November 2015

#21

CMST News

The Newsletter of the Centre for Marine Science & Technology

30th Anniversary Edition

Welcome to CMST's 2015 newsletter. This is a very special year for us - we are 30 years old!

CMST was established in 1985, as part of the Western Australian Institute of Technology (WAIT), which a year later became Curtin University. We are Curtin's oldest research centre.

CMST creates marine-related research programs that are both innovative and applied. Australia has substantial offshore energy resources, a large fishing industry, a strong maritime defence sector, booming coastal and marine tourism—all overlapping with rich and often still pristine marine ecosystems. CMST is committed to the development of technologies and methodologies, as well as environmental monitoring programmes, for the sustainable development of our marine resources. Curtin University has significant capability and infrastructure in the field of marine research. CMST works closely with other centres and departments at Curtin, other Australian and international universities, and a wide variety of industry and government bodies, both here and overseas.

CMST's research is very much interdisciplinary. The Centre melds the skills of physicists, acousticians, biologists, ecologists, and engineers. CMST currently has 12 academic research staff, four technical and administrative support staff, and 20 PhD students. We also have a large and very dear community of true and trusted casual staff, on whose brains and hands we rely at busy times.

CMST is involved in many large, multi-year, collaborative, and—last but not least—fun projects. CMST built, and since 2009 has been maintaining, the Acoustic Observatories of Australia's Integrated Marine Observing System (IMOS; http://imos.org.au). In addition, industry and government have funded CMST to listen to the underwater soundscape on-and-off at over a hundred sites around our continent, accruing almost 5000 datasets in over 20 years. This data provides a record of the marine soundscape at these locations, and lets us monitor great whales on migration, observe seasonal fishes chorusing, study ocean weather, track anthropogenic activities and identify any long-term changes in the soundscape.

CMST staff are co-investigators in four Western Australian Marine Science Institute (WAMSI) projects within the Kimberley Science Node, studying marine mammals visually and acoustically,

Continued page 2

CMST'S VISION

Our vision is to operate as a Centre of Excellence in marine science and technology that is recognised locally and internationally for the relevance of its R&D outputs, the strengths of its strategic alliances, the quality of its graduates, and the responsible and ethical approach it takes to its staff and students.

CMST'S MISSION

Our mission is to serve the current and future needs of our customers (in industry, government, defence, not-for-profit organisations, and the community) through basic research as well as applied R&D in our core competencies in marine acoustics, hydrodynamics, and marine instrumentation. Our multi-disciplinary approach is central to CMST's mission.

Image: Iain Parnum

Continued from page 1, and seabed biodiversity and geomorphology using multibeam echo-sounders. We have also been studying the effects of seismic exploration on whales, turtles, fish, squid, lobsters, scallops, plankton etc., in collaboration with other Australian universities and funded by the offshore petroleum industry as well as the Fisheries Research and Development Corporation (FRDC).

A key area of expertise is the modelling of sound propagation under water. As the Australian marine acoustic environment is unique due to its acoustically dense calcareous seabed, CMST has had a continuous stream of sound propagation projects for industry and government, including several PhD theses.

CMST staff were key contributors to the Sydney-Kormoran Project, which conducted a detailed 3D imaging survey of the two World War II shipwrecks HMAS Sydney II and HSK Kormoran, which sank each other and are now located at a depth of 2500 m, 200 km off the WA coast. Several spin-off research projects on deep-sea marine biology and corrosion have resulted from this trip. A 3D exhibition is planned at the WA Museum and partner institutions.

CMST further specialises in modelling and measuring ship under-keel clearance, ship motions in waves and stability of offshore structures. CMST has developed guidelines for under-keel clearance in several ports and led an international benchmarking study on the accuracy of ship motion codes in shallow water, that confirmed our ship clearance modelling as world's-best practice.

There are many attests to the quality of our research. Several members of staff act as the Australian representatives on international committees to standardise underwater acoustic measurement, modelling and reporting. Some staff have won fellowships. Many students are supported by domestic and international, industry and government scholarships. The relevance of our research is manifested in the number of media interviews and reports—sometimes exceeding 100 per year.

We're living in interesting and challenging times currently with our economy slowing and government cutting funds. As a result, the academic sector has recently undergone great changes reshaping its academic staff portfolio as well as support services. For a self-funded research centre like CMST such changes are unsettling and challenging—at least temporarily until "the system regains homeostasis". CMST has sailed through turmoil in the past and always managed to arrive back in port—safe and sound with dry feet, ready to set sail again. What makes CMST special are its people and our unparalleled team spirit. I am both proud and humbled to be leading this exceptional team of staff and students.

Christine Erbe, Director CMST

Biology at CMST

In its early days, under John Penrose's leadership, CMST focussed on physics and engineering. It first became involved in the application of acoustics to marine biology in the late 1980s through Tim Pauly's work on the acoustic target strength of Antarctic krill. The first marine biologist, Rob McCauley, joined 20 years ago, specialising in bioacoustics. Aspects of biology permeated CMST's strong technical framework to form the basis of a highly technical biological stream. Early research included the first Australian study on responses of humpback whales to seismic surveys, collaborating with the Centre for Whale Research (CWR) and funded by the Australian Petroleum Production and Exploration Association (APPEA). Research on responses of fishes, turtles, and squid to seismic airguns were a world's first. These studies shaped guidelines for seismic operations around baleen whales, and were applied extensively to environmental impact assessments.

Other groundbreaking work included characterising the biological components of soundscapes, studying chorusing fish aggregations, and mapping migratory routes of baleen whales. The biological stream benefited greatly from Alec Duncan's underwater acoustic modelling expertise and Justy Siwabessy's expertise in acoustic habitat mapping.

In the early 2000's CMST expanded further in areas of marine mammal behaviour and ecological modelling with the arrival of Chandra Salgado Kent. Research on potential impacts of underwater noise grew further. Marine mammal research extended to dolphins and pinnipeds, resulting in assessments of human disturbance on endangered Australian sea lions and, in collaboration with CWR, population estimates of local humpback whales. Citizen science studies on marine mammal ecology also developed, collaborating with, amongst others, Swan River Trust, Murdoch University, Two Moons Whale and Marine Research Base, WAMSI, Deb Thiele, and Richard Campbell.

Sasha Gavrilov joined CMST and increasingly contributed to biological aspects of sea-noise analysis. Our database on Australia's marine soundscape grew steadily, now covering more than a decade, and long-term trends such as the downward trend in blue whale call frequencies became obvious. More recently, the biological stream grew into crustacea and fisheries. Matthew Legg developed statistical models for sounds produced by snapping shrimp. Following completion of their PhD's at CMST, Iain Parnum and Miles Parsons joined the team as staff members progressing active and passive acoustics research for the mapping of habitats and fish schools. In 2011, Christine Erbe arrived with a background in soundscape analysis and masking.

Our biological research now covers vocal behaviour of a plethora of mammal, fish, crustacean and even penguin species, and our biological sounds catalogue is continually growing. Darlene Ketten and Klaus Lucke are our most recent team members bringing expertise in sensory systems of marine fauna, hearing and hearing impairment. Last but not least, our marine biology stream has grown stronger and stronger thanks to its increasing number of highly skilled PhD students. Through strong teamwork CMST has been able to extend its technical capacity to biology and ecology, bringing innovative solutions to classical biological, ecological problems and growing into a world-renowned research centre, recognized for excellence in marine bioacoustics and acoustic ecology.

Chandra Salgado Kent, Deputy Director, CMST

A Short History of CMST

CMST originated with a fire and a group of staff at the then Western Australian Institute of Technology (WAIT). In the 1970s, staff members from Physics, Biology, Chemistry, Geology and Electrical Engineering formed a Marine Studies Group which carried out some small projects and ran a first year elective unit in marine science.

Photo: CMST Archives

WAIT Marine Studies Group started by Tom Docherty, John Penrose, Bob Kagi, Rob Rippingale, and Lindsay Collins. (John and Tom in photo).

The fire was important because just before it took place, John Penrose of Physics was working with John de Laeter, then Physics Head, on a project in mass spectrometry. One evening, the Mass Spec lab was gutted in a fire that put it out of action for two years. John set about building an ultrasonic diver communicator during this period, reflecting a long interest in sub-sea activities. This project in turn led to a substantial focus on marine acoustics. Shortly after John led a group of six WAIT staff and students in an expedition to the site of the 17th century wreck of the Batavia in the Abrolhos Islands, beginning a long period of engagement with the Western Australia Maritime Museum.

Photo: CMST Archives

CMST supported the "Taskforce 1987" syndicate headed by Parry Corporation in defence of the America's Cup with the 12 metre yacht "Kookaburra".

The mid 1980s saw a dramatic escalation of marine activity in Physics in particular. Kevin Parry, of the then Parry Corporation, and the then WAIT Director Don Watts, approached John Penrose with a proposal to create a Centre for Marine Science and Technology. This was formed in 1985 and was charged, in the first instance, with supporting the then defence of the America's Cup and a triple circumnavigation of the world to be undertaken by noted yachtsman Jon Sanders. Parry Corp provided five graduate scholarships of which one was taken up by Kim Klaka. Kim went on to become Director of CMST for many years and brought teaching and research in naval architecture to CMST. Jon Sanders succeeded in his triple, solo, non-stop circumnavigation during which, amongst other achievements, he made echo sounder records of a seamount in the South Pacific, predicted from satellite altimeter plots. His vessel, Parry Endeavour, is on display in the Fremantle Maritime Museum.

Photo: CMST Archives

Don Watts (WAIT) and Kevin Parry (Parry Corporation) at the launch of CMST in March 1985.

Photo: CMST Archives

Acoustic transducers on the hull of Jon Sander's vessel, the *Parry Endeavour.*

Kim led a bid by CMST to form a core partnership in the Australian Maritime Engineering Cooperative Research Centre (AMECRC), which for a six-year period involved CMST in collaborative research with institutions in three other Australian states. Later, CMST formed part of the Coastal CRC, to use its short form name. This too involved centres in other states. CMST was particularly involved in acoustic assessment of seabed characteristics. Rob McCauley brought a strong program of bioacoustics to CMST, a focus which has continued to expand now for some years.

Photo: Glen Lawson

Alec Duncan, John Penrose, Mal Perry and Bill Plumb work on ROV navigation and control systems at AME CRC.

The arrival of Christine Erbe as our latest Director has brought many new contacts, both for projects and graduate students, to the Centre. Christine is leading CMST at a time of great change within Curtin University and CMST is enmeshed with many of the changes emerging. Over the years, staff and students have been the brains of the Centre and it is difficult to name all who have contributed!

Photo: Andrew Woods

Launch of the Waterfront Research Facility in Fremantle 2007.

In addition to those who have already been noted, Alec Duncan and Andrew Woods merit special mention, as do Chandra Salgado-Kent, Sasha Gavilov, Iain Parnum, Miles Parsons, Tim Gourlay, Mal Perry, Ann Smith and others. My own impression is that CMST has been an outstanding enterprise to be part of, in terms of scientific productivity, project excitement and fellowship.

John Penrose, Founder CMST

A Brief History of Hydrodynamics at CMST 1984-2015

1984 - 1985

America's Cup Syndicate Taskforce '87 offers five Masters scholarships at CMST. Two of the scholarships are taken up for hydrodynamics projects (motions of yachts in waves).

1986

First short courses and 3rd year projects in naval architecture established (by Kim Klaka, one of the scholarship students).

1987

August 1987, the next America's Cup syndicate Taskforce '90 is established with Kim Klaka seconded from CMST as Technical Director. Masters student Gary Webb recruited to work in hydrodynamics.

October 1987, stock market crash. Syndicate dissolved. No income for hydrodynamics staff and students.

The cover of the 1986 WAIT student recruitment booklet featured the work CMST was performing for the America's Cup Kookaburra Campaign.

1987- 1992

Commercial hydrodynamics research portfolio establishing by knocking on the doors of industry. Biggest contract, predicting vessel motions at the new ship-lift facility in Henderson, was the result of a misdirected invoice (a story for another time!). Ship Science stream of BSc multi-disciplinary science established by CMST hydrodynamics staff.

1992 - 1999

CMST instrumental in establishing the Australian Maritime Engineering CRC, a partnership of 26 industry, government and academic partners. CMST became the Perth node with focus on ship motions, yacht design and underwater vehicle performance (other three nodes were Monash in Melbourne, AMC in Launceston and UNSW in Sydney).

First ARC collaborative research grant in hydrodynamics won by CMST, for ship motion control research.

AMECRC Perth node (CMST) wins contract to develop motion control system "Ocean Leveller" for Austal Ships catamaran ferries. The system was fitted to 23 vessels around the world, representing an export value of more than $400M. The project was identified as an exemplar of innovation in the 1995 Federal R&D budget statement, and a presentation of the project was made to the Prime Minister at Parliament House, Canberra by Alan Haywood.

CMST staff working in hydrodynamics include Baz Binkhorst, Pat Couser, Les Denison, Alan Haywood, Kim Klaka, Amos Maggi, Mal Perry, Bill Plumb, Ann Smith and Giles Thomas. Postgraduate students in hydrodynamics include Jonathan Binns, Joshua Boyd, Stephen Cook, Dougal Harris, Jan Krasnodebski, Javier Pereira, Rick Shock and Dave Sterling.

Eight metre research catamaran "Educat" built and jointly operated with Fremantle TAFE. "Seakeeper" ship motions software was written as part of the *Maxsurf* marine software suite.

1999 - 2002

Closure of AMECRC means CMST hydrodynamics reverts to commercial research for its income. Collaboration program set up with Marintek Norway. CMST commissioned by WA Government to conduct major feasibility study into establishing an $80M ocean wave basin in Perth. $30M secured – not enough!

2002 - 2003

More research in cargo ship hydrodynamics, with arrival of Tim Gourlay. Accident investigations into the groundings of Jody F Millennium, Capella Voyager and Eastern Honor in New Zealand.

Several full-scale seakeeping trials for Tenix patrol boats and local crayboats.

2004

CMST student project on gyroscopes by Colin Ayres leads to the founding of "Sea Gyro", a company which manufactures gyroscopes for boat roll reduction.

2005 - 2009

Ship under-keel clearance (UKC) work: full-scale trials in Hong Kong and Torres Strait (Mal Perry); channel design for Albany; developing "KeelClear" UKC software for Torres Strait (Amos Maggi).

New "waterfront facility" at Fremantle Sailing Club strengthens racing dinghy research. General decline in WA shipbuilding and hence seakeeping trials work.

2010

Measuring boat wakes and wind waves on the Swan River to assess shoreline erosion. Speed limits subsequently changed along much of the Swan River. Daniel Veen completes his PhD on ship slamming.

2011 - 2012

Development of CMST in-house software for hydrodynamics work: "ShallowFlow" for cargo ships in shallow water; and "HullWave" for near-surface submarines. Kim Klaka retires from CMST.

2013 - 2015

CMST participates in Duisburg international blind benchmarking study for ship sinkage and trim, and leads international benchmarking study into ship wave-induced motions in shallow water. Validation of CMST's UKC modelling as world's-best practice helps us win UKC work for Gorgon LNG terminal and New Zealand ports. Increasing work in ship mooring analysis, including effects of swell, long waves, passing ships, current and wind.

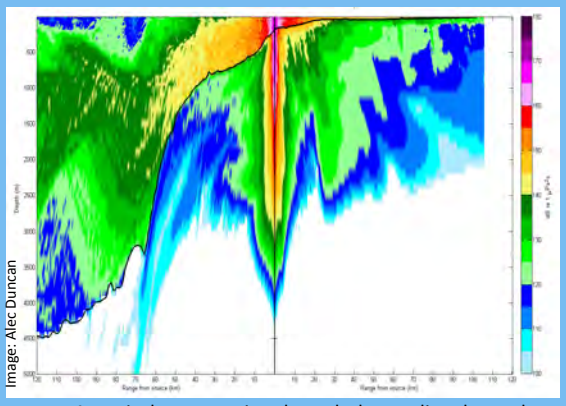
Random and enjoyable small hydrodynamics projects continue, including powered surfboards, flyboards, jetskis.

New postgraduate students Scott Ha and Mark Gooderham help continue CMST's research in shallow-water ship hydrodynamics.

Kim Klaka, former Director CMST, and Tim Gourlay

CMST Research Spotlight: Underwater Acoustic Propagation Modelling

CMST is very active in the field of underwater acoustic propagation modelling, which is used for the prediction of the characteristics of the sound received from a wide variety of acoustic sources, both natural and man-made. In some cases the characteristics of the sound source are well known, and the main complexity is in the way the sound travels through the ocean and in its interaction with the seabed. In other cases the prediction of the acoustic output of the source itself is a very difficult problem. Research work CMST is currently undertaking in this area includes developing acoustic propagation models that can accurately deal with the hard, calcaranite seabeds that are common around the Australian continental shelf, and developing accurate models of sound radiation from pile driving and coupling the resulting field to a long-range propagation model. CMST also routinely carries out underwater sound level predictions for industry as part of environmental impact assessments.



A vertical cross section through the predicted sound field, with the seismic source at the centre.

Alec Duncan

An Insider's Recollection: Development of CMST's Sea-noise Logger Capacity

CMST has studied sea-noise since the late 1980s. In those days the most common method of obtaining recordings was to hang a hydrophone over the side of a vessel, attach it to a pre-amplifier and a then top-of-the-range recorder. We first had reel-to-reel tape decks, which were quickly replaced by good quality cassette tape decks with their reliable 90 minute recording time, then digital tape decks allowing huge two-hour recordings. These were fitted into housings with fancy ways of turning on and off, so we could eke several days of recordings from our few hours of tape available. These prototype loggers were deployed pre GPS age, so a field trip also involved much radar, hand bearing compass and chart work. Recovery trips were a nervous affair: "Can anyone see a buoy?"

In the late 1990's electronic hardware developed rapidly. We heard of a prototype sea-noise logger built in Canada and bought one. After fighting with SCSI hard drives, UNIX systems, obscure data formats and little programming flexibility, we decided to build our own. The Defence Science and Technology Organisation (DSTO) provided gratefully received seed funding. Alec Duncan designed the electronics, but we also needed someone to build and make it a reality: Frank Thomas, an electronic engineer, did a terrific job of building an electronic and mechanical system that remains the most reliable, flexible and accurate sea-noise logging system we know of. In 2001, we had our first trial of the system. Three loggers went into the river, came out and...no data. We had used underwater connectors to plug the hydrophones in. But if left in the sun, they accumulated static charge, which promptly blew the preamp. Diode protection fixed that. We then ran into the next problem with these high-quality, costly connectors. They developed very slight leaks over time, affecting the electronics and resulting in gradual signal loss. Solution: hard-wire the hydrophones to the end caps. Our thanks to all the industry supporters whom had to wear us finding this out.

In 2002 the sea-noise loggers were ready, we thought, to tackle the deep ocean, so we began a program funded by Australian Defence in the Perth Canyon. We perused the available acoustic releases, naively believed the specification sheets, bought several and deployed them with loggers in 400-500 m water depth. All failed. We embarked on a 24-hour tug charter with a giant 18th century anchor arrangement towed with a km of wire which we also had to buy (and which the tug owner thankfully kept). After a night of rolling around, all loggers were recovered, came back in, and voila! another fault, this time with the processor. So instead of three months data, we had three days. A low point in CMST sea-noise logger work! The manufacturers fixed the problem.

After several years of trial and tribulation, we overcame all of these teething problems. Today the CMST sea-noise loggers remain un-paralleled in their calibration capability, flexibility and data quality. We have made many hundreds of long-term recordings around Australia from the Swan River to 1100 m depth off Antarctica with an excellent track record and reliability. We have built a massive archive of Australian sea noise - an invaluable legacy. Unimaginable in the 90-minute tape deck days. We are indebted to the many sponsors of our sea-noise research. Without your support we would never have made it!

Rob McCauley

Photo: Dave Minchin

Sarah Marley and Les Denison work on a noise logger.

Ship Motion Trials in Geraldton

Photo: Tim Gourlay

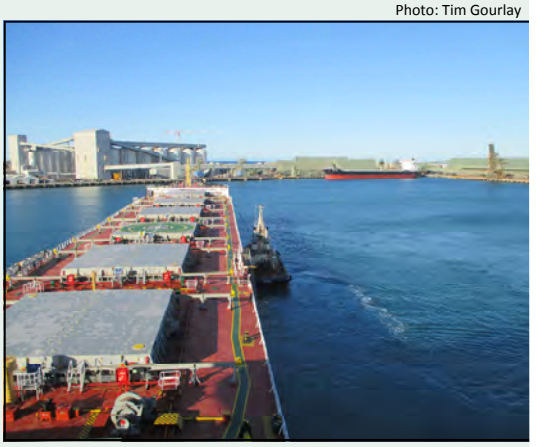


Photo: Tim Gourlay

CMST is currently conducting a set of trials to measure ship motions in the Port of Geraldton approach channel and harbour. The research is being done in conjunction with Mid West Ports and Curtin's GNSS Research Group. It will form part of Scott Ha's PhD thesis on ships in navigation channels. Geraldton is exposed to long-period ocean swells, which cause wave-induced motions of ships in the channel and harbour. High-accuracy dual-frequency GPS receivers are being used to measure the motions, and the results will be used to validate CMST's in-house and third-party ship hydrodynamics software.

Tim Gourlay

Photo: Tim Gourlay

Scott Ha (right) aboard three vessels (all images) in and around Geraldton Harbour.

FMBEM Modelling of Underwater Sound Scattering

Daniel Wilkes and Alec Duncan have recently published a paper in *The Journal of the Acoustical Society of America* (http://dx.doi.org/10.1121/1.4916603) detailing a newly developed Fast Multipole Boundary Element Method (FMBEM) model for modelling acoustic radiation and scattering from underwater objects. The 'Unified FMBEM' model operates 120x faster than the example reference model, using 10x less computer memory. It uses a boundary-only numerical model to present both the exterior fluid and interior elastic solid regions, and accelerates the numerical solution in both domains using the Fast Multipole Method. This approach allows for the acoustic field scattered or radiated from a submerged elastic solid object to be solved with a reduced computational cost compared to the standard finite element-boundary element models typically used for this type of analysis. Current work is focused on extending this model to a unified 'broadband' FMBEM which can solve large-scale numerical models at higher frequencies.

Daniel Wilkes and Alec Duncan

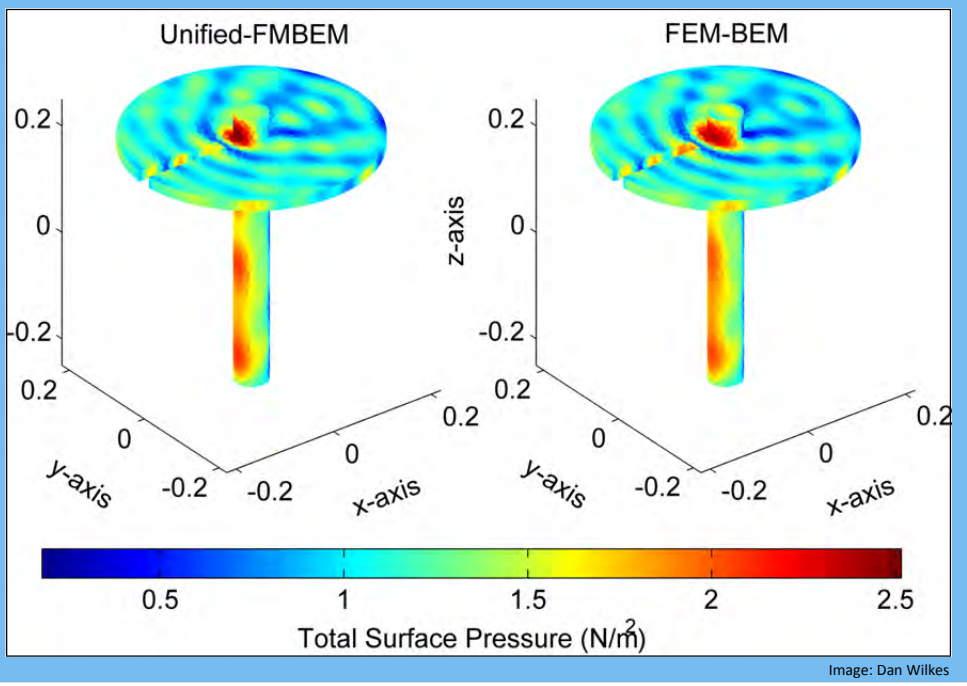


Image: Dan Wilkes

Left: Comparison of acoustic scattering results for the unified FMBEM and a reference numerical model (PAFEC-FE software).

The Wheatstone Passive Acoustic Monitoring Project: an Update

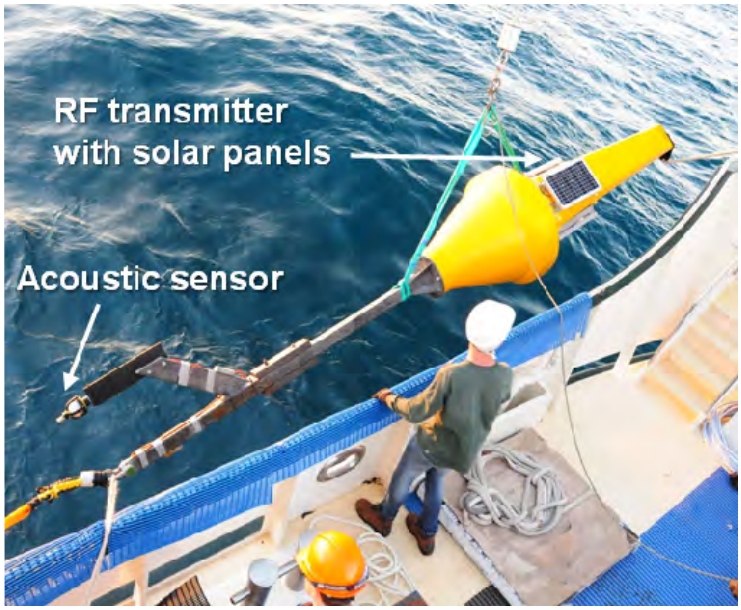
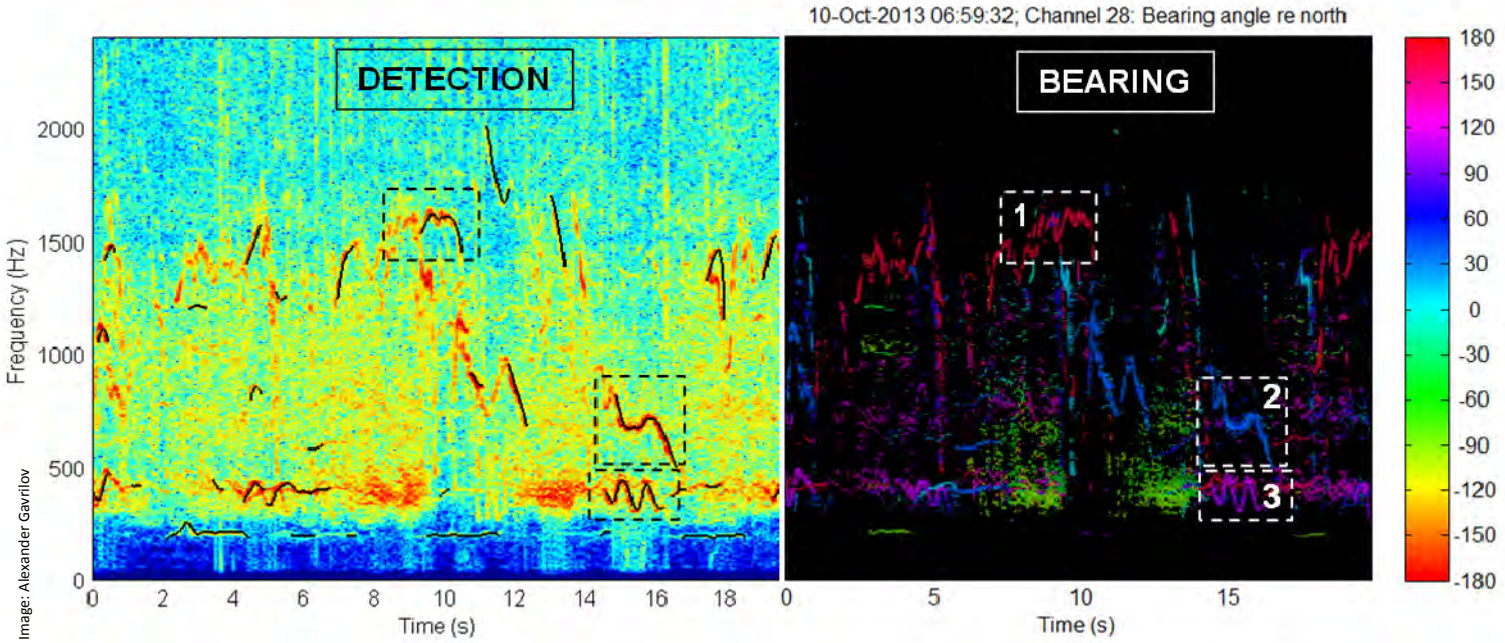


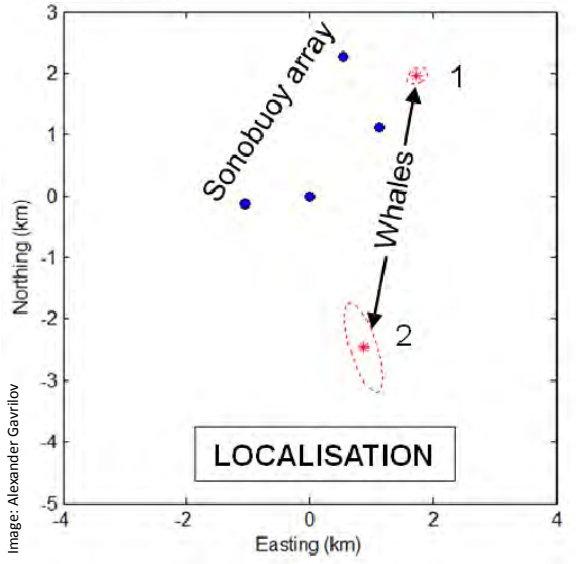
Photo: Alexander Gavrilov

L3 Oceania's acoustic buoy with a mooring line prepared for deployment.

Exmouth Gulf and the coastal shelf north of it are known as winter resting grounds for the Western Australian population of humpback whales that visit this area from early June to late October. Effective means are needed to prevent potential physiological and behavioural impacts on humpback whales from various offshore operations related to oil and gas exploration and production and the construction of associated port infrastructure in this region. Chevron Australia commissioned a research project through the Western Australian Energy Research Alliance to examine the efficiency of a passive acoustic monitoring system to detect and localise humpback whales approaching the area of the offshore activities associated with the Wheatstone LNG project. The project was carried out by CMST and L3 Oceania. CMST developed methods for the automatic detection and localisation of vocalising whales. L3 Oceania designed and built autonomous acoustic buoys equipped with directional acoustic sensors and a radio transmitter to provide real-time collection and analysis of acoustic data. With the help of the Centre for Whale Research a sparse array of moored acoustic buoys was deployed in the trial area off Onslow. Drifting DIFAR sonobuoys were also used for testing the monitoring system in the trial area and in Exmouth Gulf. Acoustic monitoring was accompanied by visual sightings. The prototype system demonstrated the detection range from about 10 km to 15 km depending on background noise. The localisation accuracy was determined using bearing data from the DIFAR sensors. Some new types of sound from humpback whales were discovered. It was also observed that pods of cow and calf stayed silent most of the time; however, they were often escorted by vocalising male whales, which increased the probability of tracking whale pods in the monitored area.



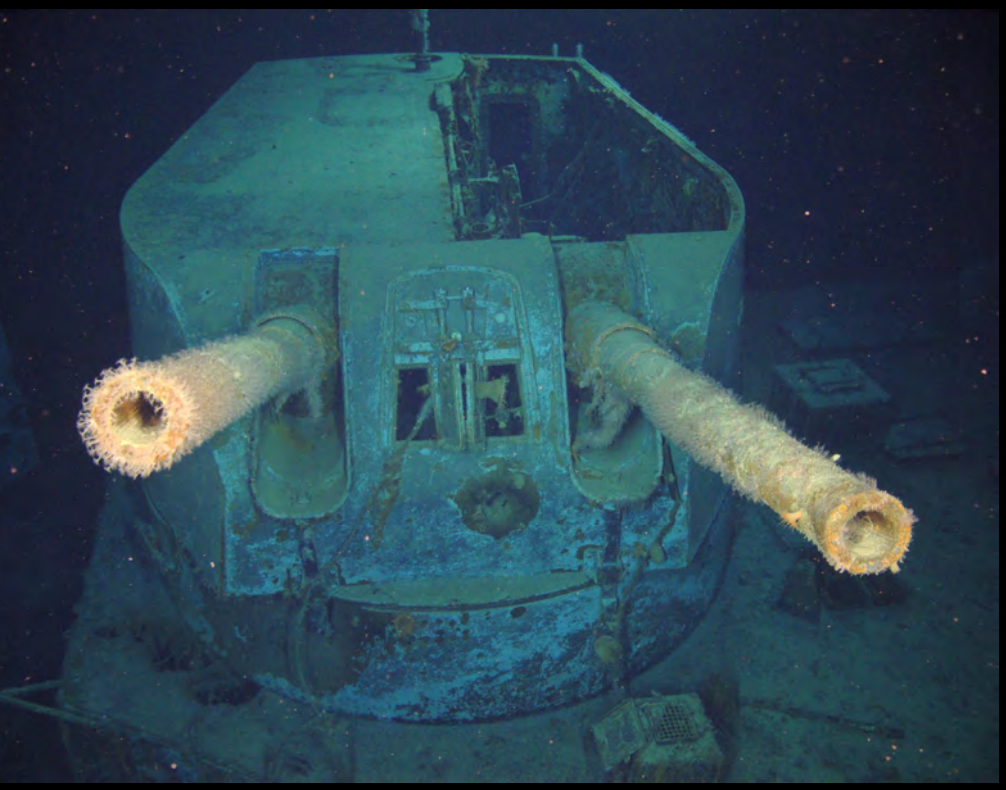
Above: Spectrogram of sea noise containing multiple calls from humpback whales identified by the automatic detector (left) with bearings taken from one of the acoustic buoys (right).



Two vocalising whales detected and localised from an array of four acoustic buoys.

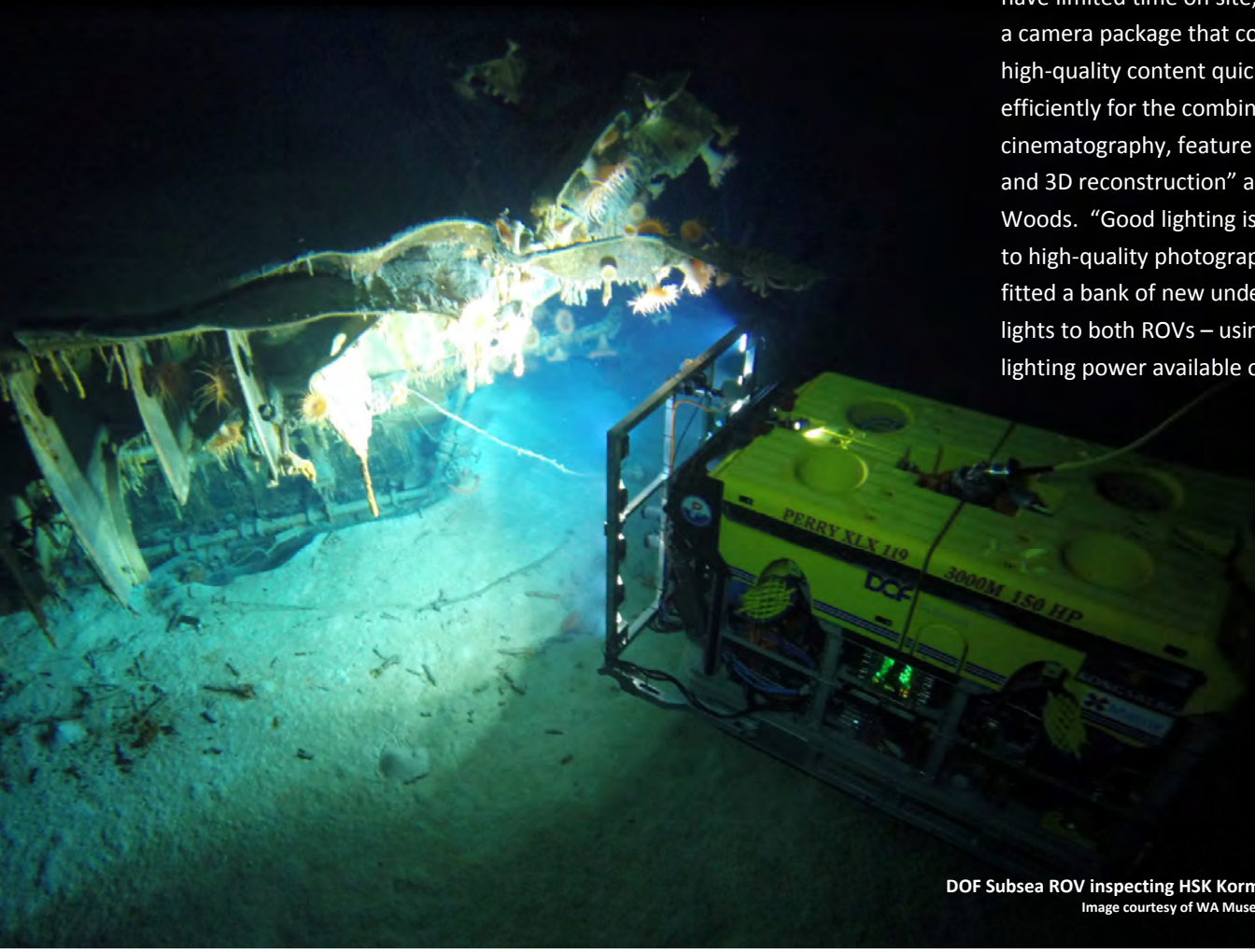
Sasha Gavrilov

3D Images Preserve HMAS Sydney



HMAS Sydney (II) damaged 'B' Turret.
Image Courtesy of WA Museum and Curtin University.
Copyright WA Museum

After four years of preparation, in April/ May this year a team from Curtin University, the WA Museum and DOF Subsea conducted a detailed 3D imaging survey of the wrecks of the HMAS Sydney (II) and HSK Kormoran. The two ships sank on 19th November 1941, in the midst of World War II, and have sat at the bottom of the ocean for over 70 years. Over a period of four days of diving, two Underwater Remotely Operated Vehicles (ROVs) were deployed from the DOF vessel Skandi Protector to collect hundreds of thousands of digital still images and hundreds of hours of HD video of the main wrecks, the extensive debris fields and the surrounding environment. The design, integration and testing of the specialised lighting and camera system that was deployed on the two ROVs was led by CMST Research Engineer Dr Andrew Woods. "We knew we would have limited time on site, so we wanted a camera package that could collect high-quality content quickly and efficiently for the combined purposes of cinematography, feature photography and 3D reconstruction" advised Dr Woods. "Good lighting is absolutely key to high-quality photography, so we fitted a bank of new underwater LED lights to both ROVs – using all the lighting power available on each ROV.



DOF Subsea ROV inspecting HSK Kormoran engine room.
Image courtesy of WA Museum and Curtin University.
Copyright WA Museum

The camera system consisted of an array of seven digital still cameras (including a 3D pair) all capturing photographs every five seconds, along with two 3D high-definition video cameras fitted to a pan and tilt. Both ROVs were fitted with a similar system to provide redundancy and also allow the site to be surveyed quickly and efficiently."

Stereoscopic 3D photography and videography and 3D reconstruction were key technologies used on the mission. CMST has been developing underwater 3D cameras for over 20 years so this project was a perfect opportunity to capture compelling and visually rich 3D footage of a nationally significant heritage-listed site. 3D reconstruction is a relatively new technique which allows digital 3D models of real-world objects to be generated from a series of 2D photographs. Additionally, the mission used a multi-beam sonar to map the wrecks and a series of scientific samples were also collected (including rusticles) which will further the understanding of the site.

The project was a massive effort, with an impressive list of sponsors, supporters and suppliers contributing to the project. Companies servicing the oil and gas industry were particularly generous including Kongsberg Maritime Camera Division (UK), Matrix Composites, Teledyne Bowtech (UK), IFAP, Ashtead Technology (UK), RTS (Norway), DSM Consultants, SubC Imaging (Canada), Seatronics (UK), Oil Equipment, Specialist Offshore Services, and many more. We are hopeful that the equipment set that we have developed for this project will be used on future projects. The project is multidisciplinary in nature and at Curtin involves researchers from a number of areas including Design and Art, Curtin HIVE, Spatial Sciences, Environment, and Corrosion Engineering as well as CMST.

The Kormoran 15cm 'Linda' gun.
Image courtesy of WA Museum and Curtin University.
Copyright WA Museum

The expedition was blessed with good weather and amazingly clear water during the dives. "We have collected a rich archive of content which will serve as an important resource for many years to come" noted Woods. The wrecks are eventually going to be absorbed by the ocean – the wooden ship's boats for example are already starting to collapse. One of the aims of the expedition was to provide the WA Museum with baseline and comparative data to help inform a heritage management plan for the sites, as the Museum is responsible for their management and protection under Commonwealth legislation.

Another important output of the project will be exhibitions at the WA Museum and partner institutions. The 3D reconstruction models, being processed at the Pawsey Supercomputing Centre, will offer a range of experience options including immersive virtual environments and 3D printing of physical artefact reproductions. Local Fremantle TV production company Prospero Productions, with CMST graduate Ed Punchard as their Joint Managing Director, are producing a documentary feature about the project and the preview footage we have seen on the large 3D projection screen looks amazing.

The project team gratefully acknowledges financial support from the Commonwealth Department of the Environment, GMA Garnet Group, the WA Museum Foundation and Curtin University.

DOF Subsea ROV with custom lighting and camera frame attached. Photo: Joshua Hollick

Orcas Ahoi!

Photo: Leila Fouda

CMST's *Team Orca* has spent three seasons with Australia's top marine predator, the killer whale (*Orcinus orca*), in the Bremer Canyon during the summers of 2014 and 2015, and off Ningaloo Reef during the winter of 2015. The team is developing both a photo-ID catalogue and a catalogue of sounds emitted by killer whales to study their abundance, movement, behaviour, within-group associations, and acoustic ecology. Killer whales were observed preying on beaked whales in both seasons in the Bremer Canyon, and on humpback whale calves off Ningaloo. A description of the calls emitted by Bremer killer whales has just been published in *PLOS ONE*: http://dx.plos.org/10.1371/journal.pone.0136535

Christine Erbe

Seafloor Mapping in the Kimberley

CMST have been carrying out multi-beam surveys in northwest Australia, as part of two WAMSI Kimberley Research Projects. One, led by the Australian Institute of Marine Science (AIMS), is investigating seabed biodiversity, for which data collected by AIMS, CMST and CSIRO, will be analysed by CMST's Iain Parnum. This study will provide much need improved bathymetry for Camden Sound and good insights into the kinds of underwater terrain and ecosystems. The second is part of a WAMSI Kimberley project being led by Curtin's Applied Geology and Environment and Agriculture Departments, investigating reef evolution and growth in the Kimberley.

Iain Parnum

Photo: Mick O'Leary

CMST's Iain Parnum running the Odom ES3 multi-beam echo-sounder in the Kimberley.

Sonar Imaging Tools

As part of on-going research, CMST has developed Matlab-based software tools for visualisation and analysis of water column data from various single- and multi-beam sonar systems. These tools have been used for a variety of studies, including: shark detection, fish school assessment, canopy height monitoring and gas seep detection. These tools are available on request. *Iain Parnum*

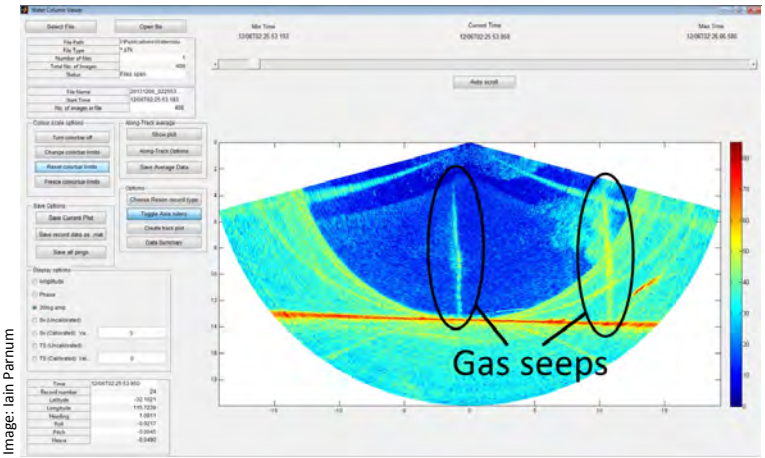


Image: Iain Parnum

WCV reviewing Reson 7125 data collected over a gas seep.

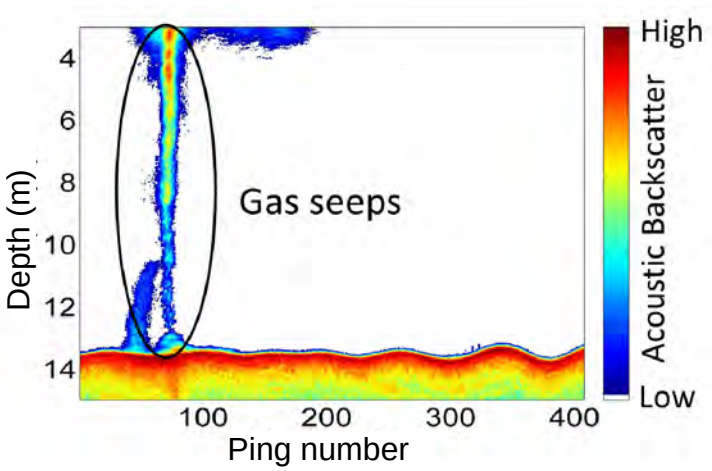


Image: Iain Parnum

Along track representation of watercolumn data collected over a gas seep.

The Underwater Soundscape of the Perth Canyon

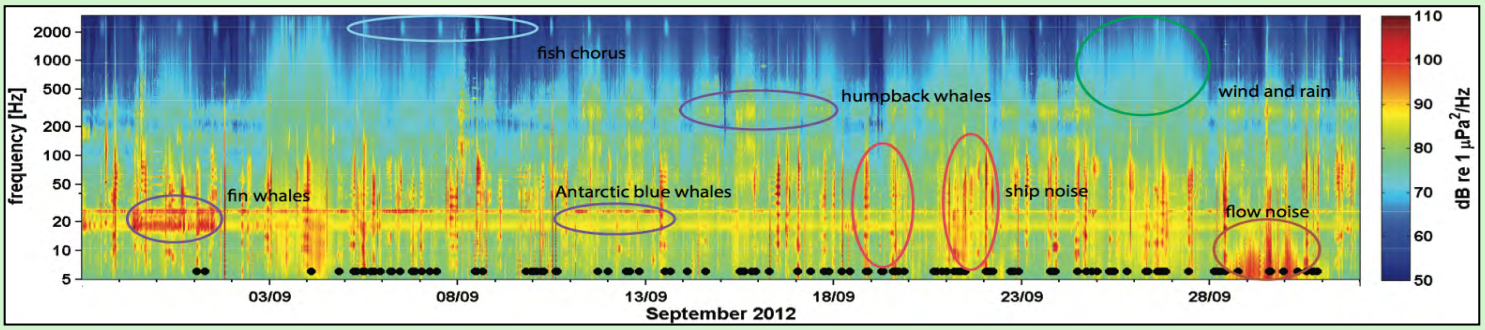


Image: Arti Verma

Spectrogram of underwater sounds recorded in the Perth Canyon highlighting biotic and abiotic contributors. The black dots at the bottom represent times when very large vessels headed for the Port of Fremantle.

CMST has been monitoring ambient noise in the Perth Canyon at 500 m depth since 2009 as part of IMOS. The Perth Canyon is a submarine canyon that was carved by the Swan River during the Tertiary period, when the sea level was much lower. It is up to 5 km deep in places and as long and wide as the Grand Canyon in the U.S.—but ours is filled with water and hence rich in marine life. We monitor humpback whales, minke whales, fin and blue whales on their seasonal migrations into and out of the canyon, chorusing fish aggregations, offshore weather, and vessel traffic. The study was recently published in *Progress in Oceanography*: http://dx.doi.org/10.1016/j.pocean.2015.05.015

Christine Erbe

Quiet(er) Marine Protected Areas

CMST recently collaborated on a study to map ship noise off Canada for marine spatial planning. The noise map was "filtered" with the hearing curves (audiograms) of 11 resident marine mammal species (whales, dolphins, porpoises, seals, sea lions) so that it was relevant or meaningful for each species. The noise maps were then correlated with animal distribution and density maps from line-transect surveys, to identify areas with overlap (many animals and much noise) and without (many animals but no noise). Marine spatial planning typically focusses on the overlap, i.e. "risk" sites, where the environment is already stressed. But we don't often take a step back and conserve the "opportunity" sites. www.sciencedirect.com/science/article/pii/S0025326X1530028X

Christine Erbe

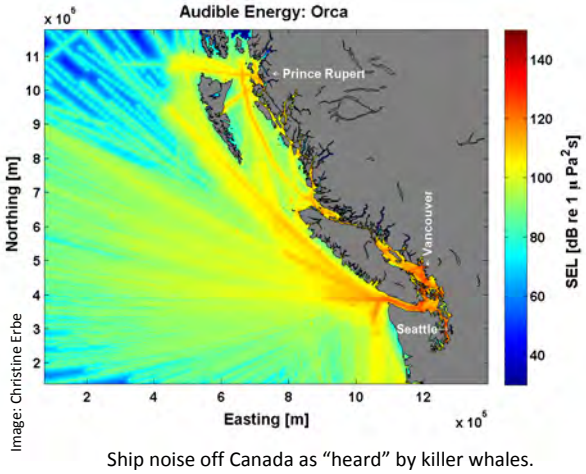


Image: Christine Erbe

Ship noise off Canada as "heard" by killer whales.

Where are they now? CMST's ex-student roundup!

Name: Daniel Veen
Years at CMST: 2005-2010
Current position and organisation: Senior Software Developer, Offshore and Marine, Bentley Systems
Some highlights of your career since CMST: Two years working on a variety of aerospace projects with SCITEK Consultants in Derby, UK. These projects included a noise evaluation of a Rolls-Royce Trent 1000 jet engine, research on alternative fuel technologies for power generation and the development of a new fuel injector spray characterisation facility for Rolls-Royce. Currently working as a developer with the Offshore and Marine group at Bentley Systems. This involves maintaining and adding new capabilities to our MOSES offshore analysis software.
Best memory of CMST: The staff and students, they made CMST a great place to learn.

Name: Grant Pusey
Years at CMST: 2008-2011
Current position and organisation: Science Teacher at Churchlands Senior High School
Some highlights of your career since CMST: Working in Hawaii for 18 months and going diving every week. Chasing down drifting buoys in the North-west Australian coast. Working in countries like Malaysia, Italy and Ireland.
Best memory of CMST: Going to the Arctic and seeing polar bears!

Name: Greg Bush
Years at CMST: 1986-1989, 1993-1997
Current position and organisation: General Manager for RPS MetOcean Pty Ltd
Some highlights of your career since CMST: RPS does some pretty cool stuff: world leading technology, building current meters and met buoys, tropical cyclone modelling, internal wave modelling…
Best memory of CMST: After 4 years working, I was back with CMST doing a PhD on the Upward Looking Sonar project, which included the "once in a lifetime experience" of Winter and Summer voyages to Antarctica!

Current CMST Students and their Projects

Photo: Sonia Pilkington

Front row: Leila Fouda, Monserrat Landero, Rebecca Wellard; Middle row: Matthew Koessler, Sarah Marley, Angela Recalde-Salas, Arti Verma
Back Row: Jamie McWilliam, Michael Bittle, Marta Galindo Romero, Scott Ha.

Michael Caley: *Development of a dynamic underwater acoustic communication channel simulator to explore transient wide-band signal distortion with configurable sea surface parameters*

Michael Caley is currently undertaking a PhD project developing a simulator to generate realistic transient distortion of transmitted underwater acoustic data signals. The focus is the real-time transient sound interaction of broad-band acoustic signals with the underside of the moving sea surface. At-sea acoustic channel probing experiments have been conducted in 14 and 50 m deep environments, over ranges of 100 to 10,000 m to assist with performance evaluation. The simulator will be used to improve the design of signalling strategies and hardware for point-to-point underwater acoustic data communication systems. The project is financially supported by an ARC Discovery Grant and L3-Oceania.

Capri Joliffe: *Working towards understanding the calling behaviour of the eastern Indian Ocean Pygmy Blue Whale and how their calling can be used to census the population*

Capri is studying the calling behaviour of pygmy blue whales and the potential for acoustic detections to be used to census a population. Her research focuses on identifying individual variations in song pattern and using arrays of passive acoustic sensors to track animals in the immediate vicinity of the acoustic sensors. This data will be combined with information gathered on the calling behaviour of pygmy blue whales in the Perth canyon to derive an abundance estimate for the population. The research aims to define methods for measuring abundance in marine mammal populations from passive acoustic detections alone.

Rebecca Wellard: *The bioacoustics of killer whales (Orcinus orca) in Australian waters and the acoustic environment of which they reside*

Bec's PhD project aims to improve our understanding of the killer whale population in the Australian region by using non-invasive techniques such as passive acoustic monitoring. This study aims to provide the first quantitative assessment of the acoustic features of killer whale vocalisations in Australian waters and the sound environment in which they reside. The project presents an opportunity to further investigate this little-known population of a data deficient species. Results from this study will provide pertinent data to help in assessing the population status of this species and deliver key scientific information, such as population dynamics and critical habitats, for guiding and assisting population management of killer whales found in Australian waters.

Claire Charlton: *Southern right whale population demographics and recovery in South Australia*

The Great Australian Bight Right Whale Study has been completed annually at Australia's largest breeding aggregation ground for southern right whales at the Head of Bight in the Great Australian Bight (GAB) Marine Reserve since 1991. The study provides valuable baseline information on population trends and recovery of the species for conservation management. Southern right whales are listed under the EPBC Act as endangered and migratory and are a matter of national environmental significance, after severe depletion from whaling in the 18th and 19th centuries. The GAB right whale study researches the abundance, distribution, life histories and movements of southern right whales in the GAB through vessel and cliff based research at the Head of Bight and Fowlers Bay aggregation areas. Study methods include photo identification, population census and underwater acoustics. The study provides a robust baseline understanding of the population status, natural variation in abundance and recovery, and allows for future impact assessment.

Photo: Claire Charlton

Southern Right Whale female and calf pair. Photo taken by Claire in 2010 at Head of Bight in the sanctuary zone of the Great Australian Bight Marine Park.

Sue Mason: *Spatial range, social structure and behaviour of 'resident' short beaked common dolphins (Delphinus delphis) in Port Phillip, Victoria: considerations for their future management and conservation*

Suzanne is investigating the residency status and behaviour of short-beaked common dolphins along the eastern coastline of Port Phillip. Due to their close proximity to the coast, Sue has used a theodolite in land-based surveys and the cetacean tracking program VADAR, written by Dr Eric Kniest from the University of Newcastle, to record dolphin behaviour. She has also completed vessel-based surveys to identify the individuals and determine social structure. This information will help inform Victorian wildlife managers of the threats to the community in the hope that they can be reduced.

Marta Galindo Romero: *Spatial variations in the peak pressure of low frequency impulsive signals propagated in range-dependent environments*

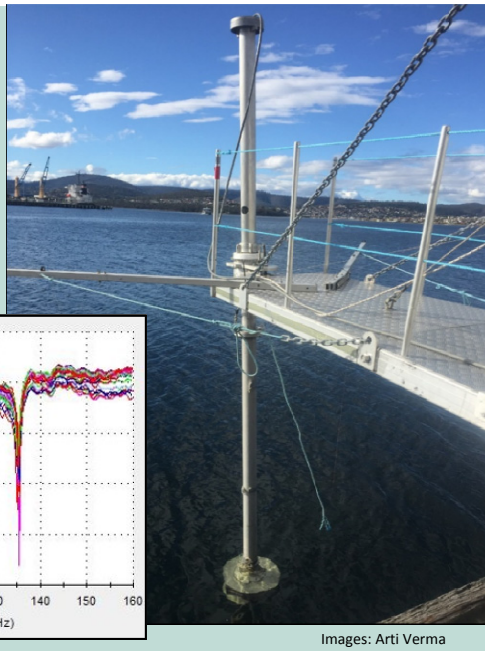
Marta is studying attenuation of the peak pressure of underwater transient sounds propagated in range dependent environments. The goal is to develop a method to predict the peak pressure as a function of acoustic source parameters, environment and range from the source, or the probability of exceeding a certain threshold, so it can be used in the context of assessment of potential impacts of man-made impulsive underwater noise on marine fauna.

Angela Recalde-Salas: *Variability of baleen whale acoustical ecology: implications for optimal monitoring and conservation planning using passive acoustics*

Angela is looking at variability of acoustical ecology of baleen whales (blue, humpback and right whales) in different areas in Western Australia, and how the information obtained using passive acoustic methods can be used for conservation. She will be specifically looking at estimation of vocalisation rates and how such rates might vary under different environmental, anthropogenic, ecological and behavioural conditions. This information will then be used to estimate the detection probability of baleen whales in different areas under different underwater noise conditions and to develop guidelines and strategies for optimal monitoring and conservation planning using passive acoustics.

Arti Verma: *Development of wideband acoustic classification techniques for mesopelagic micronekton*

Use of Frequency Modulated acoustic signals for remote classification and detection of pelagic species offers the advantage of improved spatial and range resolution in addition to better signal-to-noise ratio, enabling species identification through their acoustic signatures. In collaboration with the Great Australian Bight Research Program (GAB), Arti is working to simulate and design an acoustic based numerical model to solve the forward scattering problem. Simulation outcomes will be compared with empirical data collected by advanced optical sensors and wideband acoustic techniques providing improved quantitative information about the distribution of pelagic species in the GAB region. The ultimate aim is to acoustically and remotely classify species using only the acoustic signals.



Right: Experimental setup for calibration of the wideband echosounder EK80 (right), broadband (95–160 kHz) frequency response from a calibration sphere with outline of a numerical model (left).

Images: Arti Verma

Current Student Projects continued.../

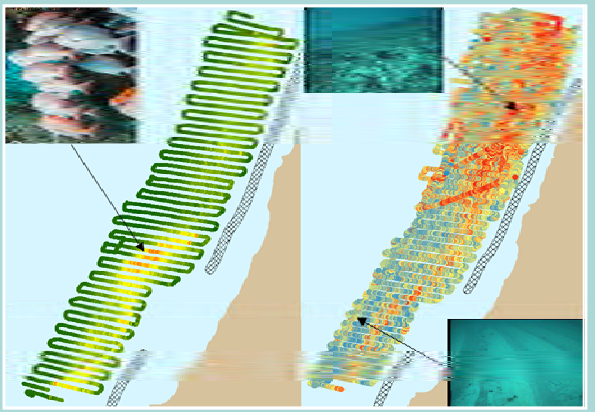


Image: Monserrat Landero

Monserrat Landero: *Using underwater acoustic data to predict distribution of demersal fish in northwest Australia*

Montserrat is using active acoustic data to characterise the seafloor and the organisms in areas of northwest Australia. In acoustics, the amount of energy reflected by the seafloor provides information on different types of substrate e.g. hard bottom vs. soft bottom. Morphometric and energetic descriptors of biomass in the water column help differentiate between major groups of organisms and can be used to produce maps of biomass present over different strata. Montserrat will be using this relationship of demersal fish biomass and seafloor characteristics to produce maps of potential distribution for important species of demersal fish.

Left: Example of spatial distribution of water column (left image, areas of high backscatter in red and low in green) and seafloor backscatter (right image, areas of high backscatter in red and low in blue, representing different substrates) in an area of the Ningaloo Marine Park.

Jamie McWilliam: *The pulse of a coral reef: Using acoustic survey as a tool for monitoring coral reef ecosystems in a changing climate*

The aim of Jamie's research is to investigate the ecological importance of soundscapes in coastal marine ecosystems. This fieldwork is being conducted at Lizard Island, in the Great Barrier Reef, with the aim of determining how fish choruses can be used to develop our understanding of coral reef systems and improve our current monitoring and management initiatives.

Sven Gastauer: *An ecosystem approach to the acoustic assessment of the Northern Demersal Scalefish Fishery Distribution - habitat and abundance*

Sven is conducting a fisheries acoustic study on the distribution of fish resources within the Northern Demersal Scalefish Fishery. Working towards abundance estimates, he is taking *in-* and *ex-situ* target strength measurements and combining results with predicted scattering characteristics, based on Computerised Tomography scans. Applying Bayesian and geostatistical parameter calibrations and uncertainty estimates can improve target strength, distribution, and abundance estimates. This is providing significant insights into the species-specific backscattering properties of fish in the area of interest. Sven is then using this knowledge to investigate species distribution and abundance within the fishery.

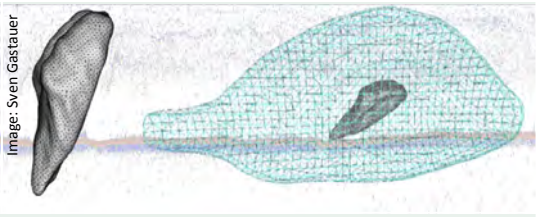


Image: Sven Gastauer

3D mesh of scanned Red Emperor, including swimbladder (right), and magnified swimbladder, the main backscattering element of the fish (left).

Matthew W Koessler: *Sound propagation modelling of acoustic-elastic, range-dependent marine environments*

Matt's research at CMST is being conducted to test and develop new numerical methods to model underwater sound propagation in environments that are characteristic of the Australian continental shelf. Range dependent bathymetry and elastic sea bottoms are two major factors that control underwater sound propagation in Australian shallow marine environments. These factors have been incorporated into Matt's numerical methods. Initial validations of the new modelling methods against other synthetic results and measured acoustic data have been successful.

Sarah Marley: *Behavioural and acoustic responses of coastal dolphins to noisy environments*

Sarah's PhD project aims to assess how coastal dolphins use their acoustic environment at various locations. Using a combination of visual and acoustic monitoring methods, Sarah can simultaneously record dolphin sounds and vessel noise from acoustic recorders, while also tracking dolphin movements and behaviour from a land-based theodolite station. This will help us to understand aspects of dolphin behaviour in a noisy environment.

Jeong Hun, Ha (Scott): *Simulation of ship under-keel clearance in shallow water*

Some grounding incidents in shallow water are attributed to ship squat and wave-induced motions. Accurate prediction of ship squat is thus essential for safe voyage of vessels from grounding. The main objective of Scott's project is to provide guidelines for ship under-keel clearance using simulations for the required depth of channels. This will contribute toward a better understanding of sinkage and trim of the ships and bring further practical support to under-keel clearance management in ports.

Shyam Kumar Madhusudhana: *Automatic software analysis tools for underwater soundscape measurements*

Automatic detection and classification of 'signals of interest' in underwater acoustic recordings comprising multiple calls of multiple species, embedded in various anthropogenic and physical ambient sounds, remains an ongoing challenge. The segregation of soundscapes into their biological, geological and anthropogenic components holds significant benefits to management, such as sound budgets. Shyam's PhD aims to develop software solutions for the automated characterisation of marine soundscapes.

Post-Graduate Students and their Theses 1978 - 2015

Name	Degree	Thesis title	Year completed	Supervisor
Andrew Woods	PhD	Crosstalk in stereoscopic displays	2014	Alec Duncan
Daniel Wilkes	PhD	The development of a fast multipole boundary element method for coupled acoustic and elastic problems	2013	Alec Duncan
Grant Pusey	PhD	Characterisation of long-range horizontal performance of underwater acoustic communication	2011	Alec Duncan Sasha Gavrilov
Daniel Veen	PhD	A smoothed particle hydrodynamics study of ship bow slamming in ocean waves	2011	Tim Gourlay Kim Klaka
Binghui Li	PhD	Acoustic observation of ice rifting and breaking events on the Antarctic ice shelf using remote hydro acoustic listening stations	2010	Sasha Gavrilov Alec Duncan
Miles Parsons	PhD	An investigation of active and passive acoustic techniques to study aggregating fish species	2010	Rob McCauley
Matthew Legg	PhD	Non-Gaussian and non-homogeneous Poisson models of snapping shrimp noise	2010	Alec Duncan
Yoa-Ting Tseng	PhD	Recognition and assessment of seafloor vegetation using a single beam echo sounder	2009	Sasha Gavrilov Alec Duncan Rob McCauley
Iain Parnum	PhD	Benthic habitat mapping using multibeam sonar systems	2008	Sasha Gavrilov Alec Duncan
Rudy Kloser	PhD	Seabed biotope characterisation based on acoustic sensing	2008	John Penrose
Peter Henley	PhD	An improved operator interface for underwater remotely operated vehicles	2006	John Penrose
Susan Rennie	PhD	Oceanographic processes in the Perth Canyon and their impact on productivity	2006	Rob McCauley
David Sterling	PhD	Performance of prawn trawl gear	2005	John Penrose
Ahmad Zakaria	PhD	Numerical modelling of wave propagation using higher order finite-difference formulas	2004	John Penrose
Kim Klaka	PhD	Roll motion of a yacht at zero Froude number	2004	John Penrose
Alec Duncan	PhD	The measurement of underwater acoustic noise radiated by a vessel using the vessel's own towed array	2004	Alexander Kritski John Penrose
Stephen Cook	MSc	An investigation into wave loads on catamarans	2004	John Penrose
Justin Hoffman	PhD	Acoustic propagation prediction in shallow water	2004	John Penrose
Javier Periera	MSc	System identification of underwater vehicles	2003	Alec Duncan John Penrose
Tim Pauly	PhD	Acoustic target strength measurements of free-swimming Antarctic krill *(Euphausia superba)*	2003	John Penrose
Dougal Harris	PhD	The downwind performance of yachts in waves	2003	John Penrose Giles Thomas
Kristoffer Grande	MSc	Prediction of slamming occurrences of catamarans	2003	Jinzhu Xia John Penrose
Justy Siwabessy	PhD	An investigation of the relationship between seabed typed and benthic and bentho-pelgaic biota using acoustic techniques	2002	John Penrose
Rick Shock	MSc	Investigation into ventilated hydrofoils using numerical and analytical methods	2002	Krish Thiagarajan Kim Klaka
Greg Bush	PhD	Measuring Antarctic sea ice drift with upward looking sonar	1997	John Penrose
Andrew Woods	MEng	A stereoscopic video system for underwater remotely operated vehicles	1997	Tom Docherty
Madeleine Gauntlett	MSc	A scientific investigation into sailing performance of HM Bark Endeavour	1995	John Penrose
Johnathan Binns	MSc	Hull-appendage interaction of a heeled and yawed vessel	1997	John Penrose
Joshua Boyd	MEng	Analysis of non-linear vessel motions using linear strip theory	1996	John Penrose
Ian Sutherland	MAppSc	Prediction of hull response to waves	1989	John Penrose
Peter Mountford	MSc	Spatial and temporal variation of the Perth sea breeze	1989	John Penrose
Gary Webb	MSc	A prediction of vertical vessel motions in shallow water	1989	John Penrose
Alec Duncan	MSc	A precision underwater position fixing system	1989	John Penrose
Kim Klaka	MAppSc	Performance prediction of a yacht sailing in waves	1988	John Penrose
Andrew di Carlo	MEng		1987	John Penrose
Dominic Palumbo	MAppSc	Limits on the use of the statistical analysis of echo ensembles in fisheries acoustics	1982	John Penrose
Peter Petrisevich	MSc		1981	John Penrose
Nick Sofoulis	MSc		1978	John Penrose

CMST @ Science Week

Photo: Perth Science Festival

Sarah Marley persuades a group of primary schoolers to imitate the marine soundscape during Science Week.

National science week is Australia's annual celebration of science and technology. Thousands of individuals from students to scientists and chefs to musicians get involved, taking part in more than 1000 science events across the nation. Curtin University did their part by hosting events, activities, talks and shows for every age group. PhD student, Sarah Marley ably represented CMST when she assisted Curtin's Science Outreach team inform and entertain visitors at the Science Week launch at the Perth Cultural Centre on 15th and 16th August.

Did you know?

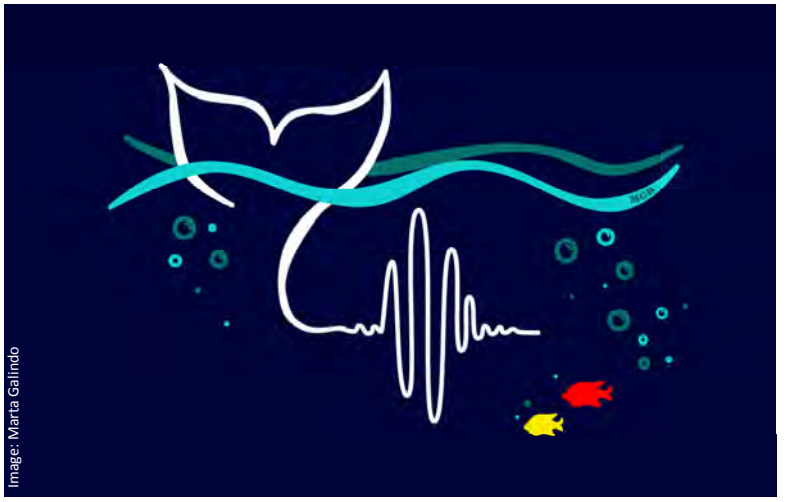


Image: Marta Galindo

The image used to decorate CMST's promotional range of t-shirts and drink bottles, and also featured in this newsletter, was designed by PhD student Marta Galindo Romero. What a multi-talented lady!

Photo: CMST Archives

CMST's Graduate Diploma in Marine Archaeology ran from 1989-1995. Here is the 1995 class. Do you recognise anyone?

CMST Seminars

CMST holds weekly seminars, with speakers from interstate and overseas, as well as CMST staff.

Please note that the Seminar time has been changed to make parking easier for external attendees.
The schedule of seminars is listed on our website:
www.cmst.curtin.edu.au/seminars

If you would like to receive email updates regarding CMST seminars, simply send an email to the following address:
seminars@cmst.curtin.edu.au

The Centre for Marine Science & Technology (CMST) conducts world-class consulting, research, development and education for the marine industry and for government agencies.

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