THE UNIVERSITY OF WESTERN AUSTRALIA
Achieve International Excellence

The UWA Oceans Institute

ANNUAL REPORT 2011

ACHIEVE INTERNATIONAL EXCELLENCE

Contents

"The oceans have the potential to supply the resources to meet the food, water and energy needs of more than nine billion people — the predicted global population by 2050. But we need to do much more than simply denounce the current problems we face. We need to both alert society to the problems, and drive and guide society through to the solutions."

Winthrop Professor Carlos Duarte, Director of The UWA Oceans Institute

Ocean solutions
for humanity's grand challenges

Advancing knowledge to safely and sustainably deliver water, food, energy and bioresources from our oceans

Strategy

The UWA Oceans Institute is focusing on the sustainable and innovative management of ocean resources to create wealth.

We aim to develop untapped opportunities to generate ocean-based solutions to safely and sustainably provide critical resources for human development, including water, food, energy and bioresources.

At the same time, we are committed to reconcile the delivery of wealth from the oceans with the conservation of the biodiversity and ecosystems that support these resources.

Underpinned by excellence in research, the deliberate exploration of ocean solutions can generate great opportunities for innovation, providing a competitive advantage to the industry partners collaborating with us to deliver this vision.

A maritime nation

Australia is a maritime nation with more territory in the ocean than on land and an economy that heavily relies on its oceans, through fisheries, oil and gas and tourism.

Australia has the potential to lead the world in the development of safe and sustainable uses of our ocean resources, opening a pathway of wealth and well-being through what is, in effect, our last frontier.

IMAGE / CORAL REEF
(PHOTO: BEN PIEK)

Director's
executive summary

The past 12 months have seen phenomenal growth of The UWA Oceans Institute. I am excited to welcome 9 new members, 10 new postdoctoral fellows and 43 new PhD students to the Oceans Institute, many of whom join us from international universities. Our growth is reflected not only in increased membership but in our rapidly expanding network of collaborators, both nationally and internationally. With the addition of new talent and research strengths, and by working closely with partner institutions around the globe, we are building the capacity needed not only to deliver excellence in marine science, but to provide Ocean Solutions for Humanity's Grand Challenges.

Collaboration is a key tenet of The UWA Oceans Institute. We are proud to be a partner in the Indian Ocean Marine Research Centre (IOMRC), a collaboration that brings together the Australian Institute of Marine Science (AIMS), CSIRO, The UWA Oceans Institute and the WA Department of Fisheries (see pages 42-43). The partners are developing new research programs and a postgraduate training platform that will significantly advance Australia's marine science capacity and profile, enabling us to address greater challenges, risks and opportunities in the Indian Ocean.

In 2011, our second full year of operation, Oceans Institute researchers have made significant discoveries across a range of disciplines, shedding light on important issues surrounding our oceans (see pages 16-25). We have learnt, for example, that sharks are colourblind, opening up new opportunities for the design of shark repellent wetsuits and lures that could reduce bycatch from long-line fishing. We have gathered new insights into how the cycles of the moon affect long-term changes in high tide levels around the world, helping us predict when and where coastal communities will be most at risk from flooding in the future. And we have built a stronger understanding of the pace of shifting climate across the globe, revealing that marine life off northern Australia is at high risk from warming waters.

The impact of the Oceans Institute's research in 2011 is reflected in substantial increases in publications (128 peer-reviewed scientific journal articles, up 56% from 2010), cites received by Oceans Institute's researchers and in research funding ($16.5 million, up 37%; see page 35 for more).

Our research has extended beyond the academic world and across to the broader public, with much of our work featuring in national and international media. Members have engaged widely with the West Australian and national community, giving a scientific voice to issues such as climate change, shark culling, and the formation of a network of marine reserves for Western Australia. Our website has received major upgrades over the last year, and together with a new strategy for social media, we aim to further communicate ocean science into the public sphere.

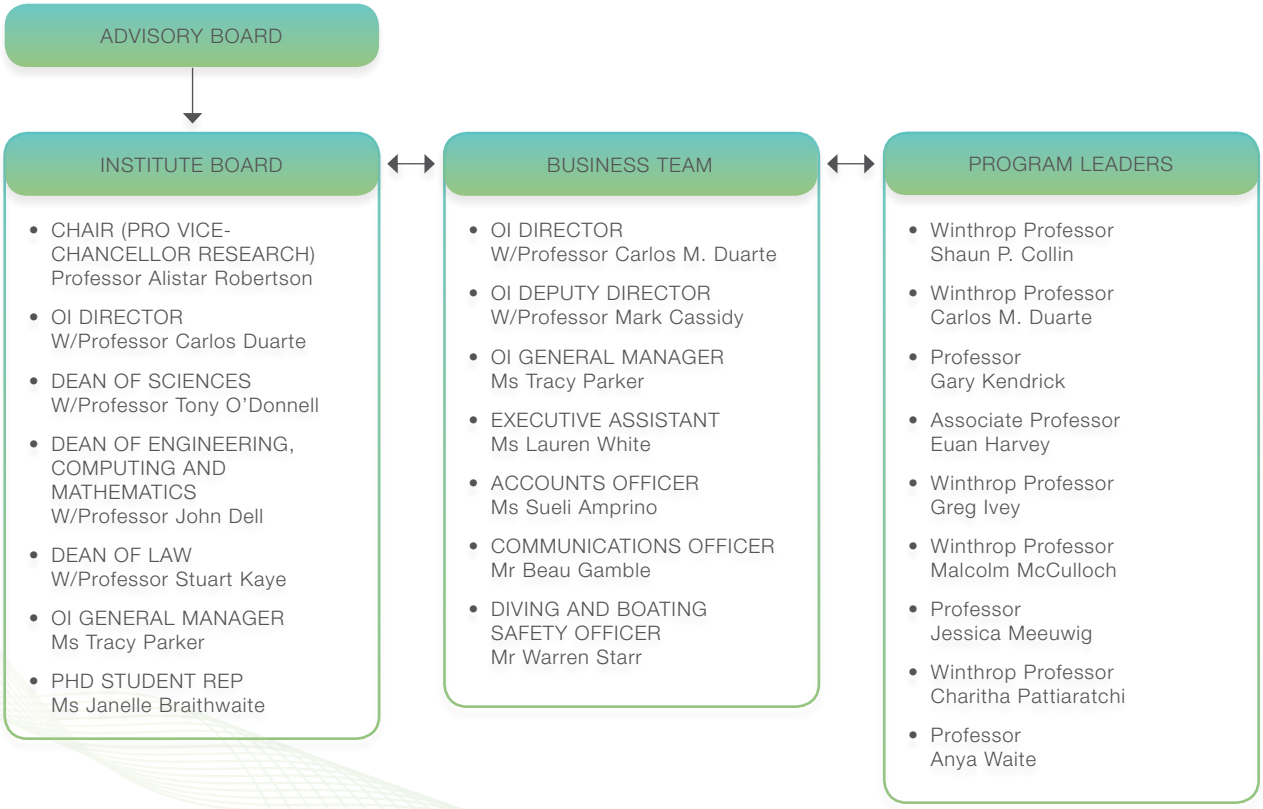
An important step forward towards our vision of ocean-based solutions has been the development of the Ocean Solutions Dialogue Series. Australia has immense opportunity to harness our oceans as a source of food, freshwater, energy and bioresources. But to achieve this vision requires the engagement of academia, industry, government and society at large. The Ocean Solutions Dialogue Series will consist of both targeted workshops and public lectures to articulate an open dialogue between the stakeholders, and to help kick-start initiatives towards Ocean Solutions (see page 37).

The vision of the Oceans Institute is powerful, and I am confident that our rapid growth will continue into 2012 and beyond. I extend my heartfelt thanks to our members, funding bodies and partner organisations — it is through your support and participation that the Oceans Institute has set itself on the path to becoming one of the nation's leading marine research providers.

Winthrop Professor Carlos Duarte
Director, The UWA Oceans Institute

Management
structure and membership

Governance Structure



New Director
Appointed

In March 2011 The University of Western Australia appointed renowned oceans researcher Winthrop Professor Carlos Duarte as Director of the Oceans Institute.

Professor Duarte's research focuses on understanding the effects of global change in aquatic ecosystems, both marine and freshwater. He has conducted research across much of the globe — from Southeast Asia and Europe to the Amazon and Arctic — and in most of the marine ecosystem types, from near-shore to the deep sea.

One of the world's leading ocean researchers, Professor Duarte's appointment helps put the Oceans Institute "at the forefront of global oceans research," according to Vice-Chancellor of UWA Professor Alan Robson.

Professor Duarte will continue his role as a Research Professor with the Spanish National Research Council (CSIC) at the Mediterranean Institute for Advanced Studies (IMEDEA) in Mallorca, Spain.

In 2011 Professor Duarte also received the Prix D'Excellence, the highest honour awarded by The International Council for the Exploration of the Sea (ICES), and an Honorary Doctorate from Utrecht University in March for his work in sustainability.

IMAGE LEFT/ POSIDONIA SINUOSA. (PHOTO GARY KENDRICK)

Research Program Leaders

In 2011 The UWA Oceans Institute appointed a new body of Program Leaders, which includes members leading or representing the Institute in significant state, national and international research programs and forums. Program Leaders form the Oceans Institute's scientific committee and help drive the Institute to strengthen and expand its capacity in marine research. The leaders are (in alphabetical order):

Winthrop Professor Mark Cassidy is Deputy Director of The UWA Oceans Institute and Director of The UWA Centre for Offshore Foundations. His research interests are in offshore geotechnics and engineering, predominantly developing wave-structure-soil interaction models for the analysis of oil and gas platforms, mobile drilling rigs and pipelines. Mark is a fellow of the Australian Academy of Technological Sciences and Engineering, The Lloyd's Register Educational Trust Chair of Offshore Foundations, Deputy Director of the ARC Centre of Excellence for Geotechnical Science and Engineering and a Fellow of the Institution of Engineers Australia.

Winthrop Professor Shaun P. Collin is a WA Premier's Research Fellow and heads the Neuroecology Group at The UWA Oceans Institute and School of Animal Biology. His team uses a range of cutting-edge techniques to investigate the neural basis of behaviour in both invertebrates and vertebrates – with a strong focus on sharks – and with special emphasis on sensory systems and vision. Professor Collin sits on the College of Experts Panel for the Australian Research Council (ARC) and is a member of the Technology and Innovation Advisory Council (TIAC) for the WA State Government.

Winthrop Professor Carlos M. Duarte is Director of The UWA Oceans Institute and a Research Professor with the Spanish National Research Council (CSIC) at the Mediterranean Institute for Advanced Studies (IMEDEA). Professor Duarte's research focuses on the effects of global change in aquatic ecosystems, both marine and freshwater. He is co-leader of a large EU-funded project on Arctic Tipping Points, and is working closely with the United Nations (UNEP and FAO) to develop strategies for sustainable aquaculture and the restoration and conservation of coastal habitats.

Associate Professor Euan Harvey is a marine ecologist at The UWA Oceans Institute and School of Plant Biology. His research focuses on the demography and population dynamics of fish; in particular how fish assemblages respond to human impacts. Over the past 20 years he has been developing fishery independent, non-destructive sampling techniques using stereo-video systems — such as baited remote underwater stereo-video stations (Stereo BRUVs) and Diver Operated stereo-video (Stereo-DOVs). Professor Harvey is the coordinator for years 1-5 for the marine science program at UWA.

Winthrop Professor Greg Ivey is Deputy Dean in the Faculty of Engineering Computing and Mathematics, and is Winthrop Professor of Geophysical Fluid Dynamics in the School of Environmental Systems Engineering and the UWA Oceans Institute. His research is in the area of physical oceanography, focusing on ocean mixing, internal waves and currents in both the coastal and open ocean environments. Professor Ivey is a Node Leader of the Western Australian Marine Science Institution (WAMSI), and a member of the ARC College of Experts.

Professor Gary Kendrick is a marine ecologist whose research focuses on species-rich algal assemblages and species-poor seagrass landscapes. he established the Marine Ecology group in UWA's School of Plant Biology – an internationally recognised profile in benthic marine ecology research – with the goal to understand the linkages between species distributions, their genetics and biology, and the physical environment. He is the former Acting Director of the Oceans Institute.

Winthrop Professor Malcolm McCulloch is a WA Premier's Research Fellow and coral reef expert at The UWA Oceans Institute and School of Earth and Environment. His research addresses important contemporary issues such as the impacts of climate change and direct human activities on coral reefs, and he has developed innovative new indicators of climate change preserved in coral skeletons. Professor McCulloch is one of two Deputy Directors at the ARC Centre of Excellence for Coral Reef Studies and has been responsible for establishing a new node for the Centre at UWA.

Professor Jessica Meeuwig works in the areas of marine and fisheries conservation and quantitative modelling, and is Director of UWA's Centre for Marine Futures. Her lab conducts research across a range of animals and includes projects such as investigating the displacement of humpback whales as a result of coastal development, researching how large sharks and fish use underwater banks and canyons, establishing baselines for fish communities, understanding the impacts of offshore oil and gas activities on the marine environment, and how marine sanctuaries generate ecological and economic benefits.

Winthrop Professor Charitha Pattiaratchi is Head of School at UWA's School of Environmental Systems Engineering. His research interests are in coastal physical oceanography and coastal sediment transport, with emphasis on field experiments and numerical modelling. He has a particular interest in ocean observation systems using ocean gliders, and is Facility Leader at the Australian National Facility for Ocean Gliders (ANFOG). Professor Pattiaratchi is the Node Leader for the WA Integrated Marine Observing System (WAIMOS) and Australian Coordinator of the Indian Ocean Tsunami Warning System.

Professor Anya Waite is a biological oceanographer at The UWA Oceans Institute and School of Environmental Systems Engineering. Her primary research interests are the links between ocean physics, biology and biogeochemistry. Her work involves researching the productivity in our regional oceans and seas, including work around Ningaloo Reef and the feeding habits of western rock lobster larvae. Professor Waite is a member of the board of directors of the Association for the Sciences of Limnology and Oceanography (ASLO).

Members
across Schools and Centres

Prof Susana Agusti❶
School of Plant Biology

Asst/Prof Bryan Boruff
School of Earth and Environment

Dr Anne Brearley
School of Plant Biology

Dr Marion Cambridge
School of Plant Biology

W/Prof Mark Cassidy
Centre for Offshore
Foundation Systems

Dr Julien Claes❶
School of Plant Biology

Asst/Prof Julian Clifton
School of Earth and Environment

Assoc/Prof Peta Clode
Centre for Microscopy,
Characterisation and Analysis

W/Prof Shaun Collin
School of Animal Biology

Asst/Prof Scott Draper❶
Centre for Offshore
Foundation Systems

W/Prof Carlos Duarte❶
Oceans Institute

Professor Christophe Gaudin
Centre for Offshore
Foundation Systems

Assoc/Prof Anas Ghadounai❶
School of Environmental
Systems Engineering

Assoc/Prof Atakelty Hailu
School of Agricultural
and Resource Economics

❶ Members who joined the Oceans Institute in 2011

Assoc/Prof Nathan Hart
School of Animal Biology

Assoc/Prof Euan Harvey
School of Plant Biology

Assoc/Prof Matt Hipsey
School of Earth and Environment

W/Prof David Hunt❶
School of Animal Biology

W/Prof Greg Ivey
School of Environmental
Systems Engineering

Asst/Prof Nicole Jones
School of Environmental
Systems Engineering

Prof Gary Kendrick
School of Plant Biology

Assoc/Prof Ryan Lowe
School of Earth and Environment

W/Prof Malcolm McCulloch
School of Earth and Environment

Prof Jessica Meeuwig
Centre for Marine Futures

Asst/Prof Nicola Mitchell
School of Animal Biology

W/Prof David Pannell
School of Agricultural and
Resource Economics

W/Prof Chari Pattiaratchi
School of Environmental
Systems Engineering

Dr Jane Prince
School of Animal Biology

Assoc/Prof David Sutton
School of Chemistry and
Biochemistry

Professor Krish Thiagarajan
School of Environmental
Systems Engineering

Asst/Prof Julie Trotter
School of Earth and Environment

Assoc/Prof Kimberly Van Niel
School of Earth and Environment

Prof Anya Waite
School of Environmental
Systems Engineering

Assoc/Prof Thomas Wernberg
School of Plant Biology

Post-Doctorates / Research Associates

Dr Selvi Dev
School of Chemistry and
Biochemistry

Dr Delphine Dissard
School of Earth and Environment

Dr Monica Gagliano
Centre for Evolutionary Biology

Dr Ivan Haigh
School of Environmental
Systems Engineering

Asst/Prof
Christine Hanson
School of Environmental
Systems Engineering

Dr Jean-Paul Hobbs❶
School of Plant Biology

Mr Ben Hollings
School of Environmental
Systems Engineering

Dr Renee Hovey
School of Plant Biology

Asst/Prof Flo Kaempf
School of Environmental
Systems Engineering

Mr Samuel Kelly❶
School of Environmental
Systems Engineering

Dr Tim Langlois❶
Oceans Institute

Asst/Prof Tom Letessier❶
Centre for Marine Futures

Dr Fabrizio Pistani
School of Environmental Systems Engineering

Asst/Prof Christin Sawstrom
School of Environmental Systems Engineering

Dr Daniel Smale
School of Plant Biology

Asst/Prof Michael Stat❶
Centre for Microscopy, Characterisation and Analysis

Mr Dennis Stanley
School of Environmental Systems Engineering

Mr Christopher Stoddart
Oceans Institute

Asst/Prof Paul Thomson❶
School of Environmental Systems Engineering

Dr Michele Thums❶
School of Environmental Systems Engineering

Dr Sarath Wijeratne
School of Environmental Systems Engineering

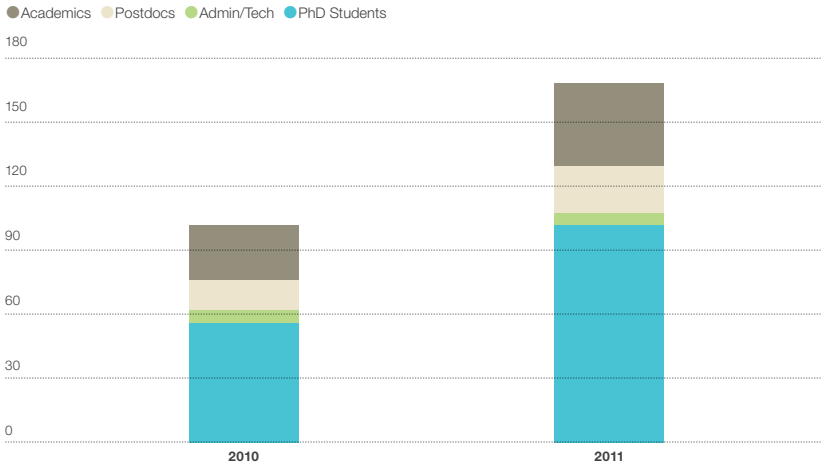
Dr Mun Woo
School of Environmental Systems Engineering

Dr Barbara Wueringer
School of Animal Biology

Dr Kara Yopak❶
School of Animal Biology

Asst/Prof Jens Zinke❶
School of Earth and Environment

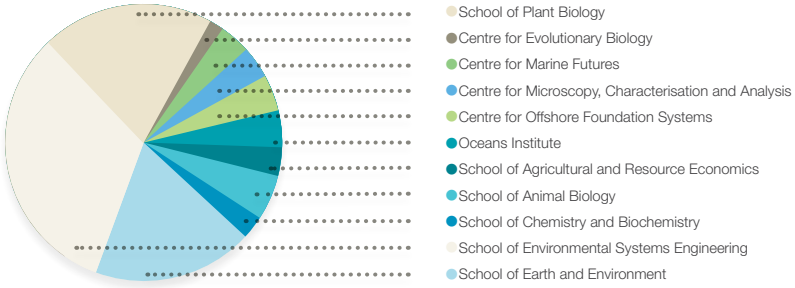
Members Growth❷



❷ Total number of members and students in 2010 and 2011

Total membership to the Oceans Institute has grown by 25 per cent. There has also been a notable rise in the number of PhD students supervised by academic members — a result of the Institute attracting multiple sources of funding for research and research personnel.

Distribution of members across Schools and Centres



Administrative Support

Mr Beau Gamble
Oceans Institute

Ms Sueli Amprino
Oceans Institute

Ms Tracy Parker❶
Oceans Institute

Mr Warren Starr❶
Oceans Institute

Ms Lauren White❶
Oceans Institute

Adjunct Members

Dr Tim Cooper
Dr Martial Depczynski
Dr Stuart Field
Dr Rebecca Fisher
Dr Kim Freidman
Dr James Gilmour
Dr Andrew Heyward
Dr Thomas Holmes
Dr Ross Jones
Dr Mark Meekan
Dr Rebecca O'Leary
Dr Jamie Oliver
Dr Ben Radford
Dr Michael Rule
Dr Christine Schönberg
Dr Jim Underwood
Dr Shaun Wilson

PhD Students

The number of PhD students at The UWA Oceans Institute increased from 56 in 2010 to 97 in 2011 – growth of 73% – with many students coming to UWA from international universities. PhD students and a key for their primary supervisors are shown below.

Audrey Appudurai SC

Mohd Asamudin A Rahman KT

Danielle Barrington GI

Scott Bennett TW

Cynthia Bluteau GI

Olga Bondarenko CP

Cyprien Bosserelle CP

Phil Bouchet JM

Janelle Braithwaite JM

Paul Branson GI

Kirsty Brooks MM

Eloise Brown EH

Mark Buckley RL

Napo Cayabyab RL

Lucille Chapuis SC

Santiram Chatterjee DW

Steven Cheng MC

Samantha Childs GK

Caroline Coombs SK

Gavin Coombes GK

Sana Dandan MM

Fanny de Busserolles SC

Asha de Vos CP

Alexis Espinosa GI

Adrian Ferguson EH

Ben Fitzpatrick EH

Ben Ford EH

Taryn Foster MM

Shari Gallop CP

Eduardo Garza Gisholt SC

Alice Gedaria MH

Indranil Guha DW

Gayan Gunaratne MH

Yasha Hetzel CP

Saskia Hinrichs AW

Shabab Hosseini GI

Pan Hu MC

Lyn Irvine JM

Martin James McLaughlin CP

Muhammad Kamarudin KT

Ryan Kempster SC

Omid Kohan MC

Vickie Kong MC

Anton Kuhar SC

Yu Li MH

Steve Lindfield EH

Chengcai Luo LC

Jiajia Ma MR

Conor Mines GI

Jalal Mirzadehniasa MK

Margie Mohring TW

Nicolas Nagloo NH

Amy Newman SC

Simone Niedermueller SC

Jillian Ooi GK

Jung Ok Kang MM

Juan Pablo D'Olivo MM

Daniel Paraska MH

Hamed Poornaki NB

Lucile Queau MK

Askan Rafiee KT

Dibakar Rakshit KT

Issam Rasadi JM

Matthew Rayson GI

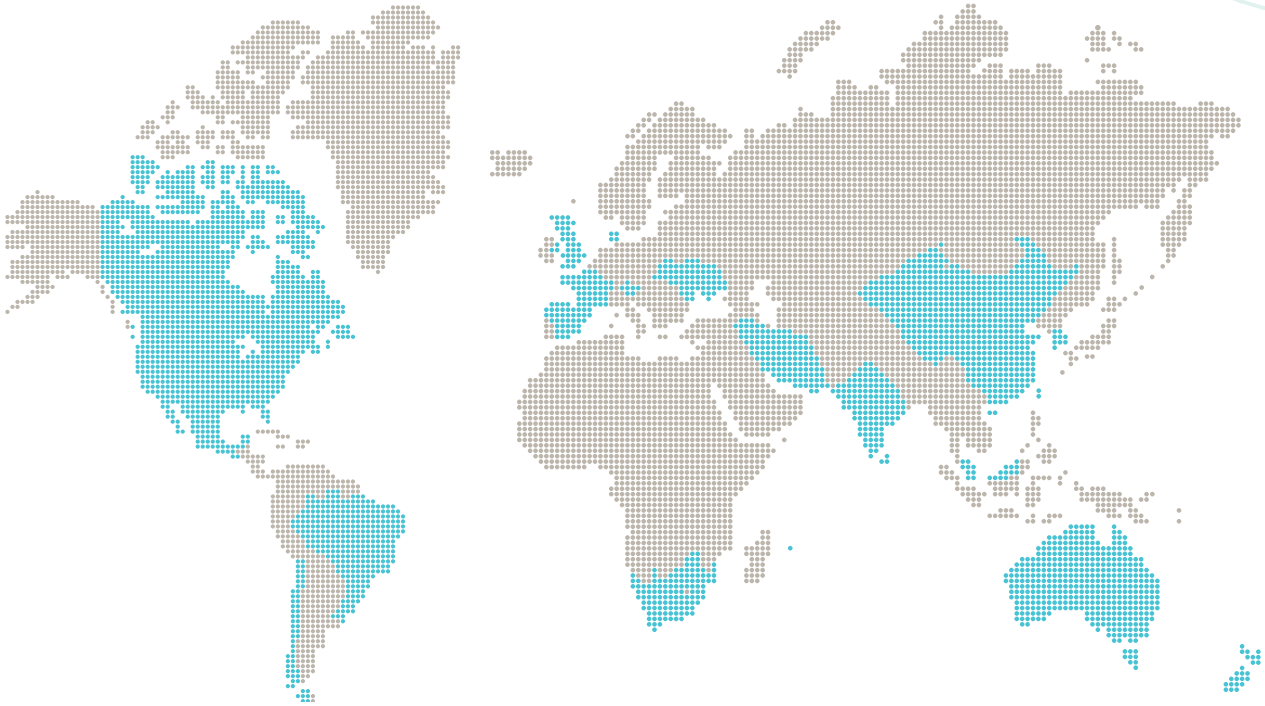
Julia Reisser CP

Nitin Repalle KT

Amin Rismanchian DW

David Rivers GK

Evan Rogers MM



Cecile Rousseaux AW

Ana Ruibal MH

Leonardo Ruiz Montoya RL

Fauzan Sahdi DW

Carlos Salas SC

Julia Santana Garcon EH

Ben Saunders EH

Divya S.K.Mana SG

Jessie Short MM

Kimberley Stone GK

Soheila Taebi CP

Jamie Tedeschi NM

Darshani Thotagamuwage CP

Lei Tien GI

Gabriel Vianna JM

Hemlata Wadhwa KT

Rachael Warrington SC

Thisara Welhena CP

Zack Westgate DW

Beau Whitney DW

Alex Wyatt AW

Yue Yan DW

Bassem Youssef MC

Youhu Zhang BB

Jiangtao Xu GI

Zhenlin Zhang RL

KEY

AW	Anya Waite	MC	Mark Cassidy
BB	Britta Bienen	MR	Mark Randolph
CP	Chari Pattiaratchi	MH	Matthew Hipsey
DW	Dave White	MK	Mehrdad Kimiaei
EH	Euan Harvey	NH	Nathan Hart
GK	Gary Kendrick	NM	Nicola Mitchell
GI	Greg Ivey	NB	Noel Boyland
JM	Jessica Meeuwig	RL	Ryan Lowe
KT	Krish Thiagarajan	SC	Shaun Collin
LC	Liang Cheng	SG	Susie Gourvenec
MM	Malcolm McCulloch	TW	Thomas Wernberg

Highlights

Researchers at The UWA Oceans Institute made significant discoveries across a range of disciplines in 2011, shedding light on important issues surrounding our oceans. Our top research highlights are showcased in the following pages. (See page 23 for a full list of the Institute's scientific publications.)

New insights
into the history of an ancient seagrass

One of the most ancient genera of seagrasses, *Posidonia*, may have a radically different evolutionary history than previously thought, according to an international study.

Posidonia is one of Australia's most important genera of seagrass, covering some 5000 square kilometres of ocean floor, and providing food and shelter to countless marine organisms.

New research involving Professors Gary Kendrick, Di Walker and Carlos Duarte from The UWA Oceans Institute suggests that the genus — comprised of one recognised species in the Mediterranean and seven in the waters around Australia — evolved very differently than what we previously thought.

Comprehensive DNA studies indicate that the Mediterranean and Australian groups split from each other around 65 million years ago — 50 million years earlier than suggested in other recent studies.

The new estimate for the split coincides with the mass extinction event that wiped out the dinosaurs. This catastrophic episode might have been responsible for the extinctions of *Posidonia* ancestors, which explains the long period of separation between the existing Mediterranean and Australian groups.

Another major finding was that despite differences in appearance, four of the Australian species are genetically indistinguishable. In other words, they in fact appear to be a single species — perhaps only morphologically distinct because they grow in different environments. Another possibility is that the four lineages, which make up the *Posidonia ostenfeldii* complex, have only recently diversified and are still undergoing speciation.

Whichever the case, the remarkable lack of species diversity in *Posidonia* shows it has among the slowest DNA evolutionary rates reported for any herbaceous plant. The research is continuing but with a different focus: the genetics of populations across Australia.

The fieldwork in Australia was supported by a Fisheries Research and Development Corporation grant and an ARC Discovery grant.

Aires T, Marbá N, Cunha RL, **Kendrick GA**, **Walker DI**, Serrao EA, **Duarte CM**, Arnaud-Haond S (2011). Evolutionary history of the seagrass genus *Posidonia*. *Marine Ecology Progress Series* **421**: 117-130.

IMAGE ABOVE/ THE RESEARCH SHOWS THAT AUSTRALIAN *POSIDONIA* SPECIES SPLIT FROM THEIR MEDITERRANEAN ANCESTORS AROUND 50 MILLION YEARS EARLIER THAN PREVIOUSLY THOUGHT. (PHOTO: GARY KENDRICK)

IMAGE LEFT/ WEEDY SEADRAGON – MARMION MARINE PARK. (PHOTO JACQUI MCGHIE)

Marine life
off Australia most at risk

Marine life in the areas to the north of Australia and elsewhere along the Equator, as well as the waters off Australia's east coast, have emerged as being at particular risk from temperature changes due to climate change, according to a study published in *Science*.

The researchers analysed global temperatures from 1960 to 2009 to determine the velocity of climate change on land and at sea over the past 50 years, which sets the pace at which marine life must shift their distribution to keep within the same temperature regime.

They found that the velocity of climate change is pronounced in the biodiversity hotspot of the 'Coral Triangle' off Australia, which includes the waters of New Guinea, Indonesia and the Solomon Islands.

The paper's authors include Winthrop Professor Carlos Duarte, Director of The UWA Oceans Institute. Professor Duarte was one of several Australian researchers among the 19 co-authors, with lead researcher Dr Mike Burrows of the Scottish Association of Marine Science.

They also studied seasonal shifts, such as spring arriving earlier due to the effects of climate change. Such changes mean that organisms may have to move to areas where temperatures are conducive to their seasonal activities such as reproduction and migrations.

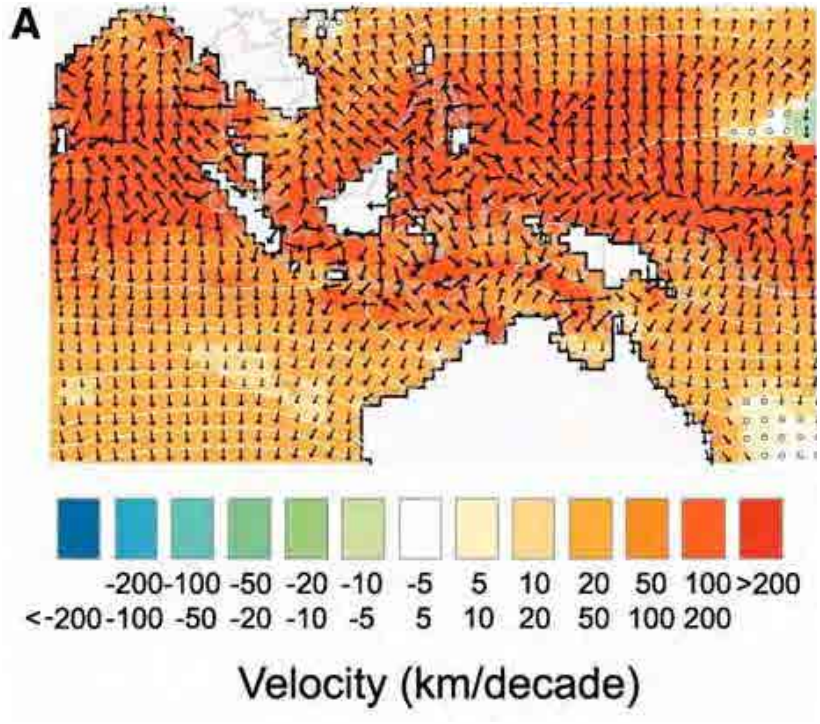


DIAGRAM ABOVE/ TEMPERATURE REGIMES ARE SHIFTING RAPIDLY IN THE 'CORAL TRIANGLE' OFF AUSTRALIA, WHICH INCLUDES THE WATERS OF NEW GUINEA, INDONESIA AND THE SOLOMON ISLANDS. (IMAGE: *SCIENCE*)

Professor Duarte said the challenge for marine organisms is to either move to areas so they remain within their temperature 'comfort zone', adapt to the new conditions, or face extinction.

"Marine organisms can shift their distribution to track the temperature regime they require, but can be left behind and forced to adapt when the velocity of climate change is too fast to cope, or where land masses intersect the migration pathways," Professor Duarte said.

"This seems to be the situation in the Coral Triangle north of Australia, where temperature shifts are particularly fast and where the presence of Australia may interfere with the displacement of biological ranges."

Burrows MT, Schoeman, DS, Buckley LB, Moore P, Poloczanska ES, Brander KM, Brown C, Bruno JF, **Duarte CM**, Halpern, BS, Holding J, Kappel CV, Kiessling W, O'Connor MI, Pandolfi JM, Parmesan C, Schwing F, Sydeman WF, Richardson AF (2011). The pace of shifting climate in marine and terrestrial ecosystems. *Science* **334**: 652-655.

Sharks
may be colour blind

New research on how sharks see may help to prevent attacks on humans and assist in the design of fishing gear to reduce shark bycatch in long-line fisheries.

The joint study between researchers at The University of Western Australia and The University of Queensland looked at the potential for colour vision in a number of Australian shark species.

Associate Professor Nathan Hart and his team measured the light-sensitive cells in the sharks' eyes using a specialised instrument called a microspectrophotometer and concluded that they have only one type of cone photoreceptor in the retina.

"Humans have three cone types that are sensitive to blue, green and red light, respectively, and by comparing signals from the different cone types we get the sensation of colour vision," Professor Hart said.

"However, we found that sharks have only a single cone type and by conventional reckoning this means that they don't have colour vision."

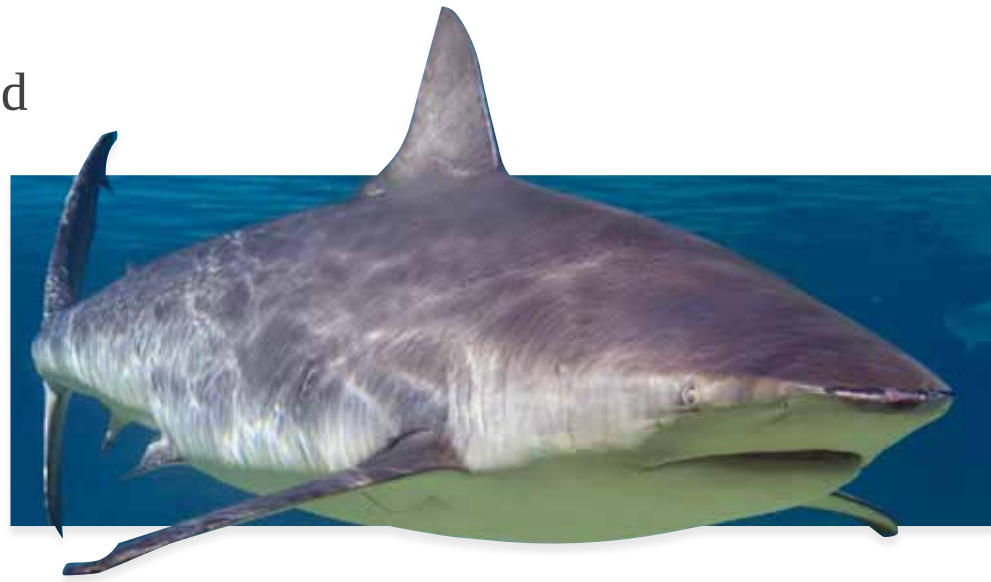


IMAGE ABOVE/ THE BULL SHARK, RESPONSIBLE FOR NUMEROUS ATTACKS ON HUMANS, WAS ONE OF THE SPECIES STUDIED.

"It has long been assumed that sharks have some sort of colour vision and indeed have a preference for certain colours.

"Our study shows that contrast against the background, rather than colour per se, may be more important for object detection by sharks, and this may help us to design long-line fishing lures that are less attractive to sharks whilst still effective for the target fish species — and thus help to reduce the massive bycatch of sharks in this industry."

One of the shark species studied by Professor Hart and his colleagues, the bull shark (*Carcharhinus leucas*), is responsible for numerous attacks on humans.

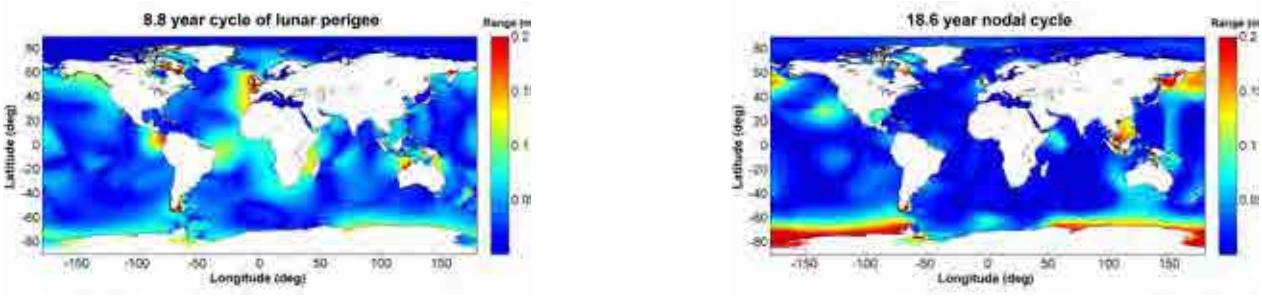
"Now we know a bit more about how such sharks see the world, it may be possible to design swimming attire and surf craft that have a lower visual contrast to sharks and, therefore, are less 'attractive' to them," he said.

"After all, most shark attacks are thought to be the result of curiosity on the part of a shark that has been attracted to an unusual stimulus, rather than some premeditated ambush."

Hart NS, Theiss SM, Harahush BK and **Collin SP** (2011). Microspectrophotometric evidence for cone monochromacy in sharks. *Naturwissenschaften* **98**: 193-201.

How lunar cycles
affect high tide levels

A deeper understanding of how the Moon's orbit influences high tides will help improve predictions of coastal flooding across different parts of the world.



DIAGRAMS ABOVE / THE INFLUENCE OF THE DIFFERENT LUNAR CYCLES VARIES DRAMATICALLY ACROSS THE GLOBE. (IMAGES: IVAN HAIGH)

Major coastal floods in the last decade, such as Hurricane Katrina and Cyclone Nargis, have highlighted the enormous damage that extreme sea level events are capable of. By understanding the factors that lead to high sea levels, such as high tides and storm surges, we can better predict the periods of increased risk — and eventually help save lives.

A study led by Dr Ivan Haigh from The UWA Oceans Institute and School of Environmental Systems Engineering assessed how two aspects of the lunar orbit, the nodal cycle and the cycle of lunar perigee, influence high tide levels all around the world.

The 18.6 year nodal cycle relates to the lunar nodes — the occasions where the apparent path of the Moon and Sun (as seen from Earth) intersect.

The 8.8 year cycle of lunar perigee relates to the Moon's elliptical orbit around the Earth. The phase is determined by the positions at which the Moon is closest (perigee) and farthest (apogee) from the Earth.

The research showed that the influence of each lunar cycle depends on where you are in the world.

The nodal cycle affects tidal range by up to 80cm in places with large daily tides, such as the South China Sea and the Gulf of Carpentaria. The shorter cycle generally has a slightly smaller affect — although up to 60cm — with the biggest impact in places with large twice-daily tides, including the Northwest Shelf of Australia.

An important finding of the study is that the phase of the nodal cycle depends on the form of the tides. At locations with daily tides, the nodal cycle last peaked in 2006 and will peak again in 2024. In contrast, at locations with large twice-daily tides the nodal cycle last peaked in 1997 and will peak again in 2015, resulting in increased likelihood of coastal flooding over this period.

The effects might sound small, but even a 10cm difference in tide range means a three times greater probability of extreme flood events in many parts of the world. So the knowledge of when and where high tides will occur in the future could be invaluable to vulnerable coastal communities.

The study was funded through the Western Australian Marine Science Institution (WAMSI).

Haigh I, **Eliot M** and **Pattiaratchi CB** (2011). Global influences of the 18.61 year nodal cycle and 8.85 year cycle of lunar perigee on high tidal levels. *Journal of Geophysical Research—Oceans* **116**: C06025.

Smallest plankton
play a big role in reef communities

New research shows that bacteria, viruses and other minute plankton are a major food source for fringing coral reef communities, such as Ningaloo Reef.

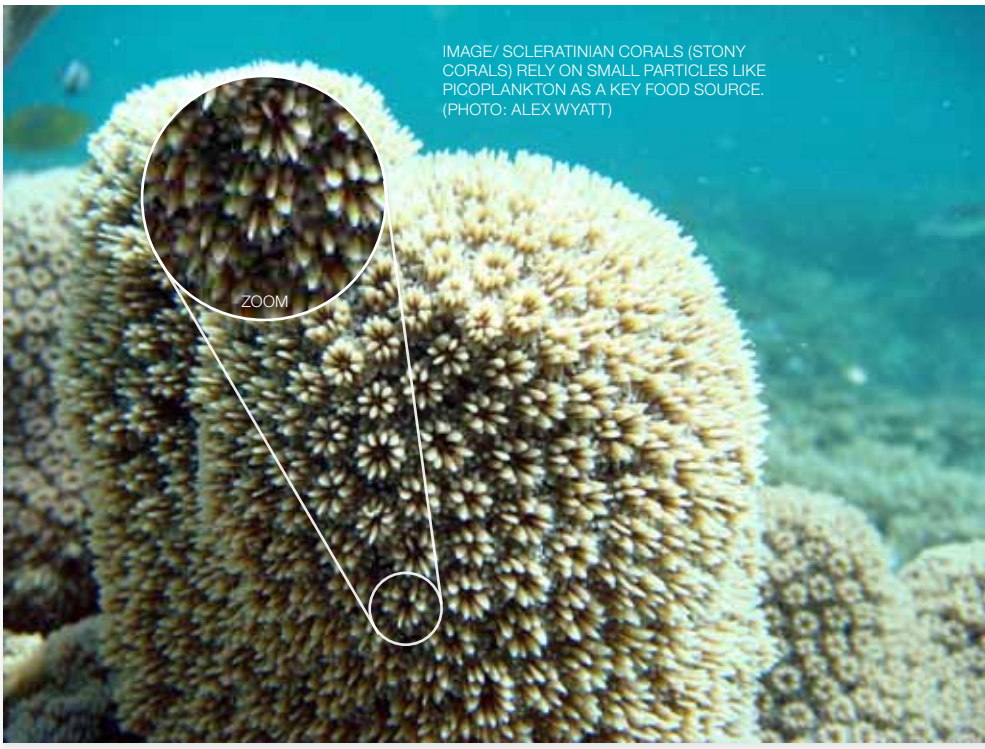
As coral reefs worldwide come under increasing pressure from threats such as climate change, it's important that we understand the factors controlling their health and productivity.

Traditionally, research into the key food sources for reef organisms like corals and sponges has focused on large particles, such as zooplankton and microplankton. In recent years, oceanographers have also confirmed the importance of picoplankton (tiny cells between 0.2 and 2 µm).

But a new study at Ningaloo Reef — led by Dr Nicole Patten from The UWA Oceans Institute and School of Environmental Systems Engineering — was the first to measure how a reef community collectively removed bacteria, viruses, and picophytoplankton from seawater as it flowed across the reef.

It was also the first study to measure picoplankton and viruses within a coral reef system inside the East Indian Ocean Rim.

The results show that the reef community relies heavily on these tiny organisms. As they flowed across the reef from the ocean toward the shore, levels of bacteria and picophytoplankton (picoplankton that photosynthesise) were depleted, on average, to about 40 per cent. Viruses, which are the most abundant cell type in coral reef waters, were depleted also, but to a more variable degree.



IMAGE/ SCLERATINIAN CORALS (STONY CORALS) RELY ON SMALL PARTICLES LIKE PICOPLANKTON AS A KEY FOOD SOURCE. (PHOTO: ALEX WYATT)

It is unclear which organisms comprising the Ningaloo Reef community are the dominant consumers of these plankton, and how minute plankton and other microbes are being assimilated into the coral reef food web. What the study shows, however, is that remotely produced bacteria, viruses and picophytoplankton are highly important for the healthy function of fringing coral reef communities.

Patten NL, **Lowe RJ**, **Wyatt ASJ** and **Waite AM** (2011). Uptake of picophytoplankton, bacterioplankton and virioplankton by a fringing coral reef community (Ningaloo Reef, Australia). *Coral Reefs* **30**(3): 555-567. doi: 10.1007/s00338-011-0777-8

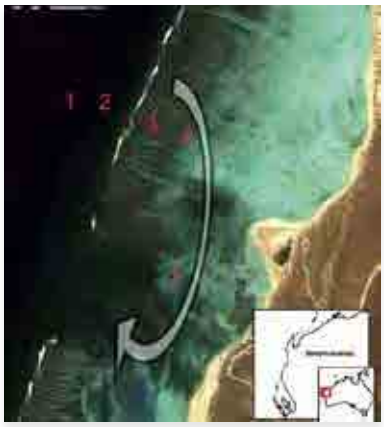


IMAGE ABOVE/ THE RESEARCHERS MEASURED THE ABUNDANCE OF BACTERIA, VIRUSES AND PICOPLANKTON AT FIVE STATIONS ACROSS THE REEF. (PHOTO: NICOLE PATTEN)

Coral geochemistry
reveals built-in resistance to ocean acidification

New insights into how corals can adjust to changes in water chemistry reveal a 'built-in' resilience to ocean acidification.

The future of many marine calcifiers is under threat from increasing CO_2, not only due to global warming, but also from the process of ocean acidification. Much of the CO_2 released from human activities is being taken up by the oceans, reducing seawater pH. This in turn affects the ability of marine species such as corals and molluscs to calcify their skeletons.

A major concern is how marine biota will be affected by this process, with some recent predictions suggesting the wholesale demise of coral reef ecosystems within decades if CO_2 emissions remain unabated.

These predictions however assume that the biological fluids from which corals secrete their carbonate skeletons have a pH similar to seawater, and so are extremely sensitive to any changes in seawater pH, such as those caused by ocean acidification.

New research involving Assistant Professor Julie Trotter and Winthrop Professor Malcolm McCulloch, from The UWA Oceans Institute and the School of Earth and Environment, has provided new perspectives on this important problem.

IMAGE ABOVE/ COLONY OF *CLADOCORA CAESPITOSA*, A TEMPERATE WATER CORAL FROM THE MEDITERRANEAN. (PHOTO: SERGIO SILENZI)

Using the isotopic composition of boron found in tropical and temperate shallow water coral skeletons, it has been possible to determine the coral's pH during the calcification process.

These results have revealed that corals adjust, or up-regulate, their internal pH in constant proportion to external seawater pH. Importantly, this allows corals to continue growing their skeletons over a much wider range of pH than previously thought, providing them with some 'built–in' resilience to the effects of ocean acidification.

Palaeoseawater pH can now also be accurately calculated from boron isotope measurements of long-lived corals, which is important to determine the natural variability of seawater pH and establish the likely thresholds of coral tolerance to increasing CO_2. Continued work is also focused on determining the inherent resilience and susceptibility of other marine calcifiers to ocean acidification.

Trotter J, Montagna P, **McCulloch MT**, Sergio Silenzi S, Reynaud S, Mortimer G, Martin S, Ferrier-Pages C, Gattuso JP and Rodolfo-Metalpa R (2011). Quantifying the pH 'vital effect' in the temperate zooxanthellate coral *Cladocora caespitose*: Validation of the boron seawater pH proxy. *Earth and Planetary Science Letters* **303**: 163-73 doi: 10.1016/j.epsl.2011.01.030.

Ocean flora
retreating to the brink

A new study has found that the warming ocean climate is causing seaweed communities, on which fauna survive, to retreat towards the brink of the continent and possibly extinction.

According to research led by Associate Professor Thomas Wernberg from The UWA Oceans Institute, modern seaweed communities to the south are becoming more similar to past communities in the north, with several temperate species contracting poleward (south).

The results published in the journal *Current Biology* predict that, given future warming, up to one quarter of species in southern Australian waters might retract towards local extinction.

The researchers studied a database of more than 20,000 herbarium records of macroalgae collected in Australia since the 1940s, and found changes in seaweed communities in both the Indian and Pacific Oceans, consistent with rapid warming over the past decades.

"We found that continued warming might drive potentially hundreds of species towards the edge of the Australian continent, beyond which there is no refuge," Professor Wernberg said.

The researchers believe while some species may be able to make adjustments to cope with natural cooling and warming cycles, the predicted rate and strength of warming in the coming decades could force many retreating species beyond the limits of available habitat.

"The potential for global extinctions is concerning because about one quarter of all macroalgal species in the world are found off Australia and these marine habitats support equally unique fish and invertebrate communities," Professor Wernberg said.

Wernberg T, Russell BD, **Thomsen MS**, Gurgel CFD, Bradshaw CJA, Poloczanska ES, and Connell SD (2011). Seaweed communities in retreat from ocean warming. *Current Biology* **21**: 1828-1832.

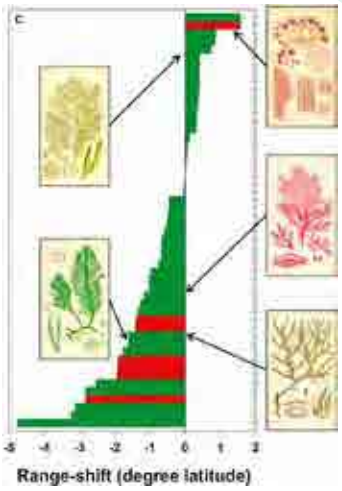


DIAGRAM ABOVE/ THE SHIFT IN NORTHERN RANGE LIMITS OF TEMPERATE SEAWEEDS ON THE WEST (GREEN) AND EAST (RED) COAST OF AUSTRALIA FROM 1940-1960 AND 1990-2009. (COLOUR PLATES OF SELECTED ALGAE FROM HENRY HARVEY'S *PHYCOLOGIA AUSTRALICA*, 1858–1863)

IMAGE BELOW/ THE STUDY LOOKED AT HOW THE DISTRIBUTION OF 52 SEAWEED SPECIES CHANGED IN AUSTRALIA SINCE THE 1940S. (IMAGE: THOMAS WERNBERG)

The Malaspina Expedition

The Malaspina Expedition is one of the world's largest collaborative scientific undertakings. The $23 million project involves some 400 scientists from 18 countries — including researchers from The UWA Oceans Institute and the CSIRO — and two ships circumnavigating the world.

The mission is twofold: to process the impact of global change on the ocean ecosystem and to explore the biodiversity of the deepest levels of the oceans.

The expedition is led by the Spanish Ministry of Science and the Spanish National Research Council (CSIC), and coordinated by Winthrop Professor Carlos Duarte, Director of the Oceans Institute. The voyage recreated the path sailed by Spanish navigator Alejandro Malaspina more than 200 years ago.

The Spanish Navy research vessel Hespérides set out from the city of Cádiz on 15 December 2010 to return to Cartagena, Spain, on 14 July 2011, after circumnavigating the world's oceans. Together with the Sarmiento de Gamboa, the two ships spent a cumulative total of 10 months at sea, crossing more than 75,000 km of the Earth's surface.

Researchers collected around 120,000 samples of air, water and organisms to analyse a wide range of factors, from plankton populations and pollutant concentrations, to salt levels and temperature.

The research will deliver new insights into the effects of climate change, pollution, acidification, plankton levels and increased UV radiation on our oceans. The sampling will also shed light on biodiversity at the deepest levels of the oceans, the largest and least explored ecosystem on Earth.

IMAGE/ MALASPINA EXPEDITION

Around one quarter of the samples were sealed and stored in the Malaspina Collection, a time capsule that will remain locked for 30 years. "It will allow a new generation of scientists to pose questions that we cannot even dream of today," Professor Duarte told COSMOS Magazine.

"The ocean south of Australia is a particularly interesting region where three oceans — the Indian, Pacific and Southern — converge," said Professor Susana Agustí, the Chief Scientist on the Perth-Sydney leg of the voyage, and a Research Professor with the Oceans Institute. "Exploring the biodiversity of these waters will surely reveal surprises."

The Malaspina Expedition docked at Fremantle on March 13, where a number of joint activities, hosted by UWA and the WA Museum, took place. These included a reception, an exhibition, a series of public lectures, visits to the research vessel Hespérides by school children and the Ocean Institute's scientists, a seminar on opportunities for international research experiences for postgraduate students, and a press conference organised jointly by the Malaspina Expedition and the Oceans Institute.

The Malaspina Expedition is a Consolider-Ingenio 2010 project funded by the Spanish Ministry of Science and Innovation, with the support of the Spanish Navy, the BBVA Foundation, and the Spanish and international scientific community in marine sciences.

IMAGE/ CARLOS DUARTE

IMAGE/ CARLOS DUARTE

IMAGE/ JOAN COSTA

Early discoveries

While much of the research has yet to be translated into data, there have been some significant early discoveries.

One of the major findings is that the Indian Ocean has the ability to absorb three times as much atmospheric nitrogen as the Atlantic Ocean and, as a result, can play a crucial climate role as a huge, offshore carbon sink.

The nitrogen supply from the atmosphere plays an important role in regulating climate because it helps plankton to grow and capture carbon dioxide from the atmosphere.

"Nitrogen is a key nutrient for phytoplankton to grow, perform photosynthesis and capture atmospheric carbon dioxide," said Professor Duarte.

"The microorganisms that make up the phytoplankton community remove more CO_2 from the atmosphere than land plants do, and therefore play a critical role in climate regulation."

The scientists collected around 4000 ocean samples in the Indian Ocean, from as deep as 4000 metres.

They also released five SMOS (Soil Moisture and Ocean Salinity) buoys to improve global observing data from the ocean. These buoys are designed to measure the salinity at 0.5m below the surface, and will serve to validate and calibrate satellite information from the Space Mission of the European Space Agency, the first mission to derive ocean salinity from space.

Among the other interesting findings was the discovery that insects resembling water striders live in abundance in the middle of the Atlantic Ocean, contrasting the common view that ocean habitats are virtually absent of insects.

Also remarkable was the discovery that photosynthetic algae — which rely on sunlight to produce energy — live as deep as 4 km below the ocean surface.

ARC
funding success

In 2011 The UWA Oceans Institute was successful in securing more than $7.9 million in Federal Government grants from the Australian Research Council (ARC).

ARC funding is directed at research that will deliver cultural, economic, social or environmental benefits to all Australians.

Two grants were awarded for ARC Discovery Projects: one on the coupled physical and biogeochemical dynamics on the Australian North West Shelf ($520,000), led by Winthrop Professor Greg Ivey; the other on the evolution of light detection and its impacts on early vertebrate evolution ($375,000), led by Winthrop Professor and Premiers Fellow Shaun Collin.

Four members of The UWA Oceans Institute were awarded ARC Future Fellowships totalling more than $2.8 million.

Assistant Professor Thomas Wernberg was awarded $697,000 over five years for his research involving seaweeds, to increase our understanding of their capacity to adjust to changing environmental conditions – in particular ocean warming.

Associate Professor Ryan Lowe was awarded $681,000 over five years for his work investigating the hydrodynamics – the effects of waves, currents and water levels – on complex coastal reef environments.

Dr Wayne Davies will receive $714,000 over five years to investigate the molecular mechanisms underlying non-visual photoreception and their implications in the treatment of human neurological disease.

Dr Jan Hemmi will receive $712,000 over five years for his neuroecology research looking at how the brain processes information under natural conditions.

AIMS, CSIRO and UWA Oceans Institute
Postdoctoral Fellowship Program

In 2011, CSIRO's Wealth from Oceans Flagship enhanced their long-standing close collaboration by joining the existing research collaboration with the Australian Marine Science Institute (AIMS) and the Oceans Institute to establish a postdoctoral fellowship program. The objective of the program is to develop new research capabilities through the development of a fund to support the appointment of research fellows.

The program now appoints five postdoctoral fellows jointly working across the partners in five separate research areas. The postdoctoral appointments focus on the oceanography and ecology of coastal and offshore waters of Western Australia and specific projects include:

- Oceanographic and biological drivers of movement and behaviour of marine megafauna in tropical waters (Dr Michele Thums)
- Climate change in the Australian North West Shelf: 200-300 year records of biogeochemical proxies in coral cores (Dr Jens Zinke)
- Tidal variability and mixing in the Australian North West shelf (Dr Samuel Kelly)
- Determining extinction risk in Western Australia's endemic reef fishes (Dr Jean-Paul Hobbs)
- Investigating the functional variability in coral-algal symbioses (Dr Michael Stat)
- A multi-trophic study of the interactions between the carbon and nitrogen cycles in coastal marine sediments of Western Australia (Dr Bonnie Laverock)
- Identifying the regional significance of Australia's North West submerged banks and shoals through multidisciplinary modelling of species distribution, connectivity and resilience (Dr Cordelia Moore)

Expanding
capabilities

The UWA Oceans Institute and the nation as a whole will expand their capacity in geochemistry and offshore engineering with the launch of two new world-class facilities.


IMAGE/ MALCOLM MCCULLOCH

New geochemical facility

In November The University of Western Australia launched a new state-of-the-art geochemical facility that includes two powerful new machines, the first of their kind in WA, which together provide unrivalled capabilities and innovative research opportunities across a wide spectrum of fields for WA scientists.

The new generation 'multi-collector plasma mass spectrometers' are part of the UWA Advanced Geochemical Facility for Indian Ocean Research, led by Premier's Research Fellow Winthrop Professor Malcolm McCulloch. They are complemented with a new laser system for direct analysis of solid samples, such as tiny microfossils, single mineral grains, and long-lived coral skeletons.

This new capability will assist researchers to solve important environmental issues unique to Western Australia, such as the future of the iconic Ningaloo Reef and the coastal Kimberly region. The facility will also provide opportunities for researchers in the resources industry to understand how some of the Earth's oldest rocks formed, and assist Indigenous studies such as dating Australia's unique Aboriginal rock art.

Part of the facility's work is to analyse corals as 'archives of the sea'. "What we're trying to understand is two things: how the conditions have changed in the past, and secondly, how the corals will respond to these new conditions in the future," said Professor McCulloch.


IMAGE/ CHRISTOPHE GAUDIN

The instruments were purchased from an Australian Research Council Linkage Infrastructure Equipment and Facilities grant in collaboration with the John De Laeter Centre for Isotope Research, Curtin University, Edith Cowan University, Murdoch University, and Charles Darwin University.

New geotechnical centrifuge

A new national geotechnical centrifuge facility will boost Australia's capacity for testing the seabed soils that have to support large offshore structures such as oil and gas rigs.

The new centrifuge, to be headed by UWA's Centre for Offshore Foundation Systems (COFS), will be part of the proposed Indian Ocean Marine Research Centre (IOMRC) to be built on UWA's Crawley Campus.

Funding for the facility comes from a $700,000 grant from the Australian Research Council along with $880,000 from UWA and several other universities.

"The funding, a total of $1.58 million, will provide a 10-metre diameter geotechnical centrifuge and upgrading of the physical modelling facilities here at The UWA Oceans Institute," said Winthrop Professor Mark Cassidy, the Director of COFS and Deputy Director of the Oceans Institute.

"With the new centrifuge, we'll be able to spin large amounts of soil – up to 2.4 tonnes – at up to 100 times the force of Earth's gravity.

"This is really required in light of the larger tests we've been asked to do by the offshore oil and gas companies. With the new centrifuge to be based at the IOMRC, our facilities will be among the best in the world."

Research Areas

The UWA Oceans Institute brings together the strength of UWA's researchers into a multidisciplinary, integrated research focus. The Institute's core research areas include:

IMAGE/ THOMAS WERNBERG

Blue water
oceanography


IMAGE/ YASHA HETZEL

The UWA Oceans Institute is a significant research provider in oceanography, with a focus on observations in biological, biogeochemical and physical oceanography, as well as the numerical modelling of coupled ocean physical-biological processes.

Biological oceanography
We are investigating the drivers of productivity and carbon flow in plankton food webs, including the regulation of settling fluxes, the role of environmental conditions in driving plankton dynamics, and the impact of global change (such as persistent organic pollutants, enhanced UV radiation, ocean warming and ocean acidification) on oceanic plankton communities. This includes coupling between physical ocean dynamics and meroplankton dynamics.

Ocean biogeochemistry
Our research is focused on carbon and nutrient fluxes in the ocean ecosystem (ranging from local to global scales), the role of micronutrients and trace elements in driving ocean production, and the exchanges of carbon and biogenic elements between the atmosphere and the mixed layer, as well as between the mixed layer and the ocean interior.

Physical oceanography
We focus on the field and numerical modelling of the physical properties of the ocean (such as ocean circulation and temperature variability). These are based on fluid mechanic principles that can be transferred across regions, as well as on coupled physical-biological models. In addition, this research examines ocean optics, particularly UV penetration and absorption in the ocean ecosystems, and the dynamics of ocean systems forced by tidal stirring.

Megafauna oceanography
This emerging field uses megafauna, such as sea lions or turtles, to sample the oceans. Instrumenting megafauna with small CTD and other oceanography sensors allows us a new opportunity to sample the oceans in the way megafauna do. Because these animals are engaged in very long range migrations, they provide data of the oceanographic structures they encounter and also sample the oceans in a deliberate way, searching the structures that conform to their requirements (feeding, reproduction, etc.).

Core members (in alphabetical order): Susana Agustí, Carlos M. Duarte, Greg Ivey, Nicole Jones, Ryan Lowe, Charitha Pattiaratchi, Anya Waite.

Coastal processes

Our researchers are investigating coastal processes, including observations, modelling and forecasts of tidal forcing of coastal environments, wave dynamics, sea level rise and sediment transport, interactions between organisms and flows, as well as transport processes across the continental shelf.

This research is complemented with an intense activity in the development and operation of coastal observing systems and remote vehicles, particularly gliders.

This research component is essential to determine risks and threats to WA coastal areas, and includes the leadership of the Australian node of the Indian Ocean Tsunami Warning System.

Core members (in alphabetical order): Marco Ghisalberti, Pauline Grierson, Nicole Jones, Ryan Lowe, Charitha Pattiaratchi, Anya Waite.


IMAGE/ YASHA HETZEL

Marine ecology

The UWA Oceans Institute conducts research on the dynamics and structure of a broad range of marine ecosystems, communities and populations, with particular emphasis of those ecosystems most important in the Indian Ocean.

Coral reef ecology

We use quantitative, process-based methods to gain an understanding of present and past reef growth, metabolism, and calcification rates in relation to environmental factors. The research addresses the functioning of the entire reef ecosystem, from the individual components, including reef fauna and symbiotic zooxanthella, to whole-system processes, such as metabolic rates.

Fish ecology

We study the demography and population dynamics of fish, habitat requirements and the evolutionary ecology of fish. Over the past 15 years, we have developed an ongoing range of non-destructive sampling techniques using stereo-video cameras to achieve this.

Marine neurobiology

Our researchers use innovative neurobiological techniques to investigate the neural basis of behaviour in marine organisms. Such techniques include molecular genetics, microspectrophotometry, bioimaging, electrophysiology and anatomy to trace the evolution of light detection and image formation, and to explore the impacts of light on biodiversity, sustainability and environmental health.

In addition to both basic and applied studies of the influences of light on animal behaviour, other sensory modalities are now being investigated, including the detection of chemosensory signals, electric fields, water borne sound and hydrodynamic disturbances.

Marine biomineralisation

We are investigating the formation of complex natural structures, such as teeth, shells and skeletons. Using a range of cutting-edge imaging and characterisation techniques, researchers investigate cellular structure-function relationships, crystal formation and growth, structure and properties of organic scaffolds, elemental uptake pathways and distributions, and the immunological properties of biomineralised tissues.

Microbial ecology

Our research aims to improve understanding of the diversity, roles and relationships of marine micro-organisms. We address the biodiversity, interactions and ecology of free-living, epiphytic and symbiotic marine bacteria.

Seagrass and macroalgal ecology

This research area centres on the production and population dynamics of seagrass ecosystems, including understanding their responses and recovery from pressures, their role in carbon cycling in the coastal zone, and the dynamics of seagrass landscapes.

Spatial ecology

We focus on the description and understanding of the drivers and patterns of both species and assemblage distribution. Some of the techniques used are continuous coverage mapping, specialising in waters too deep for spectral remote sensing, and distribution modelling.

Core members (in alphabetical order): Marion Cambridge, Peta Clode, Shaun Collin, Carlos M. Duarte, Nathan Hart, Euan Harvey, Gary Kendrick, Tim Langlois, Malcolm McCulloch, Jessica Meeuwig, Nicola Mitchell, David Sutton, Julie Trotter, Kimberly Van Niel, Thomas Wernberg.

IMAGE/ JACQUI MCGHIE

Ocean engineering

The UWA Oceans Institute conducts research to advance the safe extraction of resources in the marine environment to derive energy, food and water from the oceans and the sea floor and transport it safely to land.

Because of the growth of these activities in Western Australia, the Oceans Institute is perfectly located to build strong relationships with industry and other organisations.

The challenge of ocean engineers is to design, build and maintain the structures used to extract and transport marine resources so that they run effectively, safely and with minimal damage to the environment.

Ocean engineers not only need a combination of skills derived from the disciplines of civil, mechanical and electrical engineering; they also require a thorough understanding of other oceanographic disciplines such as marine biology, chemical and physical oceanography, marine geology and geophysics.

Offshore foundation systems

For more than twelve years the Centre for Offshore Foundation Systems (COFS) has been researching the mechanics of seabed sediments, offshore foundation systems, the stability of offshore platforms, pipeline and deep water offshore engineering and marine geohazards.

The Centre consistently produces research findings of international standard and recognition. World class facilities have allowed UWA to service the offshore oil and gas industry at a national and international level.

COFS has one of the largest teams of internationally recognised researchers and engineers in offshore geomechanics in the world.

IMAGE/ WOODSIDE ENERGY.

COFS also maintains world-leading geotechnical centrifuge and soils testing equipment.

Near shore and offshore engineering

Deep sea environments can be very harsh and pose many challenges to both fixed and floating structures such as offshore oil rigs.

One of the greatest challenges in building structures that can survive these conditions is the different loads that the structures experience during installation as they are lowered to the sea floor.

UWA researchers are investigating dynamic lifting factors to determine safer practices for subsea installations and the development of installation vessels. We also study the structural fatigue from ocean currents, called vortex-induced motions, to improve designs.

Floating structures used for oil and gas production, such as large tankers moored to the sea floor, behave in an unpredictable manner when sea states get complex.

For example, the research team is studying the motion response of one of these floating structures in seas where the long-period swells and short-term seas approach from different directions, as is common in north-west WA.

In the near-shore area, we have investigated the behaviour of concrete gravity structures when in close proximity to the seabed during tow-out from casting basins, and have researched wave-breaking and run-up in coastal structures.

Core members (in alphabetical order): Mark Cassidy, Scott Draper, Christophe Gaudin.

Marine biological resources,
management, governance and conservation

Research at The UWA Oceans Institute provides a basis to inform effective policies and management frameworks, while conserving functional and diverse marine ecosystems.

This is a challenge that requires the integration of expertise — now possible under the broad collaborative and interdisciplinary platform that the Institute provides to align and articulate research capabilities in natural and social sciences and technologies.

Marine conservation

By combining natural and social sciences, we can translate existing science into policy outcomes. The Oceans Institute helps to break down barriers to effective management of the marine environment, leading to the conservation of biodiversity and cultural heritage.

Marine biotechnology

Unlocking the genome of marine organisms has opened the door to new opportunities across a range of industries, including food, cosmetic, biomedical and energy. A key focus of the Institute is the use of living marine resources — from entire organisms to molecules to genes — to solve problems and deliver key innovations.

Maritime law and governance

This area involves spatial planning in the marine environment, national and international regulatory frameworks for biodiversity conservation, the governance of economic exclusive zones and areas beyond national jurisdiction in the Indian Ocean, and the governance of new and emerging maritime sectors and activities.

Marine resource economics

We focus on the valuation of marine ecosystem resources and services in support of policy and management, and aim to shape positive public perception and attitudes toward the marine environment.

Spatial planning

Our research provides the basis for safe and sustainable human operation in the marine environment. We evaluate the risks and synergies, both positive and negative, involved in the interactions between human activities — from fishing and boating to offshore exploration and drilling — and the sensitive biological and cultural elements therein. We consider the social and psychological drivers of perceived conflicts and reluctance towards innovation; and provide governance frameworks that adequately address the complexity inherent to the continuity and connectivity of the marine environment.

Core members (in alphabetical order): Michael Burton, Carlos M. Duarte, Euan Harvey, Stuart Kaye, Gary Kendrick, Jessica Meeuwig, Nicola Mitchell, Alistair Paterson, David Sutton, Erika Techera, Kimberly Van Niel.

IMAGE TOP/ ADAM CAMPBELL

IMAGE BOTTOM LEFT/ JUSTINE SANDERSON

Impacts of climate change
in the marine environment

The UWA Oceans Institute is focusing its research strengths and capacities to understand, forecast and mitigate the impacts of climate change on the marine environment.

Climate change is arguably one of the greatest challenges affecting the functionality and health of our oceans, as well as the safety of our operations at or near the marine environment. Since the trajectories and impacts of climate change are strongly dependent on societal and technological factors, the Institute's strong interdisciplinary capacity positions us as a key resource to provide knowledge to guide society and policy to address this important problem.

Sea level rise, coastal flooding and surges

Climate change is forecast to accelerate sea level rise, but the impact of this rise will vary greatly along the world's coasts. Rising water levels are compounded by long-term cycles and a range of other factors — such as changes in precipitation patterns, land use and coastal erosion — that need be considered in predictions of regional sea level rise and to assess the risk of coastal floods.

Impacts of climate change on marine ecosystems

We are building an understanding of the responses of marine organisms, communities and ecosystems to climate change. The goal is to forecast trajectories in biodiversity conservation and ecosystem function, and to intervene through management strategies and policies aimed at maintaining healthy ecosystems.

Carbon pools, cycling and sequestration in the marine environment

The capacity of the oceans to remove CO_2 from the atmosphere is one of the key buffers to climate change. We are researching and quantifying the capacity of marine ecosystems to act as carbon sinks, which is of fundamental importance for climate forecasting. Similarly, the increased CO_2 in seawater is causing ocean acidification, which may adversely affect marine organisms such as calcifiers — the essential components of our valuable coral reefs.

Multiple stressors

Climate change trajectories occur in parallel to major changes in other important components of the Earth System. We are investigating the compounding effects of changes in UV radiation; changes in the cycles of nitrogen, phosphorus, water and other key elements; and changes in the loads and range of pollutants reaching the marine environment.

Adaptation and mitigation of climate change

The deep understanding of the marine environment, delivered through an interdisciplinary approach, offers multiple opportunities to deploy strategies to mitigate climate change. We can achieve this by increasing the supply of energy from marine renewable sources or enhancing natural marine carbon sinks. And we can adapt to climate change through the use of ecosystems to dissipate energy, reduce coastal flooding and erosion, and by adaptively managing marine resources to accommodate their trajectories with climate change.

Core members (in alphabetical order): Susana Agustí, Bryan Boruff, Marion Cambridge, Peta Clode, Carlos M. Duarte, Euan Harvey, Greg Ivey, Nicole Jones, Gary Kendrick, Tim Langlois, Ryan Lowe, Malcolm McCulloch, Jessica Meeuwig, Nicola Mitchell, Charitha Pattiaratchi, David Sutton, Julie Trotter, Kimberly Van Niel, Anya Waite, Thomas Wernberg.

IMAGE TOP RIGHT/ YASHA HETZEL

IMAGE TOP LEFT/ ALEX WYATT

Marine observation,
monitoring and risk management

The UWA Oceans Institute is committed to the need to observe and monitor the marine environment. Our researchers deliver the knowledge and data required to detect changes, identify their drivers, and manage the risks associated with natural changes or those resulting from the increased scale of human operation in the marine environment.

Marine observation
Observing the oceans is critical for all of the Institute's goals. We observe the oceans through an array of technologies, including advanced gliders — hosting the National Glider Facility, part of the Australian Integrated Marine Observing System (IMOS) — mooring systems, surveys using towed videos, baited video arrays, investigating changes in the carbon chemistry of our coastal and marine systems, and the reconstruction of past conditions through records extracted from corals and other biological structures.

Marine forecast
We are generating capabilities in operational oceanography and in the development of models able to forecast changes in the marine environment and the response of the marine ecosystem.

Tsunami alert systems
Oceans Institute researchers are leading participants in the Coordinating Group for the Indian Ocean Tsunami Warning and Mitigation System, and are active in modelling tsunamis to better assess risks and defence strategies.

Risk management
We study the impacts — on both individuals and communities — of extreme natural events, human-induced hazards and changes to our climate, and use our expertise to inform policies and strategies to minimise the impacts from these risks. Our goal is to help build resilience and the adaptive capacity of coastal populations despite increased interactions between societies and the oceans.

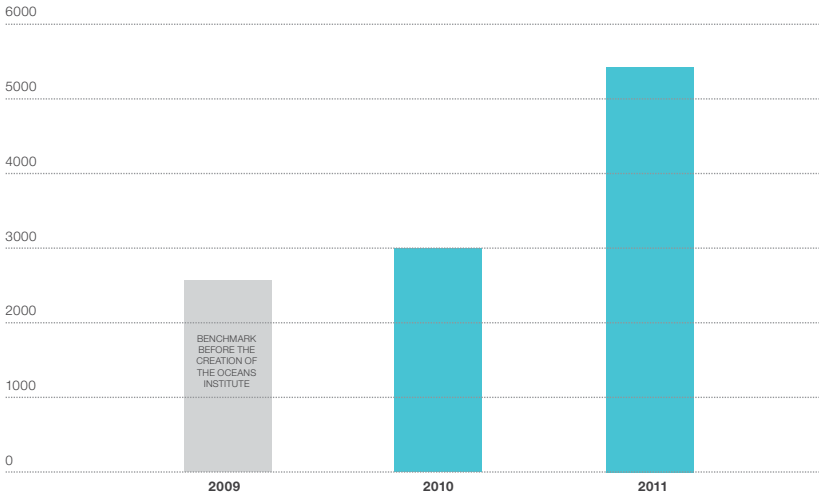
Core members (in alphabetical order): Bryan Boruff, Peta Clode, Carlos M. Duarte, Euan Harvey, Greg Ivey, Nicole Jones, Gary Kendrick, Tim Langlois, Ryan Lowe, Malcolm McCulloch, Jessica Meeuwig, Nicola Mitchell, Charitha Pattiaratchi.

IMAGE TOP RIGHT/ JOAN COSTA

IMAGE RIGHT/ GARY KENDRICK

Impact

Total citations❶

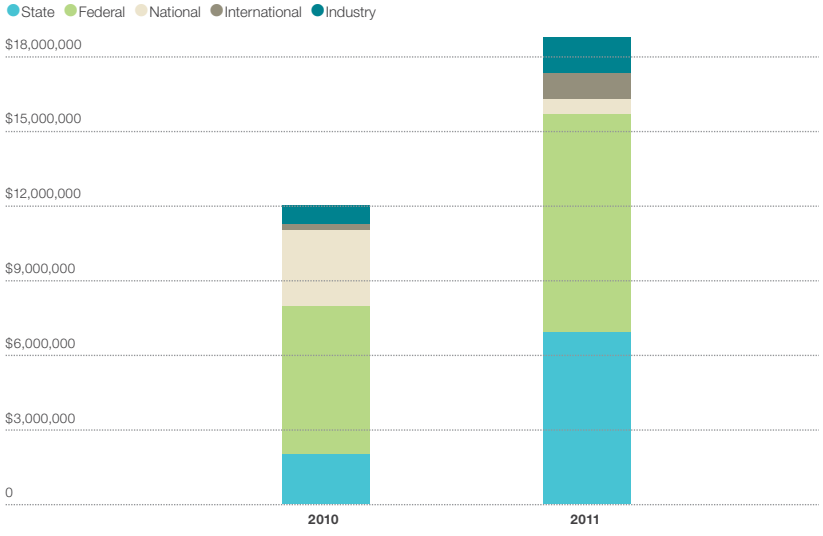


❶ Total citations for peer-reviewed journal articles by Oceans Institute members

Citations

Oceans Institute members have had a growing impact in the marine science and engineering environment, reflected in the marked increase in citations of OI member papers in 2011. The past year saw the appointment of nine new members in a targeted effort to attract high impact researchers and academics, contributing to the growth in citations.

Funding sources❷



❷ Sources of funding for the Oceans Institute over 2010 and 2011 and total funding for that year.

Funding sources

Funding of research projects for marine science and engineering at UWA has grown by 55% since the launch of the Oceans Institute. The emerging international profile of the Institute is strengthened by an increase in funding from international sources.

"The sea, the great unifier, is man's only hope. Now, as never before, the old phrase has a literal meaning: we are all in the same boat."

Oceans Explorer, Jacques Cousteau

IMAGE/ BUFF BREAM.
(PHOTO: THOMAS WERNBERG)

International
and national collaborations

Collaborative research both within the University and with our national and international partners is a key tenet of the Oceans Institute.

In a world where no single person or even organisation boasts the sum of knowledge in a given research field, collaboration has become more crucial than ever. By strengthening and expanding our collaborative network we are addressing gaps in our own research capacities, increasing the quality and impact of research outcomes and setting the Institute on a path of future growth.

In 2011 our members published scientific papers in collaboration with 113 institutions – around the state, the nation, and internationally. Of all scientific publications, more than half involved international collaboration – in total with 23 different countries. Spain, the United Kingdom, Denmark and the USA represented the Oceans Institute's strongest international links, with more than 10 papers published with researchers from each of these countries.

Some of the Ocean Institute's collaborative partners include:

- Aarhus University
- Aberystwyth University
- Australian Institute of Marine Science (AIMS)
- Australian National University
- Bermuda Institute of Ocean Science
- British Antarctic Survey, Natural Environment Research Council
- Charles Darwin University
- CSIRO
- Consejo Superior de Investigaciones Científicas (CSIC)
- Curtin University
- Department of Sustainability, Environment, Water, Population and Communities
- Edith Cowan University
- Environmental Research Institute Denmark
- Farallon Institute for Advanced Ecosystem Research
- Florida International University
- French Research Institute for Exploration of the Sea
- James Cook University
- Intergovernmental Oceanographic Commission
- Macquarie University
- Mediterranean Institute for Advanced Studies
- Ministry of Marine Affairs and Fisheries, Indonesia
- Murdoch University
- National Autonomous University of Mexico (UNAM)
- National Institute of Oceanography
- National Oceanic and Atmospheric Administration (NOAA)
- Nelson Mandela Metropolitan University
- Hydrographic Institute of the Republic of Croatia
- Plymouth Marine Laboratory
- Scripps Institution of Oceanography
- Smithsonian Institution
- South Australian Research and Development Institute (SARDI)
- Stockholm University
- Stanford University
- State Herbarium of South Australia
- Technical University of Denmark
- Universidad Las Palmas de Gran Canaria
- Universidad Rey Juan Carlos
- University of Adelaide
- University of British Columbia
- University of Cape Town
- University of Copenhagen
- University of New South Wales
- University of North Carolina
- University of Queensland
- University of Southern Denmark
- University of Tasmania
- University of Technology, Sydney
- WA Department of Environment and Conservation
- WA Department of Fisheries
- WA Department of Planning and Infrastructure
- WA Museum
- Wildlife Conservation Society, Fiji

The Indian Ocean Marine Research Centre

The Indian Ocean Marine Research Centre (IOMRC) is a collaboration that brings together four of Australia's leading research organisations working in and around the Indian Ocean. These are the Australian Institute of Marine Science (AIMS), CSIRO, the Department of Fisheries and The UWA Oceans Institute.

Through the IOMRC, the partner organisations are developing new multi-disciplinary research teams and creating a graduate training environment that will significantly advance Australia's marine science capacity, capability and profile.

By integrating the research strengths of the partners, the IOMRC will be able to address greater challenges, risks and opportunities in the sustainable and safe use of marine resources, and in the conservation of the Indian Ocean's biodiversity.

The IOMRC will build Australia's international marine research status through stimulating innovative research and the teaching and training of next generation researchers. The IOMRC will be the largest marine research partnership in the Southern Hemisphere and the largest marine research capability in the Indian Ocean Rim.

Partners

The Australian Institute of Marine Science (AIMS) is committed to the protection and sustainable use of Australia's tropical marine resources. The IOMRC component of the Institute's work focuses on the pristine Ningaloo Marine Park and the resource-rich waters of the Kimberley coast and northwest shelf
aims.gov.au

CSIRO is Australia's national science agency. CSIRO manages the Marine National Facility – *RV Southern Surveyor*, and a number of marine and atmospheric collections. The research effort at CSIRO Marine and Atmospheric Research is delivered largely through CSIRO's Wealth from Oceans Flagship, and with the Bureau of Meteorology through The Centre for Australian Weather and Climate Research. The Wealth from Oceans Flagship focuses on understanding Australia's oceans and their biodiversity, resources and relationships with the climate system and provides CSIRO's contribution towards national challenges where oceans play a central role.
csiro.au/oceans

The Department of Fisheries in Western Australia manages the State's fish, marine and aquatic resources to world-class standards to conserve, develop and share the fish and other living aquatic resources of WA — for the benefit of present and future generations.
fish.wa.gov.au

The UWA Oceans Institute brings together the strength of marine researchers at UWA into a multi-disciplinary, integrated research focus. The goal is to capitalise on UWA's existing research strengths — in areas such as oceanography, ecology, engineering, resource management, and governance — to deliver Ocean Solutions for Humanity's Grand Challenges.
oceans.uwa.edu.au

Infrastructure

As part of the collaboration, the partners are developing new marine research facilities. This major development consists of two projects: the construction of a new $62 million IOMRC facility on UWA's Crawley campus, and an $11 million upgrade of the Department of Fisheries' Watermans Bay Marine Centre on the coast, approximately 24km from Crawley.

Funding support for the development of the new facilities comes from the Australian Government, through the Commonwealth Education Investment Fund ($34m), and from the partner organisations ($22m from UWA, $10m from CSIRO, $6m from AIMS and $4m from the Department of Fisheries).

The University of Western Australia will become the home of a new purpose-built marine research facility and will bring together more than 240 researchers working across a broad range of subjects, extending from oceanography to marine ecology, to fisheries, geochemistry, law, marine technologies and engineering, among others.

The partners will not only be co-located within the same facility, laboratories and capacities will be integrated by function, enhancing the culture of collaboration and, in doing so, capability and the efficient use of public resources.

The site of the existing Watermans Bay Marine Centre will undergo significant refurbishment including upgrades to the internal laboratories, offices and marine cultural facilities with direct access to good quality sea water.

The upgrade and refurbishment to the existing Watermans Bay Marine Centre is expected to be completed and ready for occupancy by mid-2013. The building contract award and commencement of construction for the Crawley facility is anticipated in early 2013, with the new facility fully operational and ready for occupancy in 2015.

Upon completion the IOMRC will be set to lead the scientific exploration of the Indian Ocean.

Information specific to the construction and development of these facilities can be located at: **uwa.edu.au/campusdevelopment/current-projects/iomrc**

WAIMOS

The Western Australian Integrated Marine Observation System (WAIMOS) is a regional node of the national IMOS (Integrated Marine Observation System) program, with specific focus on observations in the Western third of the Australian coastline. The main areas of interest to WAIMOS are the continental shelf and slope regions offshore from Fremantle extending northwards to Jurien Bay and the north-west shelf.

With funding provided through IMOS, the UWA Oceans Institute hosts The Australian National Facility for Ocean Gliders (ANFOG), at the School of Environmental Systems Engineering. ANFOG has a fleet of gliders which are used to acquire data from around Australia. Ocean gliders are designed to operate in water depths up to 1000 m and can navigate to pre-programmed waypoints using GPS, internal dead reckoning and altimeter measurements but can be remotely controlled during a mission. Equipped with a variety of sensors, the ANFOG gliders provide real-time ocean profile data via satellite communication. This data, along with that from a range of ocean observing equipment, can be freely accessed through the IMOS Ocean Portal. The ANFOG facility operates gliders in target regions including the Coral Sea, the East Australian Current and the Southern Ocean. In Western Australia gliders make repeat observations of the Leeuwin and Capes currents and have been deployed to the north of Rottnest Island (Two Rocks) as well as the Pilbara and the Kimberley.

Historically, scientists have used ships to obtain data to describe the physical, chemical and biological processes in the oceans. The high cost of ship operations and adverse weather conditions can limit the extent of surveys and data collected. Autonomous ocean gliders undertake routine subsurface measurements of the oceans at a fraction of the costs associated with ship based systems.

Other IMOS infrastructure located in the WA region include continental shelf moorings (ADCP, thermistor and water quality loggers); HF radar for surface current measurements; ocean glider transects for subsurface water properties; passive acoustic sensors for whale monitoring; Autonomous Underwater Vehicle transects for benthic monitoring and, remotely sensed data products (SST and ocean colour).

WUN
The Worldwide Universities Network

The WUN comprises 18 research-intensive institutions spanning five continents, with the goal of creating new opportunities for international collaboration in research.

Researchers from The UWA Oceans Institute are closely involved with two of the WUN's research programs.

Professor Gary Kendrick and Associate Professor Thomas Wernberg, an ARC Future Fellow, are heading a project that brings together leading seaweed scientists and their research students to form an Algal Research Coalition with partners from the Oceans Institute, the University of Cape Town and the University of Bergen in Norway. The goal is to produce a global benchmark for how climate change affects kelp beds, some of the most productive and biodiverse ecosystems on Earth.

Winthrop Professor Malcolm McCulloch, a WA Premier's Research Fellow, is collaborating with scientists in the US and Europe in a WUN project that targets the issue of ocean acidification. The mission is to address this global problem with global collaboration that integrates different approaches and data.

WAMSI
Western Australian Marine Science Institution

The University of Western Australia is a partner in the Western Australian Marine Science Institution (WAMSI), a collaborative venture involving 15 partner organisations and more than 250 scientists..

WAMSI carries out research into climate change, biodiversity, the iconic Ningaloo Marine Park, sustainable fisheries, biotechnology and oceanography, and has overseen the development of a marine bioresources library that will store thousands of marine samples collected by researchers.

Oceans Institute members are involved in a number of WAMSI research projects, from studying the nutrient dynamics and fish biodiversity at Ningaloo Reef to investigating the formation of extreme waves.

Winthrop Professor Greg Ivey, of UWA's School of Environmental Systems Engineering and the Oceans Institute, leads Node 6 of WAMSI: Ocean Science for Offshore and Coastal Engineering.

He is leading a series of oceanographic research projects to quantify and predict the physical oceanographic processes that operate in the highly energetic waters of WA's North West Shelf – work that has benefits for the offshore industry, for the coastal engineering industry, and for the community.

In 2011 the WAMSI program supported 8 PhD students at the Oceans Institute, as well as 8 final year undergraduates in UWA's marine science programs. All students doing individual research projects were involved in one of three sub-projects in Node 6:

- Offshore and coastal engineering and the effects of climate change
- Impact of tides and internal waves on offshore engineering
- Ocean glider deployment as part of WAIMOS

The first WAMSI program concluded at the end of 2011, and preparations are currently underway for WAMSI 2. Priorities for moving forward include: Kimberley Browse Marine Region; Dredging science; Pilbara coast and the North West Shelf; Shark Bay; West Coast Bioregion; Climate change science; and the South Coast.

ANNiMS
conference for early career marine researchers

The University of Western Australia hosted the third annual Australian National Network in Marine Science (ANNIMS) conference over three days in November/December. The conference brought together 119 postgraduate students and early career marine researchers and students from UWA, The University of Queensland and The University of Tasmania.

The aim is to give participants the opportunity to present papers and posters in a relaxed and supportive environment, and to exchange ideas, collaborate and network. Sixty-six attendees gave oral presentations. The theme of the 2011 conference was 'Marine Science in Tropical, Temperate and Southern Oceans'.

IMAGE ABOVE/ MATTHEW FRASER WON THE AWARD FOR BEST HONOURS STUDENT PRESENTATION WITH HIS TALK "THE AVAILABILITY OF NUTRIENTS FOR SEAGRASS COMMUNITIES DEPENDENT ON TERRESTRIAL INPUTS INTO SHARK BAY, WA" (PHOTO: YASHA HETZEL)

UWA and Spain
join forces in major research projects

In April The University of Western Australia and the Spanish National Research Council announced collaboration in major joint research programs, including ocean sciences and technology.

UWA Vice-Chancellor Professor Alan Robson and Consejo Superior de Investigaciones Cientificas (CSIC) President, Professor Rafael Rodrigo, signed a Memorandum of Understanding on Monday 11 April. The signing ceremony outlined collaboration in four broad areas of research.

Collaborating interests are in ocean sciences and technology, astrophysics and radio astronomy, plant and agricultural sciences, computationally-intense sciences and complex system theory.

The two organisations have already established joint positions in ocean science with the appointment of Professors Carlos Duarte as the Director of The UWA Oceans Institute and Susana Agusti as Professorial Fellow in the School of Plant Biology and Oceans Institute.

CSIC and UWA have committed to developing staff exchanges, leading to applications for joint research funding and joint supervision of higher degrees by research students and postdoctoral fellows, as well as jointly badged publications. It is expected that over five years this will result in major joint research programs.

Shell and UWA
announce chair in offshore foundations

A new professorial chair in metocean engineering and offshore foundations will strengthen education and research in Western Australia.

The agreement between Shell Australia and The University of Western Australia involves the appointment of the Shell EMI Chair in Offshore Foundations-Metocean Engineering as well as two research assistant professors and two PhD students.

An abbreviation of meteorology and oceanography, “metocean” is often used in the offshore industry to describe the physical environment around an offshore platform.

The new appointments will build on the University’s commitment to supporting and developing the industries which continue to drive WA’s economy.

Shell Australia Country Chair Ann Pickard said Shell was delighted to support the professorial chair.

“We see this as an important opportunity to contribute to research that will benefit the whole offshore industry, and better equip Western Australia to fulfil its potential as a global energy hub.

“Along with the deployment of what we hope will be the world’s first floating LNG facility off the coast of Western Australia, Shell believes this professorial chair will help reinforce Western Australia’s position at the forefront of LNG technology.”

IMAGE ABOVE/ SHELL IS DEVELOPING THE 488M-LONG PRELUDE FLOATING LNG PLANT. (IMAGE: SHELL AUSTRALIA)

Visiting scholars

In 2011 The UWA Oceans Institute hosted nine international visiting scholars, who stayed from between four weeks to six months to conduct collaborative research.

The program helps to forge new relationships between Oceans Institute members and international researchers.

Looking into 2012, the Institute plans to launch a formal Visitors Program to enhance opportunities for academics and PhD students to bring highly regarded researchers to the Institute, to provide mentoring, develop collaborations and enhance networking.

Visitor profile: Professor James Fourqurean

Professor Jim Fourqurean, from Florida International University, conducted research on the vast seagrass meadows of Shark Bay. The meadows act as a massive carbon sink which – according to Professor Fourqurean's research – potentially stores more than $8 billion worth of carbon dioxide, if valued according to the Federal Government's proposed carbon price.

He also investigated different aspects of Shark Bay's food web, such as how a fear of sharks can affect where turtles and other herbivores choose to feed. These decisions, in turn, affect the seagrass communities.

"We know that when sharks are in the bay, turtles avoid the high quality seagrass beds where they'd like to be feeding," Professor Fourqurean says. "The sharks are in fact protecting seagrasses from these herbivores."

IMAGE RIGHT/ PROFESSOR FOURQUREAN VISITED THE OCEANS INSTITUTE THROUGH UWA'S GLEDDEN FELLOWSHIP AND AS A 2011 AUSTRALIAN NATIONAL NETWORK IN MARINE SCIENCE VISITING SCHOLAR. (PHOTO: NICOLE CHAVARRY)

Visitor profile: Dr Hrvoje Mihanovic

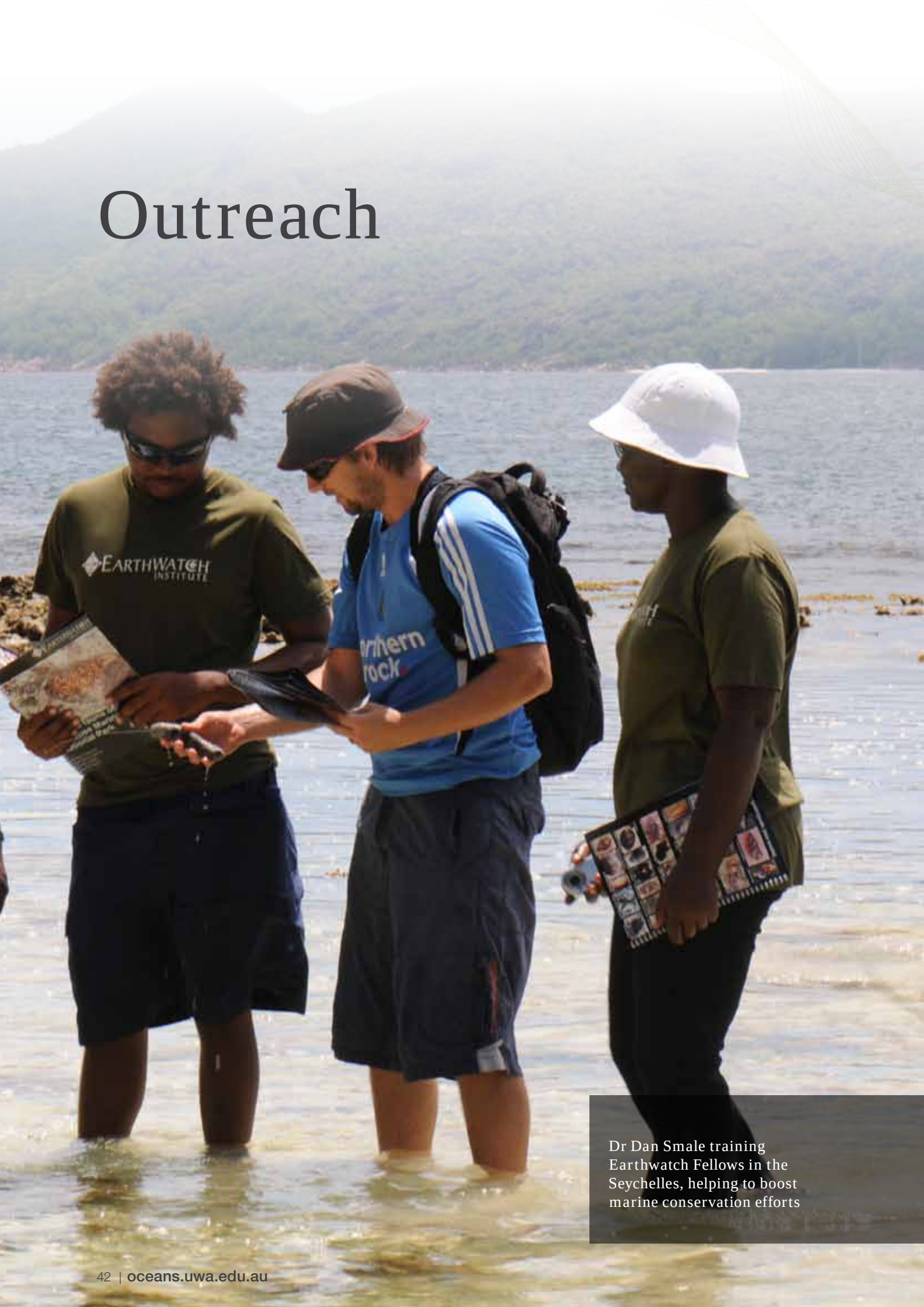
IMAGE ABOVE/ DR MIHANOVIC VISITED THE OCEANS INSTITUTE THROUGH A SIX-MONTH GO8 EUROPEAN FELLOWSHIP, OFFERED BY AUSTRALIA'S GROUP OF EIGHT UNIVERSITIES. (PHOTO: TONY MALKOVIC)

Dr Hrvoje Mihanovic, a research scientist with the Oceanographic Department at the Hydrographic Institute of the Republic of Croatia, Split, conducted research on WA's blustery sea breezes.

He used novel techniques to study the effects of the sea breezes – some of the strongest sea breeze systems in the world – on ocean surface currents and the behaviour of the Leeuwin and Capes currents.

The research could have wider benefits, says Dr Mihanovic. "[The data] could be used in short-term ocean forecasts, significantly shortening the decision time during search and rescue missions and hopefully mitigating potential disasters and accidents on the sea," he says.

Outreach



Dr Dan Smale training Earthwatch Fellows in the Seychelles, helping to boost marine conservation efforts

Ocean solutions
dialog series

To realise the Institute's vision of Ocean Solutions requires the engagement of government, industry and society at large.

The development of ocean-based solutions is a recent phenomenon, providing immense scope for innovation and the growth of new industries and businesses associated with this concept.

To articulate a dialog between key stakeholder groups, The UWA Oceans Institute is developing the Ocean Solutions Dialog Series.

The Dialogs will be a series of targeted workshops, each with 15-20 participants, which provide a collaborative framework for academia, government and industry members, and the relevant society stakeholders. The goal is to raise awareness of the problems affecting our oceans and address opportunities in ocean-based solutions.

Through targeted debate and discussions, the Dialog Series will seek to change the paradigm for how Australian society addresses problems and opportunities in the marine environment, from a reactive to a proactive mode.

Mrs Susan Fleming, the Convener of the Ocean Solutions Dialog Series, will have the central role of moderating and facilitating discussion and stakeholder engagement.

The initial outcomes of each Dialog will be a report and media materials made available to the public that summarise the problems identified and the initiatives and potential projects to be developed to deliver solutions.

The Ocean Solutions Dialog Series is being developed through a number of brainstorming sessions initiated in late 2011. The first workshop will take place in March 2012 and will address the role of science in responding to emergencies and disasters in the marine environment.

Subsequent workshops will focus on spatial planning for safe and sustainable operation in the marine environment, the role of the oceans as a source of water, a source of food, a source of energy, and a source of key bioresources.

Making the most
of Earth's final frontier

With the world's population estimated to swell to nine billion people in the next 40 years, countries should look to the oceans to provide the means to feed and improve our standards of living.

That was the main point made by Winthrop Professor Carlos Duarte at his Professorial Oration – Ocean: Opportunities in Exploring the Planet's Last Frontier – hosted by the Institute of Advanced Studies at the UWA Club.

Professor Duarte elaborated on his Ocean Solutions vision for the Oceans Institute — that not enough is known about the world's oceans yet they provide unique opportunities to address humanity's grand challenges.

He said the planet's growing population is already putting pressure on resources such as food supplies, fresh water, energy, biodiversity and climate.

And that instead of looking to outer space for other planets to help solve some of these problems, we should instead look to the oceans. More than 400 planets had been discovered, but none of them provided the water that would make them inhabitable, he said.

"But we are largely ignoring the exploration of our oceans which we can refer to as the 'inner space' of planet Earth," said Professor Duarte.

Although oceans cover 70 per cent of the world's surface, only 10 per cent of all named species are marine species.

"With conservative estimates of the number of species in the ocean, it will be 200 to 1,000 years before we have a complete inventory of the species in the ocean," he said.

"We actually know more of the topography of the Moon, or even that of Mars, than we know about the topography of our oceans."

He said examples of ocean solutions could involve re-thinking the way we grow our food and developing aquaculture even further; developing new uses for genes discovered in the seas; harnessing tidal and wave energy; and using marine ecosystems as natural carbon sinks to mitigate climate change.

Ocean solutions
vision outlined at industry forum

At a forum addressed to industry members, Oceans Institute scientists highlighted the capacity of the Institute to help provide solutions to some of the world's most pressing problems, including how to feed the nine billion people estimated to be on the planet by 2050.

"The main goal of this industry forum today is to see how we can best align this vision with the needs of industry and the needs of the society of Western Australia and even beyond in the Indian Ocean," said Winthrop Professor Carlos Duarte, Director of The UWA Oceans Institute.

Professor Anya Waite spoke about currents and surface temperatures in the North-West of WA and related it to work involving the life cycle of the western rock lobster and implications for aquaculture.

Winthrop Professor Mark Cassidy, the Director of the Centre for Offshore Foundation Systems, outlined the Centre's role in modelling underwater structures for engineers that could withstand pressures of some 300g.

Colin Beckett, Chevron's General Manager of the Greater Gorgon Area, gave an industry response in which he outlined environmental safeguards undertaken as part of dredging operations at Barrow Island for the Gorgon LNG project.

Artist
in residence

In 2011 The University of Western Australia appointed Angela Rossen as Artist in Residence to the Oceans Institute. The appointment foresees Angela working with members of the Oceans Institute research team on the university campus, in the studio and in the field.

The appointment is a continuation of the collaborative project "Seagrass: a Vital Resource" with Emeritus Winthrop Professor Di Walker. The project began in 2009 and joins two methodologies: artistic investigation and expression, and scientific research.

Despite a wealth of academic research, the vital role of seagrasses in coastal ecosystems is seldom communicated to the general public. The project aims to address this deficit and contribute to a culture of conservation through education, exhibitions and publications.

Artistic productions in 2011 included a series of studies of seagrass meadows and associated marine communities throughout Western Australia. Angela is also running ongoing Environmental Science Art Workshops throughout WA primary schools.

2012 will see the commencement of a series of large scale paintings to be developed from coastal fieldwork.

The Oceans Institute Artist in Residence project will culminate in a multi-media exhibition and publication. To follow the project visit **www.angelarossen.com.**

Communicating
shark science

Ryan Kempster, a PhD student in marine neuroecology from The UWA Oceans Institute and School of Animal Biology, won both first place and the people's choice award in UWA's Three Minute Thesis Competition.

Ryan Kempster, a PhD student in marine neuroecology from The UWA Oceans Institute and School of Animal Biology, won both first place and the people's choice award in UWA's Three Minute Thesis Competition.

In the 3MT, PhD candidates have to talk about their research in an engaging way in only three minutes, in language appropriate to a non-specialist audience.

Ryan described how sharks developing in egg cases use their seventh sense – called electroreception – to detect when predators are lurking nearby, and to 'play dead' accordingly.

The research is useful is determining how sharks respond to other electrical fields, such as those being developed for shark repellent devices.

Ryan went on to compete in the international 3MT in late September, held at UWA's Octagon Theatre. He won his way into the final round, finishing in the Top 11 out of 42 speakers from Australia, New Zealand and Fiji.

IMAGE ABOVE/ RYAN KEMPSTER HOLDS A YOUNG PORT JACKSON SHARK. (PHOTO: PAUL RICKETTS)

Media

Research by Emeritus Winthrop Professor Di Walker and Professor Gary Kendrick showed that Shark Bay's stromatolites are at risk from increased flooding due to climate change. The story was covered by Cosmos Magazine and The Conversation.

IMAGE/ GARY KENDRICK.

Media

The University released 30 media statements with a focus on Oceans Institute members and their research in 2011. This resulted in more than 200 media stories in international, national, state and local news media – including articles in The Australian, National Geographic Online and the Sydney Morning Herald. (International print and radio coverage is not recorded.) The Institute also published three newsletters and 54 articles in the Oceans Institute Online Newsroom.

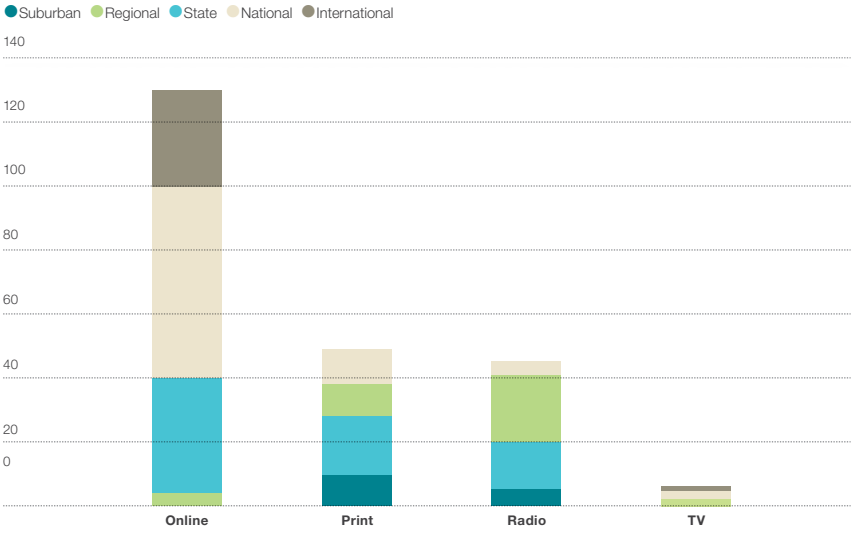


IMAGE ABOVE/ THE WORK OF ASHA DE VOS, A PHD STUDENT STUDYING BLUE WHALES OFF THE COAST OF SRI LANKA, FEATURED IN THE BBC DOCUMENTARY OCEAN GIANTS AND ON CHANNEL 7'S SUNDAY NIGHT. (PHOTO: ASHA DE VOS)

Research Funding

IMAGE/ CENTRIFUGE (PHOTO CURTESY OF CENTRE FOR OFFSHORE FOUNDATION SYSTEMS (COFS))

Ocean Institute
research grants awarded in 2011

Researchers	Project Title	Funding Period	Funding Body	Amount
Brummer GJA, Zinke J	CLIMATCH – Climatic and anthropogenic change in seasonal river runoff and impacting cyclones resolved by novel spectral geochemistry of giant corals in Indian Ocean catchments	2011-2014	Netherlands Organisation for Scientific Research (NWO)	$300,000
Camoin GF, Bard E, Dullo WC, Zinke J	Reefs and Corals from the Eparses	2011-2014	CNRS France	$40,000
Cleary DFR, de Voogd N, Erpenbeck D, Polónia Correia ARNM, Cahyarini Y, Zinke J	Less coral: The impact of human settlements on coral reef ecosystems	2011-2015	FCT Portugal	$20,000
Clode PL, Erez J	Towards a mechanistic understanding of coral calcification: a bio-geochemical approach	2011	UWA Research Collaboration Awards	$15,000
Collin SP, Hart NS, Gisholt E	Vision and light detection in chondrichthyans	2011-2012	Sea World Research and Rescue Foundation	$6,450
Collin SP, Johnstone R	Applying emergent sensor network technologies to elasmobranch sensory research: the significance of environmental electromagnetic fields	2011	UWA-UQ Bilateral Research Collaboration Award	$19,740
Collin SP, Lamb TD, Hunt DM, Potter IC, Hart NS	The evolution of light detection and its impacts on early vertebrate evolution	2011-2013	ARC Discovery Grant	$375,000
Collin SP, Raston CL, Sampson DD, Whelan JM, Dunlop SA, Martins RN, Verdile G, Ogden MI, Watson CR, Li Q, Lou X, Massi M	Multiphoton confocal microscope for high speed, deep tissue imaging and multimodal nanoscale characterisation	2011	Australian Research Council LIEF Grant	$968,000
Collin SP, Yopak K, Northcutt RG	Developing quantitative measures of brain evolution in early vertebrates	2011	UWA Research Collaboration Awards	$10,000
Cook P, MacNally R, Beardall J, Hindell J, Reich P, Glud R, Hipsey M, Quinn G, White M	Functional links between estuaries and their catchments: How does land use change affect estuarine ecological and bio-geochemical function?	2011-2013	ARC Linkage Projects	$284,000
Davies W	Investigating the molecular mechanisms underlying non-visual photoreception and their implications in the treatment of human neurological disease	2011-2015	ARC Future Fellowship	$714,528
Gagliano M	Rainbowfish: Cost of living and ageing in the far west	2011	UWA Research Development Awards	$29,578
Gaudin C, Cassidy MJ, Randolph MF, White DJ, Sloan SW, Carter JP, Indraratna BN, Williams DJ, Kodikara JK, Jaksa MB, Krabbenhoft K, Fourie AB, Merifield RS, Rujikiatkamjorn C, Geng X, Pedroso D, Scheuermann A, Bouazza A	The national geotechnical centrifuge facility	2011	Australian Research Council Linkage Infrastructure & Equipment Facilities	$700,000
Haigh I	Storm surge propagation and coastal flooding in the Peel Harvey Estuary	2011	UWA Research Development Awards	$25,940
Hanson CE	Dense shelf water cascades off southwestern Australia: their impact on phytoplankton nutrient dynamics and community composition	2011	UWA Research Development Awards	$29,770
Harvey E, Saunders B	Post Development Impact Surveys: Sub-Tidal Demersal Fish (Stereo-BRUV's)	2011	Sinclair Knight Merz SKM	$420,405

Researchers	Project Title	Funding Period	Funding Body	Amount
Harvey E, Saunders B	DOMGAS Marine Baseline Summer Survey	2011	Chevron	$330,005
Harvey ES, Shortis MR, Mian AS, Culverhouse PF, Edgington D, Cline D	Automation of species recognition and size measurement of fish from underwater stereo-video imagery	2011-2014	ARC Linkage Projects	$802,000
Hemmi J	Neuro-ecology: information processing under natural conditions	2011-2015	ARC Future Fellowship	$711,993
Hovey R, Kendrick GA	Seagrass monitoring in Owen Anchorage mooring scars	2011	Oceanica Consulting Pty Ltd ex Cockburn Cement Pty Ltd	$62,094
Hovey R, Statton J, Ooi J, Kendrick GA	Effects of sedimentation on seagrass: experimental exposure development	2011	Woodside Energy Ltd (R2D3)	$48,000
Hunt DM and Collin SP	Role of a novel miRNA in the dominant syndromic disorder of macular dystrophy and split hand and foot malformation	2011	Retina Australia	$30,000
Hunt DM, Key B, Collin SP, Hart NS, Gaudin A	The zebrafish as a model organism for the study of visual processes and associated inherited disorders in humans	2011	UWA-UQ Bilateral Research Collaboration Awards	$11,000
Ivey G, Jones N, Lowe R, Kelly S, Brinkman R, Steinberg C, Book J, Burrag D	The connectivity of the Australian North West Shelf with the Leeuwin Current	2011	Office of Naval Research NICOP program	$442,700
Ivey G, Jones N, Lowe R, Wake G, McConochie J	Ocean response to tropical cyclone forcing on the Australian North West Shelf	2011-2014	ARC Linkage Projects	$559,000
Ivey G, Lowe R, Strutton P, Jones N, Furnas M, Brinkman R	Coupled physical and biogeochemical dynamics on the Australian North West Shelf	2011	ARC Discovery Grant	$520,000
Jones N	The influence of nonlinear internal waves on mixing and transport in the ocean	2011	UWA Research Development Awards	$20,943
Jones N, Strutton P, Ivey G, Lowe R, Falter J, Brinkman R	The importance of internal waves in the stimulation of primary productivity at Ningaloo Reef	2011	ANNIMS Springboard	$29,930
Kelly S, Jones N, Ivey G, Simmons H, Klymak J, Nash J	Structure and propagation of an internal tide beam in the Tasman Sea	2011	UWA Research Collaboration Awards	$15,000
Kendrick GA, Harvey E	Assessing the ecological impact of the Western Rock Lobster fishery in fished and for the unfished areas: Demersal Fish Surveys	2011	WA Department of Fisheries (FRDC)	$40,000
Kendrick GA, Harvey EA, Van Niel K	Key ecological features – Abrolhos Islands WA	2011-2013	Australian National Environmental Research Program	$220,000
Kendrick GA, Van Niel K	Understanding the spatial ecology of the western rock lobster	2011	WA Department of Fisheries	$86,000
Lowe R	The role of ocean dynamics on seagrass seed dispersal along Western Australia	2011	UWA Research Development Awards	$20,820
Lowe R	Dynamics of time-dependent hydrodynamic processes in complex nearshore reef systems	2011	CSIRO Flagship Collaboration Fund	$84,000
Lowe R	Physical processes in complex coastal reef environments: the dynamics of wave and tide- dominated systems	2011-2015	ARC Future Fellowship	$681,000
McCulloch M, Ivey G, Lowe R, Falter J	Indian Ocean Climate Change: Ningaloo Reef, a litmus test for the survival of coral reefs	2011-2014	ARC Super Science Fellowships	$556,800
Meeuwig JJ	Benchmarking the fish assemblages of the Timor Sea's banks and shoals: is the Montara Oil Spill detectable?	2011	PTTEP AustAsia	$191,755
Meeuwig JJ et al.	Triangulating climate records derived from fish, marine invertebrates, and trees to predict marine fisheries productivity in the face of ocean warming	2011	ANNIMS	$298,022
Meeuwig JJ, Waddington KI	A comparison of diver and remote based benthic sampling	2011	Chevron – URS	$155,000
Meeuwig JJ, Waite AM	Megafauna interactions with oceanographic features	2011	Australian National Environmental Research Program	$507,000

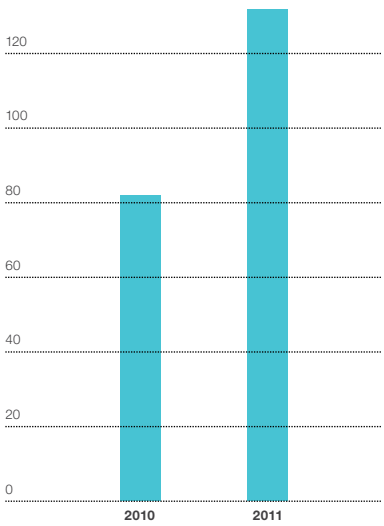
Researchers	Project Title	Funding Period	Funding Body	Amount
Pannell D, Renton M	Invasive species under climate change: Economic impacts	2011	Worldwide Universities Network Research Development Fund	
Pannell DJ, Rolfe JC, Burton MP, Meeuwig JJ	Do scientists' and public preferences diverge? Analysing expert and public preferences for environmental and social outcomes for the Swan River	2011	ARC Linkage Projects	$97,985
Pattiaratchi CB	Expansion of IMOS infrastructure in northern Australia	2011-2013	WA State Government	$6,000,000
Pattiaratchi CB	SEA SERPENT project	2011	ENI Australia	$200,000
Pattiaratchi CB, de Vos A	New insights into blue whales, the Sri Lankan enigma: linking oceanography, prey, and blue whale distribution in an ecological cul-de-sac	2011	UWA Research Collaboration Awards	$15,000
Pattiaratchi CB, de Vos A	Unravelling the blue: determining the relationship between blue whales and oceanic process off southern Sri Lanka	2011	Ocean Park Conservation Foundation	$9,994
Pattiaratchi CB, Gallop S, Bosserelle C	Long-term changes in perched beach morphology and response to climate change in Australia and the UK	2011	UWA Research Collaboration Awards	$12,500
Pattiaratchi CB, Haigh I	Comparing changes in extreme sea level: Australia and northern Europe	2011–2012	Go8 Germany Joint Research Co-operation Scheme	$14,400
Pattiaratchi CB, Haigh I	Sea level exceedance probabilities for Australia – stage 2: inclusion of tropical cyclone-induced surges	2011	Antarctic Climate and Ecosystems CRC, Department of Climate Change and Energy Efficiency	$122,000
Pattiaratchi CB, Haigh I	Sea level exceedance probabilities for Australia – stage 3: cyclone database	2011	WA Department of Transport	$70,000
Pattiaratchi CB, Mihanovic H	Group of Eight European Fellowship: Mihanovic	2011	Go8 European Fellowships	$20,000
Pattiaratchi CB, Thums M, Whiting S, Meekan M, Harcourt R, Pendoley K, McMahon C	Acoustic tracking and modelling services for marine wildlife	2011	WA Department of Environment and Conservation	$49,600
Ruiz C, McClanahan T, Zinke J	Evaluating current responses and projecting the effects of climate change on Western Indian Ocean coral reef ecosystems from historical environmental variability	2011-2014	Western Indian Ocean Marine Science Association – MASMA Grant	$150,000
Thrusher, Pecl, Wernberg T, Smale D, Tobin	Understanding the global impacts and implications of range-shifting species in marine systems	2011-2013	ANNIMS Issues in Marine Science Program	$300,000
Waite AM, Trull T	Sedimentation in the Southern Ocean	2011-2012	ANNIMS Springboard Program	$13,000
Walker DI, Kendrick GA, Haigh I	Shark Bay – effects of rising water levels on the Faure Sill and stromatolites.	2011-2013	Caring for our Country	$218,750
Wernberg T	Climatic forcing of ecological function in temperate marine habitats: bridging the gaps	2011-2015	ARC Future Fellowship	$697,000
Wernberg T, Gurgel F	Long term changes in the phenology of Australia;s temperate marine macroalgae – Has climate change impacted the worlds most diverse algal flora	2011	ARC Linkage Projects	$240,000
Wernberg T, Kendrick GA, Bolton J, Anderson R	SHARC: Southern Hemisphere Algal Research Collaboration	2011	UWA Research Collaboration Awards	$17,000
Wernberg T, Kendrick GA, Bolton J, Anderson R, Sjotun K	Global patterns of climate adaptation in kelps	2011	Worldwide Universities Network Research Development Fund	$24,000
Wernberg T, Kendrick GA, Johnson C, Wright J	Reproduction and ecophysiology of Ecklonia radiata at the margins of its Australian distribution	2011	ANNIMS Springboard Program	$28,000

TOTAL FUNDING $18,710,117

IMAGE/ EUAN HARVEY

Publications

Peer-reviewed journal articles❶



❶ Total number of peer-reviewed journal articles published by The UWA Oceans Institute members.

Oceans Institute members published 131 articles in peer-reviewed scientific journals in 2011, a 20 per cent increase from 2010. Two papers appeared in the top international journal *Science*: one on the pace of shifting climate in marine and terrestrial ecosystems (see page 16), the other which proposes a new international system to ensure the fair use of marine genetic resources.

Peer-reviewed scientific journals

1. Agawin NSR, Tovar-Sanchez A, Alvarez M, **Agustí S**, Stal LJ and **Duarte CM** (2011). Low water column nitrogen fixation in the Mediterranean Sea (Basin-wide experimental evidence). *Aquatic Microbial Ecology* **64**: 135-147.

2. Aires T, Marbá N, Cunha RL, **Kendrick GA**, Walker DI, Serrao EA, **Duarte CM** and Arnaud-Haond S (2011). Evolutionary history of the seagrass genus Posidonia. *Marine Ecology Progress Series* **421**: 117-130.

3. Arnaud-Haond S, Arrieta JM and **Duarte CM** (2011). Marine biodiversity and gene patents. *Science* **331**: 1521-1522.

4. Baird ME, Suthers IM, Griffin DA, **Hollings B**, **Pattiaratchi CB**, Everett JD, Roughan M, Oubelkheir K and Doblin M (2011). The effect of surface flooding on the physical-biogeochemical dynamics of a warm-core eddy off southeast Australia. *Deep Sea Research II: Topical Studies in Oceanography* **58**: 592-605.

5. **Barrington DJ**, **Ghadouani A** and **Ivey GN** (2011). Environmental factors and the application of hydrogen peroxide for the removal of toxic cyanobacteria from waste stabilization ponds. *Journal of Environmental Engineering, ASCE* **137**(10): 952-960. doi:10.1061/(ASCE)EE.1943-7870.0000401.

6. Bellchambers LM, **Meeuwig JJ**, Evans SN and Legendre P (2011). Modelling habitat associations of the common spider conch Lambis lambis in the Cocos (Keeling) Islands. *Marine Ecology Progress Series* **432**: 83-90.

7. Bellchambers LM, **Meeuwig JJ**, Evans SN and Legendre P (2011). Modelling habitat associations of 14 species of holothurians from an unfished coral atoll: implications for fisheries management. *Aquatic Biology* **14**: 57-66.

8. Black R, Johnson MS, **Prince J**, **Brearley A** and Bond T (2011). Evidence of large, local variations in recruitment and mortality in the small giant clam, *Tridacna maxima*, at Ningaloo Marine Park, Western Australia. *Marine and Freshwater Research* **62**: 1318-1326.

9. **Bluteau CE**, **Jones NL** and **Ivey GN** (2011). Dynamics of a tidally-forced stratified shear flow on the continental slope. *Journal of Geophysical Research—Oceans* **116**: C11017. doi:10.1029/2011JC007214.

10. **Bluteau CE**, **Jones NL** and **Ivey GN** (2011). Estimating turbulent kinetic energy dissipation using the inertial subrange method in environmental flows. *Limnology and Oceanography: Methods* **9**: 302-321. doi: 10.4319/lom.2011.9.302.

11. **Bosserelle C**, **Pattiaratchi C**, and **Haigh ID** (2011). Inter-annual variability and longer-term changes in the wave climate of Western Australia between 1970 and 2009. *Ocean Dynamics* doi: 10.1007/s10236-011-0487-3.

12. Brown CJ , DS Schoeman, Sydeman W, Brander K, Buckley L, Burrows M, **Duarte CM**, Moore PJ, Pandolfi JM, Poloczanska E, Venables W and Richardson AW (2011). Quantitative approaches in climate change ecology. *Global Change Biology* **17**: 3697-3713.

13. Burrows MT, Schoeman, DS, Buckley LB, Moore P, Poloczanska ES, Brander KM, Brown C, Bruno JF, **Duarte CM**, Halpern, BS, Holding J, Kappel CV, Kiessling W, O'Connor MI, Pandolfi JM, Parmesan C, Schwing F, Sydeman WF and Richardson AF (2011). The pace of shifting climate in marine and terrestrial ecosystems. *Science* **334**: 652-655.

14. Cahyarini Y, Pfeiffer M, Dullo W-C, **Zinke J**, Hetzinger S, Kasper S, Grove CA and Garbe-Schönberg D (2011). Comment on 'A snapshot of climate variability at Tahiti at 9.5 ka using a fossil coral from IODP Expedition 310,' by KL Delong, TM Quinn, Chuan-Chou Shen and Ke Lin (2010). *Geochemistry, Geophysics, Geosystems* **12**. doi:10.1029/2010GC003377.

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16. Carstensen J, Sánchez-Camacho M, **Duarte CM**, Krause-Jensen D and Marba N (2011). Connecting the dots: responses of coastal ecosystems to changing nutrient concentrations. *Environmental Science and Technology* **45**: 9122-9132.

17. **Cassidy MJ** (2011). Assessing the three-dimensional response of jack-up platforms in directional seas. Special Issue on *Energy Geotechnology — KSCE Journal of Civil Engineering* **15**(4): 623-634.

18. **Clode PL**, Lema K, Saunders M and Weiner S (2011). Skeletal mineralogy of newly settling *Acropora millepora* (Scleractinia) coral recruits. *Coral Reefs* doi: 10.1007/s00338-010-0673-7.

19. Cole AJ, Lawton RJ, Pratchett MS and **Wilson SK** (2011). Chronic coral consumption by butterflyfishes. *Coral Reefs* **30**:85-93. doi: 10.1007/s00338-010-0674-6.

20. **Cooper TF** and Fabricius KE (2011) Pigmentation of massive corals as a simple bioindicator for marine water quality. *Marine Pollution Bulletin* doi:10.1016/j.marpolbul.2011.07.01

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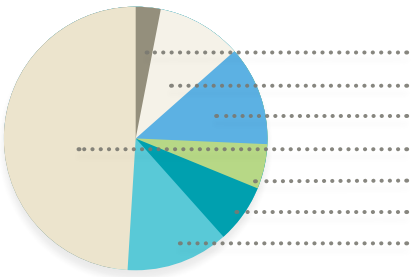
25. **Duarte CM** (2011). Molecular identification of the tropical seagrass *Halophila stipulacea* from Turkey. *Cahiers De Biologie Marine* **52**: 227-232.

Publications by research area



	Total
Ocean engineering	5
Marine biological resources❶	10
Impacts of climate change❷	15
Marine ecology	70
Marine observation❸	8
Blue water oceanography	9
Coastal processes	14
	131

❶ Marine biological resources, management, governance and conservation
❷ Impacts of climate change in the marine environment
❸ Marine observation, monitoring and risk management

26. **Duarte CM**, Kennedy H, Marbà N and Hendriks I (2011). Assessing the capacity of seagrass meadows for carbon burial: current limitations and future strategies. *Ocean & Coastal Management* doi 10.1016/j.ocecoaman.2011.09.001.

27. Fabricius KE, **Cooper TF**, Humphrey CA, Uthicke S, De'ath AG, Davidson J, LeGrand H, Thompson AA and Schaffelke B (2011). A bioindicator system for water quality on inshore coral reefs of the Great Barrier Reef. *Marine Pollution Bulletin* doi: 10.1016/j.marpolbul.2011.09.004.

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29. **Fisher R**, Knowlton N, Brainard RE and Caley MJ (2011). Differences among major taxa in the extent of ecological knowledge across four major ecosystems. *PLoS ONE* **6**: e26556.

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31. **Gagliano M**, Lema K, **Depczynski M** and Whalan S (2011). Use it and lose it: lipofuscin accumulation in the midbrain of a coral reef fish. *Journal of Fish Biology* **78**: 659-666.

32. **Gallop SL**, **Bosserelle C**, **Pattiaratchi C** and Eliot I (2011). Hydrodynamic and morphological response of a perched beach during sea breeze activity. *Journal of Coastal Research, Special Issue* **64**: 75-79.

33. **Gallop SL**, **Bosserelle C**, **Pattiaratchi C** and Eliot I (2011). Rock topography causes spatial variation in the wave, current and beach response to sea breeze activity. *Marine Geology* **290**: 29-40.

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IMAGE/ ALEX WYATT

IMAGE/ ALEX WYATT

Future directions
2012 and beyond

2009

- The UWA Oceans Institute is established

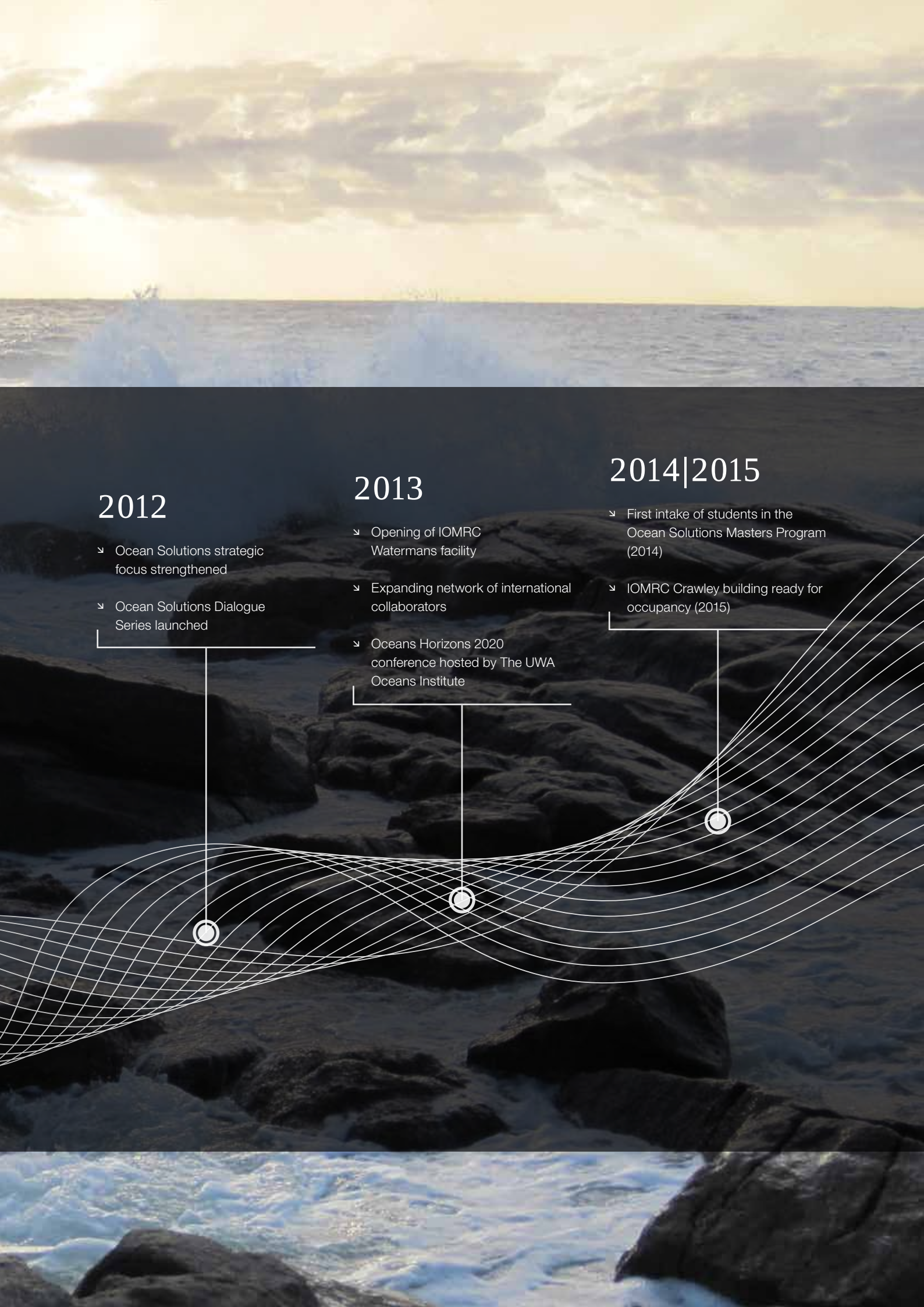
2010

- The UWA Oceans Institute is formally launched

2011

- IOMRC collaboration formed with AIMS, CSIRO and the Department of Fisheries
- Memorandum of Understanding signed with Consejo Superior de Investigaciones Cientificas (CSIC)

IMAGE/ CARLOS DUARTE



2012

- Ocean Solutions strategic focus strengthened
- Ocean Solutions Dialogue Series launched

2013

- Opening of IOMRC Watermans facility
- Expanding network of international collaborators
- Oceans Horizons 2020 conference hosted by The UWA Oceans Institute

2014|2015

- First intake of students in the Ocean Solutions Masters Program (2014)
- IOMRC Crawley building ready for occupancy (2015)

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