longer at lower sampling rates), extremely flexible scheduling software and low power consumption meant this was a massive improvement on the digital audio tape (DAT) recorders used previously that allowed a maximum of 4 hours of recording. The CMST design proved highly successful, and was steadily improved to give greater reliability, additional features such as precise clock synchronization to GPS, the ability to switch sample rates to record high-frequency synchronization beacons, and to take advantage of larger hard drives and ultimately solid-state drives as they became available. CMST built more than fifty of these sea noise recorders (SNRs) and they have been used (mainly by CMST's Rob McCauley) for hundreds of long-term deployments and returned terabytes of invaluable data. An example from 2009 is shown in Figure 3. Although now largely superseded by commercial recorders, there are still occasional applications where a SNR is the preferred choice.

The advent of the CMST SNR and similar devices developed by other research groups around the world, made long-term underwater acoustic measurements almost anywhere in the ocean economically feasible. Each device could operate autonomously for a long time (often a year or more), so a vessel could deploy the SNR on a suitable mooring, then return at the end of the measurement period to recover it, after which the data would be downloaded. Of course, the downside was (and still is) that if the mooring recovery failed for any reason, no data was recovered.

Figure 3: CMST Sea Noise Recorder (SNR), c.a. 2009.

Between 2000 and 2016 the energy efficiency of computing hardware roughly doubled every 2.6 years (Naffziger and Koomey, 2016). Assuming this trend continued until 2025, the hardware of today would be almost 1000 times as energy efficient as it was in 2000. This has been further improved by the switch from mechanical hard drives to solid state drives, which are now readily available in capacities of 4 TByte, a factor of 500 greater than the 8 GByte hard drive used by the original SNR. These developments open up many possibilities for autonomous recording systems, including longer deployments, higher sampling duty cycles, higher sampling rates, more hydrophone channels, and the incorporation of onboard processing for such tasks as signal classification.

4.2 Signal classification

The need for automated signal detection and classification algorithms became apparent at the beginning of the hard-drive recorder era as it became increasingly tedious to manually search through ever larger data sets looking for signals of interest. As a result, there is a large literature on post-processing signal detectors, particularly for biological signals. Examples include Erbe (2000), Erbe and King (2008), Madhusudhana et. al. (2015), and Madhusudhana et. al. (2020). These have traditionally been manually designed, based on the known characteristics of the signals, but machine learning techniques are increasingly being used to make the design process more straightforward and/or lead to more reliable or faster detectors (e.g. Jin, 2025; Tary et. al., 2025).

4.3 Sensors

Piezo-ceramic hydrophones are a mature technology and have not changed significantly in the last 25 years, apart from some manufacturers now incorporating digitising electronics into the same package as the hydrophone.

In 2014 the Canadian company GeoSpectrum Technologies Inc. started selling commercial sensors capable of measuring the three components of acoustic particle velocity in water with a useful bandwidth of about 3 kHz and with sufficient sensitivity to measure biologically relevant signals. These sensors have a number of applications but are particularly relevant for studies of hearing in fish species that sense particle velocity rather than pressure. Prior to the GeoSpectrum sensors becoming available, the only particle velocity sensors being produced were strictly controlled military items, and it was necessary to infer the particle velocity field indirectly from acoustic pressures measured by hydrophones.

The most recent advance in underwater acoustic sensing technology is a result of the realisation that distributed acoustic sensing (DAS), a technique commonly used in geophysics that allows a conventional optical communication fibre to be used in place of a large array of geophones, can be used to sense underwater sound at frequencies up to about 100 Hz (Sidenko, 2025; Xenaki et. al. 2025). The promise of this method is that it could make it vastly cheaper to deploy large acoustic sensing arrays than is currently the case, and it is even possible to turn existing undersea optical fibre communication cables into acoustic sensing arrays, simply by adding an optical interrogator to the dry end of the cable. However, the physics of the coupling of underwater sound in the water column to the longitudinal strain in the optical fibre that the DAS system senses is complicated, and as yet poorly understood, and the sensing elements have very different directionality characteristics to a conventional hydrophone, making it unclear how best to process the data from the array. The potential payoffs make DAS a very active research topic internationally.

4.4 Modelling and simulation

The commonly used acoustic propagation models today are based on the same theoretical approaches as those in use in 2000, the details of which can be found in Jensen et. al. (2011). However, advances in computational power have allowed them to be applied to larger problems such as longer ranges, deeper depths, more frequencies, higher frequencies, more azimuths. Greater computational capacity has also increased the popularity of fully three-dimensional propagation models that can take into account cross-track changes in sound speed profile or bathymetry. In most cases traditional 2D modelling along one range-depth slice at a time is adequate, however there are situations where 3D effects are important, for example for propagation across steeply sloping bathymetry (Section 6.9.5 of Jensen et. al. 2011), or nearly parallel to the crests of high-amplitude nonlinear internal waves (Duncan et. al. 2019).

Increased computational capacity has also made it feasible to incorporate propagation models into simulations of underwater acoustic communication systems and the like, improving the ability of such simulations to provide realistic results.

4.5 Passive acoustic monitoring of marine fauna (PAM)

Marine biologists have embraced the use of underwater sound recorders to record sounds made by marine animals as a way of finding out more about their ecology. This has been an active field of research since the first underwater sound recorders were developed but received a boost in the late 2010s when several different companies started making relatively low-cost underwater sound recorders specifically for this market. PAM studies have also been carried out using fixed hydrophone systems, such as the CTBTO hydroacoustic station off Cape Leeuwin.

4.6 Anthropogenic noise impacts on marine fauna

The last 25 years have seen a large amount of research around the world on the impacts of human made underwater noise on marine animals. These studies have particularly focussed on marine mammals, but there has also been work on sea turtles, fish, and various marine invertebrates, much of it carried out in Australia by, or involving Rob McCauley. (e.g. McCauley et. al. 2002; Fewtrell and McCauley, 2012; Day et. al. 2016)

The largest study in Australia was Project BRAHSS: Behavioural Response of Australian Humpback Whales to Seismic Surveys. This project was led by Doug Cato (DSTO and University of Sydney) and funded by the Sound & Marine Life Joint Industry Program and the US Bureau of Ocean Energy Management. The other principal investigators were Michael Noad (University of Queensland), Rebecca Dunlop (University of Queensland), and Rob McCauley (CMST). Four major experiments were carried out from 2010 to 2014, three off the east coast of Australia and one off the west coast, all involving controlled exposures of migrating humpback whales to sounds from seismic survey airguns. These experiments involved over 60 scientists and more than 120 volunteers. The results of the study are summarised in Cato et. al. (2019).

In a landmark paper, Southall et. al. (2007) made recommendations for marine mammal noise exposure criteria based on a review of all the experimental results available at that time. Starting in 2015, these were revised in the light of more recent data by the U.S. National Marine Fisheries Service, with the most recent recommendations being published in NMFS (2024).

4.7 Long range ocean acoustics

The CTBTO hydroacoustic station at Cape Leeuwin has been operating since 2021, and the data from this station, as well as several others in the Indian Ocean has been made available for scientific research. These data have proved useful for a wide range of purposes, including tracking migrating whales, studies of temporal changes in ice cracking noise from around Antarctica (Li and Gavrilov 2006), acoustic propagation experiments (Li et. al. 2009), and even to aid a (so far unsuccessful) search for a missing aircraft (ATSB, 2017).

4.8 Underwater acoustic communications

By 2020 underwater acoustic communications technology was already quite sophisticated and pushing at the bounds of what is physically possible given the very severe constraints imposed by the underwater acoustic environment. Increased computational capacity has led to incremental improvements since then, but underwater acoustic communications remains, and will likely always remain, extremely slow and unreliable compared to what we have come to expect from terrestrial wireless communications. It is, however, the only choice for through-water wireless communications except at extremely short ranges where much higher rate optical communications may be possible if the water is clear.

4.9 Autonomous underwater vehicles

Autonomous underwater vehicles (AUVs) have come of age in the last twenty-five years and there are now a wide range of commercially available vehicles to choose from. These include propeller driven vehicles primarily used for search and survey tasks, and underwater gliders that are used for oceanographic measurements. Propeller driven AUVs are commonly fitted with a variety of active sonar systems but are a noisy platform for passive acoustic sensors. On the other hand, gliders have been used for passive acoustic sensing, but this requires special programming to minimise the motor-driven ballast shifts required to maintain the desired ascent or descent angle. No doubt, both these types of AUV could be made quieter and therefore better platforms for passive acoustic sensors, however the limitations of underwater acoustic communications mean they will always be constrained in their ability to transfer significant amounts of data without surfacing.

5 Towards the future

Before polishing up the crystal ball it is interesting to consider the “hot topics” in underwater acoustics in 2000, and what happened to them in the intervening 25 years. In the highly subjective opinion of the author, these were time-reversal acoustics - the ability to reproduce a source signal by time-reversing and re-transmitting the signals received at an array of hydrophones (Kuperman et. al. 2000), and acoustic daylight – imaging targets by using ambient noise as an illuminating source (Readhead, 2000). These techniques were both validated by proof of principle experiments and underwent a period of intense study for a number of years but were then largely abandoned as being inferior to more conventional ways of achieving the same thing. Time-reversal acoustics remains a fascinating physical curiosity with few practical applications, and it seems unlikely that acoustic daylight will be revisited unless the cost of building large, planar hydrophone arrays diminishes dramatically.

What are the equivalent “hot topics” in 2025? Two candidates would be distributed acoustic sensing (DAS) and the use of machine learning and massively parallel neural networks for signal classification and other signal processing tasks. Both these techniques have significant potential to address real-world problems in underwater acoustics, but they also have limitations that are still being explored, and it is yet to be seen how much impact they will have on the field.

The rise of AUVs threatens to make the ocean a much more dangerous place for conventional naval vessels. AUVs are smaller, orders of magnitude cheaper and much harder to detect than submarines and are rapidly increasing in capability. Massive improvements to existing undersea surveillance technology will be required to counter this threat and perhaps DAS technology will play a role. Machine learning is also likely to be useful in this regard, but it will be interesting to see if it lives up to the hype or simply leads to incremental improvements over what can be done with existing methods.

Much more is now known about the environmental impacts of human generated underwater sound than was the case in 2000. There are now scientifically based underwater noise exposure criteria for marine mammals that are routinely applied in environmental impact assessments. There is no doubt more work to do, particularly in establishing criteria for a wider range of vertebrate and invertebrate species but this is likely to be less urgent (at least in the eyes of the public) now that the charismatic megafauna have been dealt with.

Passive acoustic monitoring of marine fauna is now established as an extremely useful addition to traditional study methods, and will no doubt continue to be used by marine biologists far into the future. Automatic signal detectors and classifiers are already available for many species of interest and more – both conventional and machine learning based – will no doubt be developed in the future.

Continuing improvements in computing technology will make it feasible to run more accurate acoustic propagation models but propagation prediction accuracy is already limited in most cases by an imperfect knowledge of the environment (sound speed profile, bathymetry and seabed properties), rather than by the accuracy of the underlying numerical algorithm. There is a need to develop rapid in-situ methods for determining the necessary environmental parameters to address this issue, particularly in the defence context where it is the current propagation conditions that are of primary interest. Some preliminary work has been done that showed promise (Clarke and Jones, 2012), but this seems to have lapsed.

One other item of unfinished business in propagation modelling is the lack of a fast, robust model that can accurately deal with range dependent propagation over the calcarenite seabeds that make up much of the Australian continental shelf. There are workarounds that allow reasonable results to be obtained in most situations, but it takes considerable skill to apply these properly and a single model that accurately deals with this situation would be much better.

6 Conclusion

A lot has happened in the last 25 years. Environmental applications of underwater acoustics have gone from being a niche area to dominating the field, and technological improvements, particularly the advent of autonomous underwater sound recorders, have vastly increased our knowledge of what goes on in the ocean.

It has been an exciting time to be an underwater acoustician! What will happen next?

REFERENCES

AAS 1994, *Proceedings, International Conference on Underwater Acoustics*, UNSW, 5-7 December. https://acoustics.asn.au/conference_proceedings/aas_acoustics1994_Underwater_Acoustics.pdf

ATSB 2017, *The Operational Search for MH370*. Australian Transport Safety Bureau, external aviation investigation AE-2014-054 Final report, 3 October 2017.

Cato D.H., Noad, M.J., Dunlop R.A. and McCauley R.D. (2019), *Project BRAHSS: Behavioural Response of Australian Humpback Whales to Seismic Surveys Final Report.* OCS Study BOEM 2019-002, https://gis-server.intertek.com/JIP/DMS/ProjectReports/Cat3/JIP-Proj3.1.2_BRAHSS_final_report_2019.pdf

Clarke, P.A. and Jones, A.D., 2012 'Shallow water seafloor inversion using ship-generated striation patterns', *Proceedings, Acoustics 2012*, Fremantle 21-23 November.

CTBTO, 2008 'Two new IMS stations certified in Wyoming and Western Australia', https://www.ctbto.org/news-and-events/news/two-new-ims-stations-certified-wyoming-and-western-australia

Day, R.D., McCauley, R.D. Fitzgibbon, Q.P., Hartmann, K., Semmens, J.M. 2016, *Assessing the impact of marine seismic surveys on southeast Australian scallop and lobster fisheries*, Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, ISBN 978-0-646-95910-8.

Duncan, A.J., Shimizu, K., Parnum, I., MacLeod, R., Buchan, S. J., 2019 'Acoustic propagation in realistic 3D nonlinear internal waves', *Proceedings of Acoustics 2019*, Cape Schanck, Victoria, Australia, 10 – 13 November.

EPBCA 1999, *Environment Protection and Biodiversity Conservation Act, 1999*, Australian Government, https://www.legislation.gov.au/C2004A00485/latest/text

Erbe, C., and A. R. King. 2008. 'Automatic detection of marine mammals using information entropy.' *Journal of the Acoustical Society of America* 124 (5): 2833-2840.

Erbe, C. 2000. 'Detection of whale calls in noise: performance comparison between a beluga whale, human listeners, and a neural network..' *Journal of the Acoustical Society of America* 108 (1): 297-303.

Fewtrell J.L., McCauley R.D. (2012) Impact of air gun noise on the behaviour of marine fish and squid. *Marine Pollution Bulletin* 64 (2012) 984–993

Jensen, F.B., Kuperman, W.A., Porter, M.B., Schmidt, H. 2011, *Computational Ocean Acoustics*, 2nd Ed., Springer, ISBN 978-1-4419-8677-1

Jin, M., 2025 'An Application of Machine Learning to the Classification of Vessels Using Underwater Acoustic Sensor', *Proceedings Acoustics 2025* , Joondalup Resort, November 12 – 14.

Kuperman, A.A., Hodgkiss, W.S., Akal, T., Kim, S., Edelmann, G., Song, H.C. 'Time-Reversal Acoustics', *Proceedings, Acoustics 2000*, Joondalup Resort, Western Australia, 15-17 November 2000.

Li, B., Gavrilov, A.N. 2006 'Hydroacoustic Observation of Antarctic Ice Disintegration Events in the Indian Ocean', *First Australasian Acoustical Societies' Conference, Acoustics 2006: Noise of Progress,* pp 479-484, Christchurch New Zealand, 20-22 November 2006

Li, B., Gavrilov, A., Duncan, A.J. 2009 'Experimental observation of the frequency dependence of horizontal refraction effect on bearing estimation of hydroacoustic events', Australian Acoustical Society, in *Proceedings of Acoustics 2009 Annual Conference*, 23-25 November 2009, Adelaide, South Australia. ISBN 978-0-9757855-7-7.

Madhusudhana, S., A. Murray, and C. Erbe. 2020. ‘Automatic detectors for low-frequency vocalizations of Omura's whales, Balaenoptera omurai: A performance comparison’, *Journal of the Acoustical Society of America,* 147 (5)

Madhusudhana, S., A. Gavrilov, and C. Erbe. 2015. ‘Automatic detection of echolocation clicks based on a Gabor model of their waveform.’ *Journal of the Acoustical Society of America,* 137 (6): 3077-3086.

McCauley, R.D., Fewtrell, J., Duncan, A.J, Adhitya, A., 2002. Behavioural, physiological and pathological response of fishes to air-gun noise. *Bioacoustics* 12(2/3):318-321

Naffziger, S.; Koomey, J., 2016 ‘Energy Efficiency of Computing: What's Next?’. *Electronic Design*, November 29, 2016) https://www.electronicdesign.com/technologies/embedded/digital-ics/processors/microprocessors/article/21802037/energy-efficiency-of-computing-whats-next

NMFS. 2024. Update to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 3.0): Underwater and In Air Criteria for Onset of Auditory Injury and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA *Technical Memorandum NMFS-OPR-71*, 182 p.

Readhead, M.L., ‘Acoustic Daylight – Using ambient noise to see underwater’, *Proceedings, Acoustics 2000*, Joondalup Resort, Western Australia, 15-17 November 2000.

Sidenko, E., 2025 ‘Whale localisation and tracking using fibre-optic telecommunication cables on the Sunset Coast’*, Proceedings, Acoustics 2025*, Joondalup Resort, November 12 – 14.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, Jr., D. Kastak, D.R.Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals* 33:411-521.

Tary, J.B., Proveda, S.F., Li, K.L., Peirce, C., Hobbs, R.W., 2025, “Detection and localization of Bryde's whale calls using machine learning and probabilistic back-projection”, “*Journal of the Acoustical Society of America,* 158, pp. 1386-1397

Xenaki, Gerstoff, Williams, Abadi (2025) ‘Overview of distributed acoustic sensing: theory and ocean applications’, *J. Acoust. Soc. Am*., 158, pp. 801-825.