RESEARCH HIGHLIGHTS
REFLECTIVE

THE UNIVERSITY OF WESTERN AUSTRALIA | OCEANS INSTITUTE

The Oceans Institute is a meeting place for experts across all fields of ocean study. The ocean does not have borders and nor does knowledge; we believe that complicated problems demand a cross-disciplinary approach.

IMAGE
Nudibranch by Jo Watson

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Our Vision

A thriving and sustainable blue planet for future generations.

Our Mission

Under our stewardship, UWA will deepen our collective understanding of the world's oceans, leading an engaged community to address the challenges of the Indian Ocean and beyond through exploration, collaboration and innovation.

ABOUT THE OCEANS INSTITUTE

The Oceans Institute is a meeting place for experts across all fields of ocean study.

The Oceans Institute was founded in 2010 to bring about a new era of collaborative marine research at the University of Western Australia.

The ocean does not have borders and nor does knowledge; we believe that complicated problems demand a cross-disciplinary approach. Whether we are supporting the training of the next generation of offshore innovators, developing new marine research programs, or engaging with our local community, the Oceans Institute is committed to supporting scholarship about our blue planet for a better tomorrow.

ACKNOWLEDGEMENT OF COUNTRY

Sea Country
Wardan Boodja

We pay our respects to the past and present Traditional Owners of the land on which our experts reside, the Whadjuk Nyoongar people of Western Australia, and to all the native peoples of the lands and seas on which our researchers work.

STRENGTH IN COMMUNITY

The Oceans Institute brings together researchers, policymakers, industry leaders and ocean allies from across UWA and partner institutions. By uniting these experts, we foster fruitful partnerships that cross disciplines, industries and national borders.

Message from the Directors

We are now two years into the 2021-30 United Nations Decade of Oceans Science for Sustainable Development. Advancing transformative science to protect and develop sustainable usage of our oceans has never been more important, and the Oceans Institute (OI), through its talent, expertise and capabilities, is playing a critical role in growing the vitality and resilience of our oceans.

Early next year, the Institute will launch its 2024-28 Strategy, focussing on research outcomes that contribute to a better future for our oceans and our communities.

The Institute is focussed on amplifying the numerous collaborative and multidisciplinary projects in progress — all delivering significant impact across a broad range of important challenges. Sustainability, in our focus and in our practice; climate change adaptation and mitigation; partnership with First Nations people; equity, diversity and inclusiveness will guide our decisions and actions.

The OI has been collaborating with Traditional Owners in the South-west, including the Wadandi Rangers to conduct marine socio-economic and biodiversity surveys, and data analysis. This work is contributing valuable insights to Australian Marine Park reporting, guided by cultural wisdom and perspective.

In collaboration with Traditional Owners spanning Wudjari Sea County, the OI is actively involved in cultural seascape mapping and marine biodiversity discovery across the Eastern-Recherche Marine Park. This initiative is raising awareness of submerged cultural heritage in the southwest region of Australia.

The OI signed of 'The Blue Tonne Kelp Challenge Stage 2' project, representing the next step forward in what is shaping up to be a long and rewarding industry-driven research collaboration. Through our continued partnership with Canopy Blue, we are building significant research capacity and pushing the current boundaries of kelp culturing, seaweed farming, kelp restoration and carbon cycling, with implications for climate mitigation.

Offshore renewable energy is one of the world's fastest-growing energy industries and will play a crucial role in future sustainable energy production. As the renewable energy industry continues to grow, OI will remain at the forefront, developing innovative and transformative solutions to the world's energy challenges.

Continuing our commitment to innovation and excellence, we extend our expertise into the 'Omics' space, the Minderoo OceanOmics Centre at UWA. By harnessing the latest advances in DNA sequencing and analysis of environmental DNA' or 'eDNA' the facility will deliver major breakthroughs in the way global ocean health is measured and understood. This research is vital to inform conservation efforts before marine ecosystem and biodiversity loss becomes catastrophic.

Additionally, we have led national and international data synthesis efforts, consolidating fish and shark distribution data into publications that inform the design of effective marine conservation strategies.

These achievements only skim the surface of breadth and depth of the Oceans Institute's activities, and I invite you to find additional details in this report.

The success of the Ocean Institute is a collective endeavour that engages all its members and stakeholders, and I thank them all for their passion in driving excellence within the OI. I extend my thanks to all our supporters who have played an instrumental role in our accomplishments, without you the Institute could not achieve what it does and aim to reach new heights.

I would also like to express my gratitude to Associate Professor Julian Partridge's exceptional contributions to the UWA Oceans Institute during his tenure as Deputy Director and Director.

As we embark on the next chapter of the Institute's journey, I, alongside my team, look forward to progressing the Oceans Institute as our region's leading, multidisciplinary research hub for marine science and ocean conservation.

Professor Christophe Gaudin
DIRECTOR

Research Highlights Reflective 2020–22 presents an overview of the Institute's key achievements and accomplishments. We're proud to highlight how we engage with our communities, the excellence of our scientific endeavours, the significance of our partnerships, and the tangible impact of our research outcomes.

Message from the Directors

After 8 years at The University of Western Australia (UWA) I retired in October 2022, stepping down from the role of Oceans Institute (OI) Director and handing over the baton to Professor Christophe Gaudin. I look forward with anticipation to seeing the new directions Christophe will take the Institute.

Supporting the establishment of the Minderoo UWA Deep-Sea Research Centre is an achievement to celebrate: by bringing both new research capability to UWA and 'full ocean depth' research capacity to Australia. Similarly, the AIMS@UWA Alliance developed from an informal conversation to a rapidly growing partnership involving jointly supervised PhD students, co-funded postdoctoral researchers and more senior research staff, and increasing numbers of co-publications between AIMS staff and OI members.

The AIMS@UWA partnership has the potential to significantly boost the profile of tropical marine research from our base in Western Australia. Similarly, the large-scale Indian Ocean Marine Research Centre (IOMRC) ICoAST research work in Shark Bay, largely led by OI Early Career Researchers, the allied Gathaagudu Animal Tracking project, and the Malgana Sea Country Project are producing outstanding information essential for the management of this world heritage area.

Additionally, the Minderoo OceanOmics Centre at UWA marks a step-change for the OI, with the employment of a growing team of 9 OI research scientists and laboratory technical staff who will work alongside Minderoo researchers to advance the use of high throughput genetic sequencing marine species and marine environmental DNA.

Big projects are, however, just part of the OI's remit. Essentially, the OI exists primarily to support the diverse and internationally recognized high-quality marine research of OI Members, to increase marine research capacity at UWA, and to communicate this research to the broader community. In the face of the tight financial situation in the university sector the OI team, with valued support from UWA Development and Alumni Relations, have welcomed new philanthropic donors, both individual and corporate.

I am greatly appreciative of the generosity of the OI's Ocean Supporters, our philanthropic donors, whose invaluable financial assistance is now supporting diverse OI marine research projects, particularly helping mid-career researchers maximize their research impact. I also thank the OI Advisory Board Chair, Jock Clough, for his unwavering support, and his guidance to me personally. I also thank the Jock Clough Marine Foundation for funding the Robson and Robertson Awards which support research projects undertaken by OI postgraduates and early career marine researchers. The annual 'R&R' event is always an uplifting and inspiring reminder of the talent of the OI's emerging researchers.

I would like to end by thanking UWA for the opportunity to work as Director of the Oceans Institute and for the support of senior management, especially DVCRs Tim Colmer and Anna Nowak. It has been a privilege to have worked with so many smart, dedicated and engaged people across campus. There are far too many OI colleagues to thank here; please know that I recognise all of you for your dedication and support. I look forward to watching the OI forge ahead in the remaining years of the UN Decade of Ocean Science and linking its priorities to the UN Sustainable Development Goals.

Associate Professor
Julian Partridge
DIRECTOR (2020-2022)

Adapting to a global pandemic was certainly an unexpected challenge, but the OI kept going by innovating our communications and changing our priorities. Despite the restrictions of the last few years the OI achieved significant goals, and it is worth focusing on these major achievements.

Our Role in a Sustainable Future

Invigorated by the start of The Ocean Decade, the Oceans Institute is committed to supporting global efforts towards prosperity for people and the environment.

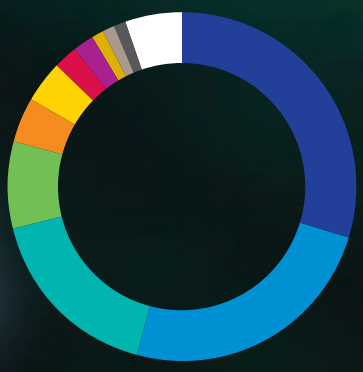
We actively support and work towards the United Nations Sustainable Development Goals (SDGs) that are most relevant to our field of research. The SDGs are the blueprint to achieve a better and more sustainable future for all, and our work centres around Goal 14 – Life Below Water.

This work is complemented by secondary focuses around Goal 2 – Zero Hunger, Goal 7 – Affordable and Clean Energy, Goal 12 – Responsible Consumption and Production, Goal 13 – Climate Action, Goal 15 – Life on Land, and Goal 17 – Partnerships for the goals. We contribute towards these global goals by conducting impactful research, providing world class education, inspiring our community, informing policy, and forging partnerships.

GOAL 14: LIFE BELOW WATER

The ocean drives global systems that make the Earth habitable for humankind. Careful management of this essential global resource is a key feature of a sustainable future. Saving our ocean must remain a priority as we face the growing challenges of overfishing, marine pollution, and ocean acidification.

Oceans Institute Highlights



AREAS/SUBJECTS OF RESEARCH

- Agricultural and Biological Sciences
- Environmental Science
- Earth and Planetary Sciences
- Engineering
- Biochemistry, Genetics and Molecular Biology
- Multidisciplinary
- Social Sciences
- Neuroscience
- Chemistry
- Computer Science
- Medicine
- Other

263
OCEANS INSTITUTE MEMBERS

45
INTERNATIONAL PARTNERS

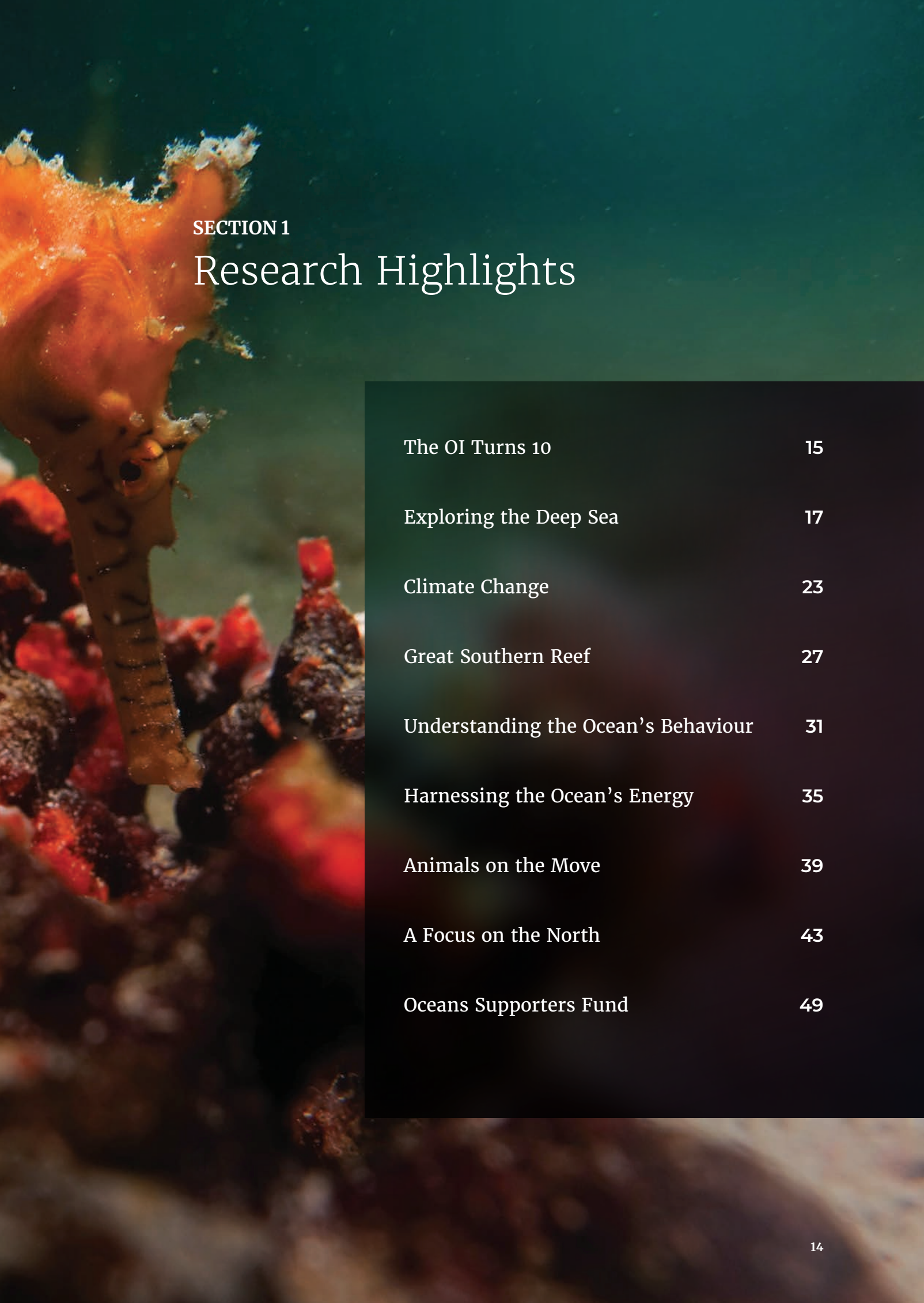
319
ANNUAL PUBLICATIONS

7
FOCUSED SGD'S

42
ANNUAL UWA IMPACT ARTICLES

50
PHD CANDIDATES

For over a decade, the UWA Oceans Institute has nurtured an ecosystem of researchers and educators to serve the needs of the ocean community of Western Australia, the Indian Ocean and the world.



SECTION 1

Research Highlights

The OI Turns 10

The Oceans Institute (OI) rounded out its first 10 years in December 2020, and entered the new decade with a refreshed vision, mission, and aesthetic to reflect its maturation as a leading research hub in the Indian Ocean region.

"The Oceans Institute has always been a place of multi-disciplinary research, full of diverse academics passionate about our blue planet," said UWA Adjunct Research Fellow Robert Pemberton. "We felt it was time that our vision and visual identity captured this passion, as well as the uniqueness of the Oceans Institute within The University of Western Australia and the Indian Ocean rim region as a whole."

The rebrand included a new colour palette, new style, website and collateral materials. "Promoting the Oceans Institute is not a difficult task. The ocean is a source of fascination for many people, and we were privileged to draw upon a great deal of arresting imagery of marine flora and fauna, coastal vistas and impressive research vessels to inform the Oceans Institute redesign," said the Creative Lead of the Oceans Institute re-design, Jo Tapodi.

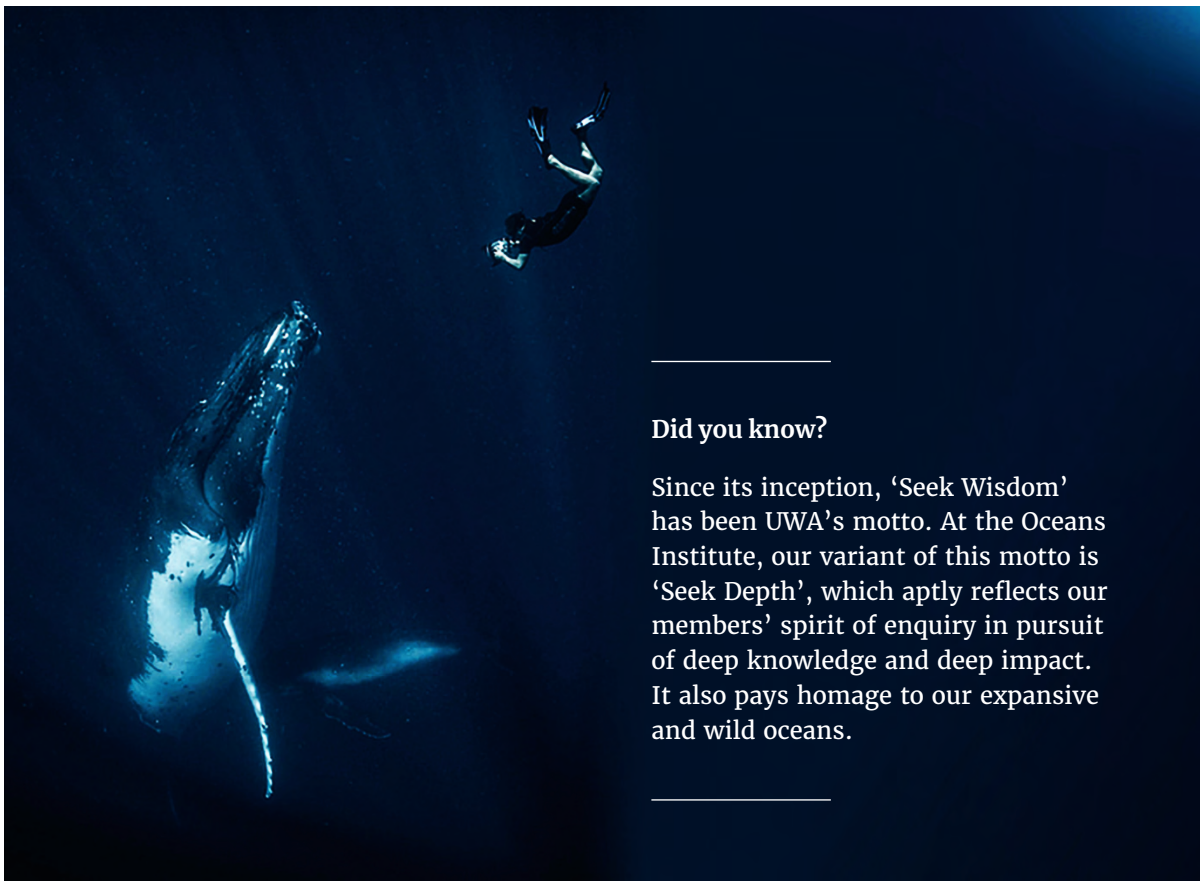
The OI worked with advertising agency The Brand Agency to develop a brand strategy in keeping with the University's master brand strategy that better positioned the Institute to achieve its key challenges: Improve global competition for share of heart and mind, curate innovative research projects, attract donors, and engage the ocean community. As well as a new vision for the Institute, the agency created a distinctive toolkit of brand assets as an extension of the UWA brand platform 'Seek Wisdom', developing a version for the OI: 'Seek Depth'.

A new immersive and engaging website was also created to tell the Institute's story, build its community, and match research projects with interested partners and engaged donors. "We wanted to create a site where the user felt like they were being immersed into the amazing depths of our ocean, and the further they travelled, the greater their sense of exploration," explained Dan Agostino, Head of Design at The Brand Agency. "It had to strike an even balance between aesthetics and functionality, all the while respecting the University's overarching identity."

The launch of the new website was a celebration of the importance of oceans research at UWA and the unique position of the OI in leading multidisciplinary research across the Indian Ocean and beyond. "We hope this site will become the front door to continued collaboration between scientists, industry leaders, policymakers and the wider community," said previous OI Director Julian Partridge at the launch.

To authentically reflect the OI experience, instead of using stock imagery, our website and media feature real imagery of OI research, and imagery taken by OI members. We are fortunate to have many talented photographers and videographers among our members who regularly work in and visit some of the world's most photogenic and inspiring locations. The ocean is the largest ecosystem in the world, offering boundless beauty, wonder, and opportunity for learning. We hope to continue to photograph, study, and protect the ocean for many decades to come.

The OI now moves into the future under the stewardship of Director, Christophe Gaudin. Together, we have done extraordinary work to address the greatest challenges facing our blue planet. Now, invigorated by recent global events, and with an increased urgency to address climate change, our work and our responsibility as a leading multi-disciplinary research hub continues.



Did you know?

Since its inception, 'Seek Wisdom' has been UWA's motto. At the Oceans Institute, our variant of this motto is 'Seek Depth', which aptly reflects our members' spirit of enquiry in pursuit of deep knowledge and deep impact. It also pays homage to our expansive and wild oceans.

Exploring the Deep Sea

PROFESSOR ALAN JAMIESON (FOUNDING DIRECTOR, MINDEROO-UWA DEEP-SEA RESEARCH CENTRE)

Professor Alan Jamieson is a biologist, engineer, explorer, and author, with over 20 years' experience in deep-sea science, technology, and exploration. We sat down with Alan to talk about his work in the deep ocean, the Hadal Zone.

It's great to be chatting with you, Alan. Could you tell us a little more about the Hadal Zone?

"The Hadal Zone sits at 6000 – 11000 meters below sea level. This is the deepest part of our ocean, and mostly lies within ocean trenches formed by tectonic movement. The word 'Hadal' was actually inspired by the name of the Greek god of the underworld - 'Hades'."

How many times have you visited the Hadal Zone?

"I've been a part of nearly 70 deep-sea expeditions spanning every ocean, I've done 16 submersible dives now including eight at hadal depths, of which two were deeper than 10,000 metres."

What kind of work do you do when you're down in the depths of the Hadal zone?

"This part of our planet is mostly unexplored and there are a lot of new things to learn, and we get to see wonderful things firsthand and for the first time. I specialise in where and why organisms live in the very deepest parts of the oceans. We dive in the world's most advanced submersibles, and we use some pretty unique technologies to collect data and samples while we're down there. In addition to my research identifying and studying deep-sea organisms, I've also been part of exploratory missions. I was the chief scientist of the 'Five Deeps' expedition, which successfully put the first person to the deepest point in every ocean, and have since remained with the submersible project through the Ring of Fire Expeditions in 2020-2022. I have recently signed up to remain with the ship and sub, as Chief Scientist, for another 5 years under a new ownership called Inkfish."

The Hadal zone must be an entirely different world to the one we live in up here. Can you tell us about the most surprising or unexpected thing you've learned about the ocean's depths?

"The most unexpected thing from the deepest parts of the oceans is that so many, if not most of our most familiar marine groups, like fish, crustaceans, sea anemones, and octopus, are present as deep as 8000m underwater. It's truly incredible how life always finds a way in the most seemingly inhospitable parts of our planet."

Incredible! Speaking of incredible, you currently hold a total of eight Guinness World Records – could you tell us a little more about those?

"Most of my Guinness World Records are for finding deep sea animals – Deepest Fish, Deepest Eel, Deepest Octopus, and so on. But there is one world record that is a little bit different.

In 2014, I was part of a team conducting research in the Mariana trench. We found a new species of deep-sea amphipod (a crustacean which resembles a shrimp). We collected some specimens using bait traps to confirm that this was in fact a new species. To our horror, on examination, one of the individuals was found to have plastic in its gut. Now keep in mind that this amphipod was living at over 6000 metres below sea level, and it was a species entirely new to science, and yet it was already being impacted by the rampant issue of plastic pollution in our oceans. The plastic was found to be PET, which is a plastic used in food and drink packaging. We were awarded the World Record for 'First New Species Contaminated with Plastic', but this time the record was a warning rather than a celebration."

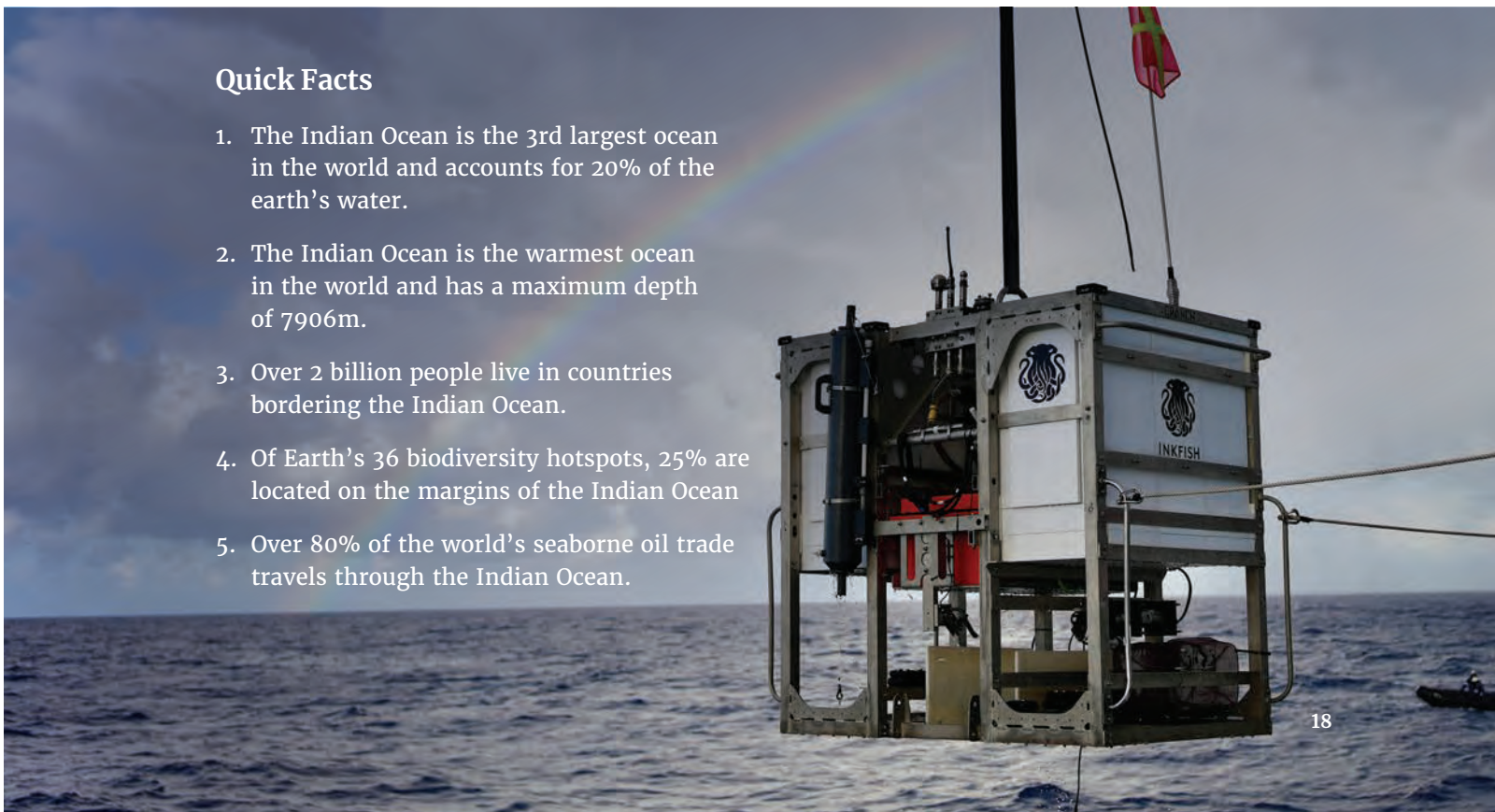
This is disheartening to hear. Is there anything that the average person can do to support our oceans?

Just remember that the oceans are one big connected body of water, and that the surface or the shallows are not any more important than the great depths. Most of planet Earth is deep-sea and we should think of it like that. I would ask that people challenge the stereotypical narrative that the deep- sea is a place of 'creatures of the abyss' and other such tropes, and think of it as a place with wonderful biodiversity and species that serve our ecosystem as much as our more familiar shallower species. We will never truly care for an environment that we are always being told is otherworldly or mysterious when it is just the ocean.

BELOW
Deep sea lander deployment (Image by Inkfsh)

Quick Facts

1. The Indian Ocean is the 3rd largest ocean in the world and accounts for 20% of the earth's water.
2. The Indian Ocean is the warmest ocean in the world and has a maximum depth of 7906m.
3. Over 2 billion people live in countries bordering the Indian Ocean.
4. Of Earth's 36 biodiversity hotspots, 25% are located on the margins of the Indian Ocean
5. Over 80% of the world's seaborne oil trade travels through the Indian Ocean.



MINDEROO-UWA DEEP-SEA RESEARCH CENTRE

The Hadal Zone is one of the largest continuous ecosystems on the plant. Yet, because of its profound depth, it has remained largely unexplored until now. The Minderoo-UWA Deep-Sea Research Centre was established with a mission to increase understanding about the deepest parts of the ocean through research in the Hadal Zone, and is the only deep-sea research team on the Indian Ocean Rim.

Building an understanding of deep-sea ecosystems, processes, and the human impacts on these areas is a crucial part of the effective and sustainable management of the oceans. The Centre aims to gather this much-needed knowledge by exploring the deepest areas of the Indian Ocean and beyond. Their work includes a variety of exploration and investigation activities such as mapping the ocean floor, discovering new species, assessment biodiversity, and charting deep-sea habitats.

Future goals for the Centre are to explore places no person has gone before, and ultimately acquire datasets and insight from the extreme depths across a geographical expanse that was recently not thought possible.

The Minderoo-UWA Deep-Sea Research Centre has been supported with a major five-year grant from Minderoo Foundation's Flourishing Oceans initiative, as part of its commitment to increasing knowledge of the deep sea and to return the oceans to a healthy, thriving state.

ABOVE
Lander Deployment

RIGHT
Members of the Minderoo-UWA Deep-Sea Research Centre

RESEARCH EXPEDITION OVERVIEW

Scientists from The Minderoo-UWA Deep-Sea Research Centre embarked on a 25-day voyage aboard the Deep Submersible Support Vessel (DSSV) Pressure Drop to explore, sample and map key seabed features of the East Indian Ocean at abyssal and hadal depths between 3,000 – 8,000 metres.

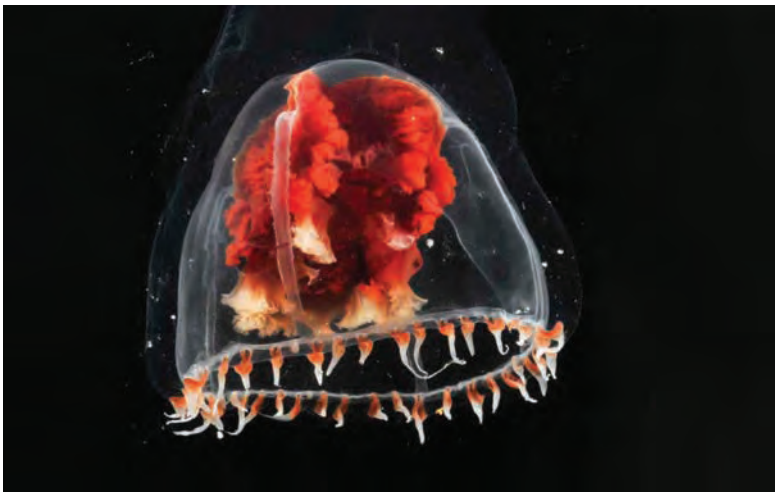
The Deep Submergence Vehicle (DSV) was deployed 8 times at sites across the Eastern Indian Ocean, taking onboard researchers to full ocean depth. Three lander vehicles were also deployed, allowing the team to observe and monitor deep sea life and the environment. High-resolution 3D charts of the sea floor were produced with the ship's multibeam echosounder.

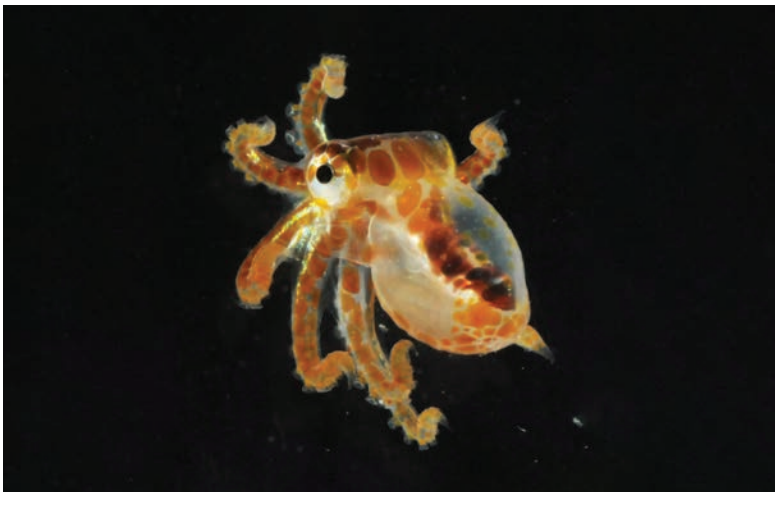
The trip explored three sites of interest: the Wallaby-Zenith Fracture Zone (WZFZ), the Wallaby-Cuvier Escarpment (WCE), and the Perth Canyon (PC).

The expedition mapped over 20,000 square kilometres of seafloor, collecting hydrographic data, and acquiring over 250 hours of video footage of deep-sea fauna and habitat from some of the deepest and most complex sea-floor structures in the Indian Ocean. The combined data collected provides information about the region's deep-sea habitats and environments, and will allow researchers to interpret the results of initial biodiversity and biomass surveys in the depths of the East Indian Ocean.

The largest discovery made during this expedition was the sheer density, expanse, and depth of manganese nodule fields within the Wallaby Zenith Fracture Zone. Manganese nodule fields are areas where the sea floor is covered in rounded uniform rock-like structures formed by manganese and iron. These manganese nodules can be microscopic, quite large, but they are usually between 3cm and 10cm (about the size of eggs or potatoes). The diversity of animals inhabiting these manganese nodule fields surprised even the most experienced on board.

Following on from this initial expedition, the team embarked on a 14-day voyage aboard the Pangaea Ocean Explorer to explore, sample, and map key seabed features off the southwest of Australia, at abyssal and hadal depths between 3,000 - 7,000 metres.





The trip explored two sites of interest: the Diamantina Fracture Zone (DFZ) and the Naturaliste Plateau (NP). Reaching depth of around 7,000 meters, the Diamantina Fracture Zone is the deepest point off the Australian mainland. Descending to 6,500m below the surface, two previously undiscovered species of snailfish (*Liparidae*) were found. At these depths, they are the deepest fish ever caught off Australia.

The Naturaliste Plateau is recognised for its biodiversity, featuring a unique seafloor that resembles a massive island under the sea. The area is thought to host a number of unique marine species yet to be discovered. Further dives and observations were made in this area, and full details of the trip are still to be released.

The DSSV Pressure Drop has recently been renamed the RV Dagon, while the DSV Limiting Factor is now known as the Bakunawa.

DOWN TO THE DEPTHS

To reach the ocean floor, the team used the Deep Submergence Vehicle Limiting Factor, a world-class two-person full ocean depth submersible.

This sub is the only human-occupied vessel that can visit anywhere in our oceans, no matter the depth. The Limiting Factor is also the first deep sea vehicle that can make multiple journeys to the ocean's deepest parts. Previous manned submersibles have been single-trip vehicles, unable to withstand the enormous pressures 11,000m below the surface more than once.

The $50 million Limiting Factor is equipped with a wide range of scientific sampling equipment, 4K cameras, high-performance lighting and a highly agile multi-axis manipulator arm. Technology within the titanium hulled sub allows for dives of up to 16 hours at a time. The Limiting Factor measures 4.6m long, 1.9m wide and 3.7m high and is strangely square-shaped compared to traditional submarines. This permits are relatively quick ascent to the deepest parts of the oceans.

"The journey is surprisingly graceful. The word 'extreme' is often used to describe these depths, but the experience in the sub is very humbling, peaceful and utterly fascinating", described Professor Alan Jamieson. *"It might not be everyone's idea of a fun day out, but to be honest, it is a very pleasant experience."*

The expedition was a joint scientific mission between the Minderoo Foundation and Caladan Oceanic.

ABOVE
The DSV Limiting Factor (recently renamed the Bakunawa)

LEFT
DSSV Pressure Drop (recently renamed the RV Dagon)

Climate Change

Climate change represents a threat to both terrestrial and aquatic ecosystems, however, researchers at the Oceans Institute (OI) are at the forefront of climate research, studying and describing the impacts of climate change and warming events on marine food chains and genetic diversity. Research is highlighting the impending threat of sea levels rising on our coastal cities and ecosystems. Despite the at-times alarming findings of these studies, research using 'Ocean Gliders' shows us that the ocean could also provide us with the valuable answers we need to combat climate change and understand the impacts of its progression.

GLOBAL WARMING POSES THREAT TO MARINE FOOD CHAINS

Global warming is already having far-reaching effects on our oceans and influencing the delicate balance and efficiency of marine food chains. UWA OI Adjunct Senior Research Fellow, Dr Diego Barneche, is part of an international collaboration deciphering this phenomenon and the threat it poses to the survival of larger animals.

The research team, consisting of experts from the University of Exeter, Queen Mary University of London and the Australian Institute of Marine Science, have been studying the transfer of energy and nutrients up an aquatic food chain. In particular, the team is interested in the impact of increasing water temperatures on single-celled algae (phytoplankton) and the microscopic animals that feast on them (zooplankton).

The team's seven-year experiment (2006-2013), conducted in warming artificial freshwater ponds, simulated a 4°C warming relative to ambient temperatures. The experiment resulted in a reduction in nitrogen transfer efficiency, ultimately leading to a decline in how much energy is

passed on through the food chain from these foundation species to their predators.

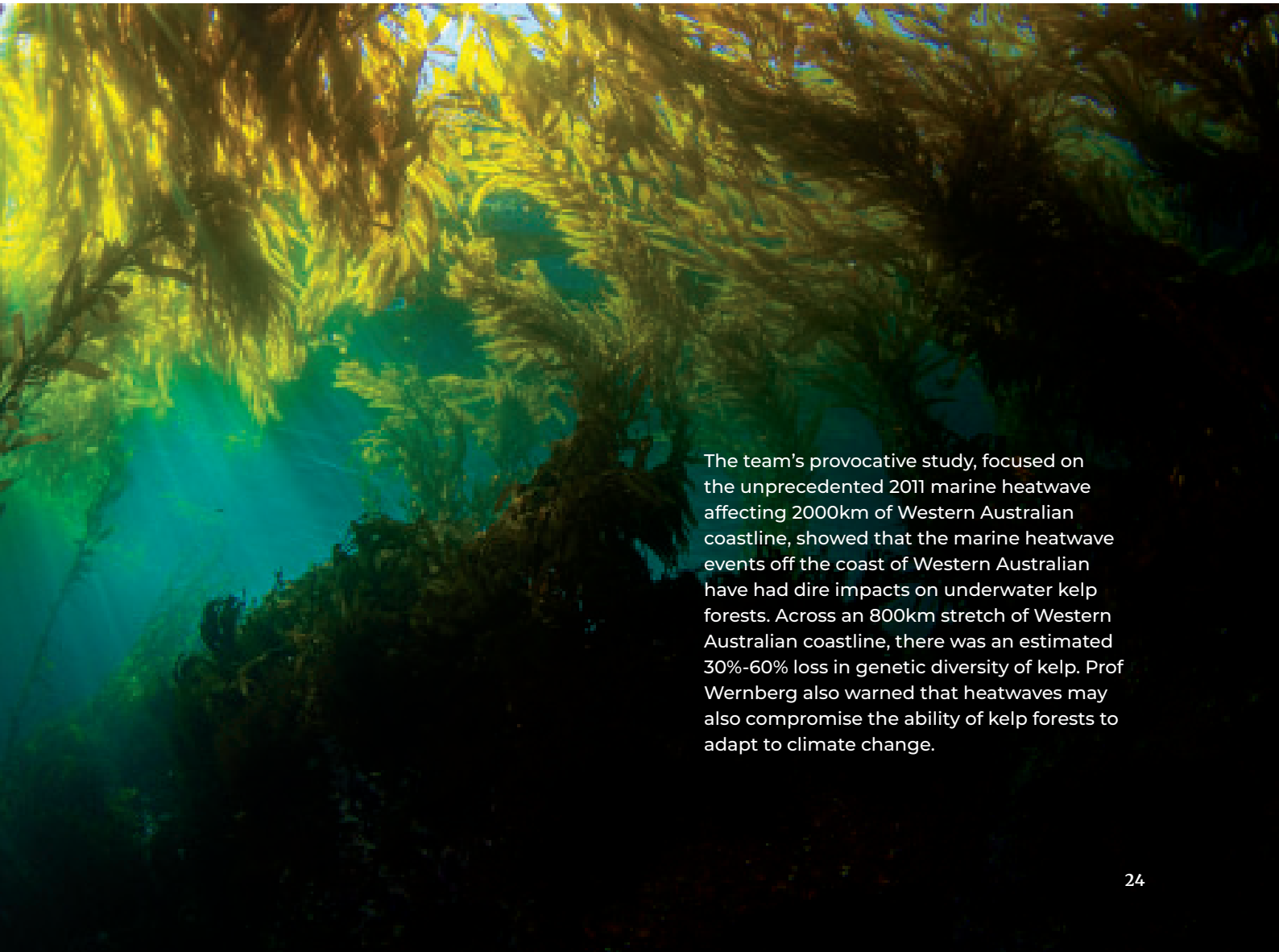
"When an organism eats, about 90% of the energy it consumes is expended, and about 10% of the energy it consumes is stored in its biomass. This means that only 10% of the energy at one level of the food web makes it up to the next level, and that food scarcity on the lower levels impacts organisms on the higher levels."

– Dr Diego Barneche
UWA Oceans Institute, Senior Research Fellow

MARINE HEATWAVES COMPROMISE KELP FOREST ADAPTABILITY TO CLIMATE CHANGE

In recent decades, marine heatwaves and extreme warming events have wreaked havoc on coastal marine species and ecosystems within Western Australia.

A recent study conducted by a team of international collaborators, including Professor Thomas Wernberg from the OI and UWA Adjunct Professor Melinda Coleman, investigated the response of kelp forests to these climate change events.



The team's provocative study, focused on the unprecedented 2011 marine heatwave affecting 2000km of Western Australian coastline, showed that the marine heatwave events off the coast of Western Australian have had dire impacts on underwater kelp forests. Across an 800km stretch of Western Australian coastline, there was an estimated 30%-60% loss in genetic diversity of kelp. Prof Wernberg also warned that heatwaves may also compromise the ability of kelp forests to adapt to climate change.

"The ecological impacts of extreme climate events are obvious and well documented, but little is known about their impact on genetic diversity and adaptability."

– Professor Thomas Wernberg
UWA Oceans Institute & School of Biological Sciences

The study also found that two ecologically important kelp species (*Sargassum Fallax* and *Scytothalia Dorycarpa*) were severely impacted, with 100% loss of these species in some areas. Despite the significance of these findings, this species loss would not have been detected using the conventional measures of kelp forest cover that are usually employed to determine the ecological impacts of marine heatwaves. This means that it is possible we have previously underestimated the impact of marine heatwaves.

Genetic data, for the first time, has shed light on the true extent of the kelp's adaptability and response to these extreme warming events.

EXTREME SEA LEVEL POSING THREAT TO LOW-LYING WA COASTLINE

Coastal flooding risk to the WA coastline is a not-too-distant reality. Accelerated by extreme sea level rise, the impact could have far-reaching impacts on coastal populations, infrastructure, and low-lying flood-prone areas - presenting many challenges for the future.

Professor Ryan Lowe and a team of researchers from UWA's Oceans Graduate School have utilised a 50-year dataset of sea level trajectories and climate cycle data to highlight a likely acceleration in coastal flooding risk in the future.

"With sea levels increasing at a steady 3 to 5 millimetres per year, the occurrence of stronger La Niña events in recent decades, especially the largest in modern history (2010 – 2012), has caused the frequency of extreme sea levels to increase," Prof Lowe said.

During the La Niña climate phases, there is a significant rise in sea levels in ocean waters north of Western Australia, which are carried along the coast by the southward moving

Leeuwin Current. The team show that sea levels can vary by as high as 30 centimetres during these climatic events, double the total sea level rise which has occurred over the past 50 years in Western Australia.

The research published in *Earth's Future* supports a call for action by government and authorities to enhance the protection, mitigation, and climate adaptation strategies to stem the impacts of future coastal flooding and erosion.

"We must develop new solutions for large-scale coastal erosion. Conventional ways of protecting the coastline such as sea walls and breakwaters may become increasingly unsustainable as the problem worsens."

– Professor Ryan Lowe
UWA Oceans Institute & Oceans Graduate School

HOW AUTONOMOUS UNDERWATER VEHICLES ARE PROVIDING MUCH NEEDED DATA ON OCEAN WEATHER

OI researchers have been using sophisticated ocean gliders to collect real-time 'ocean weather' data, such as temperature, salinity, dissolved oxygen, and currents. This pioneering mission, led by Professor Chari Pattiaratchi, from the UWA OI and Oceans Graduate School, will use the collected real-time data to study the impacts of climate change on our oceans, predict both marine and land heatwave events, and predict cyclones and typhoons.

"We are particularly interested in analysing tidal mixing which plays a strong role in controlling ocean temperatures," Prof Pattiaratchi said.

Their operation involves a series of ocean gliders from the Australian Integrated Marine Observing Systems (IMOS) facility. These gliders are currently collecting data off of Western and Northern Australia, and are also working on circumnavigating the rim of the Indian Ocean. The team aims to expand the deployment of gliders off northern WA, the Great Barrier Reef (Queensland) and coastal New South Wales.

Great Southern Reef

The Great Southern Reef is a massive series of reefs that extend around 8,000 kilometres of Australia's southern and western coastlines, covering an area of around 71,000 km2 from New South Wales and Tasmania in the East, to Kalbarri in the West. Thanks to the work of Oceans Institute (OI) researcher Dr Sahira Bell, the Great Southern Reef was named a 'Hope Spot' by the Mission Blue Foundation in 2019, "in recognition of the reef's exquisite, raw beauty, immensely rich biodiversity, indigenous values and the important work local stewards in the area have dedicated to research, education and public awareness." (Mission Blue, 2019).

A NEW HOPE FOR OUR REEF

Mission Blue bestows the title of 'Hope Spot' to areas that are scientifically identified as being critical to the overall health of the ocean and planet.

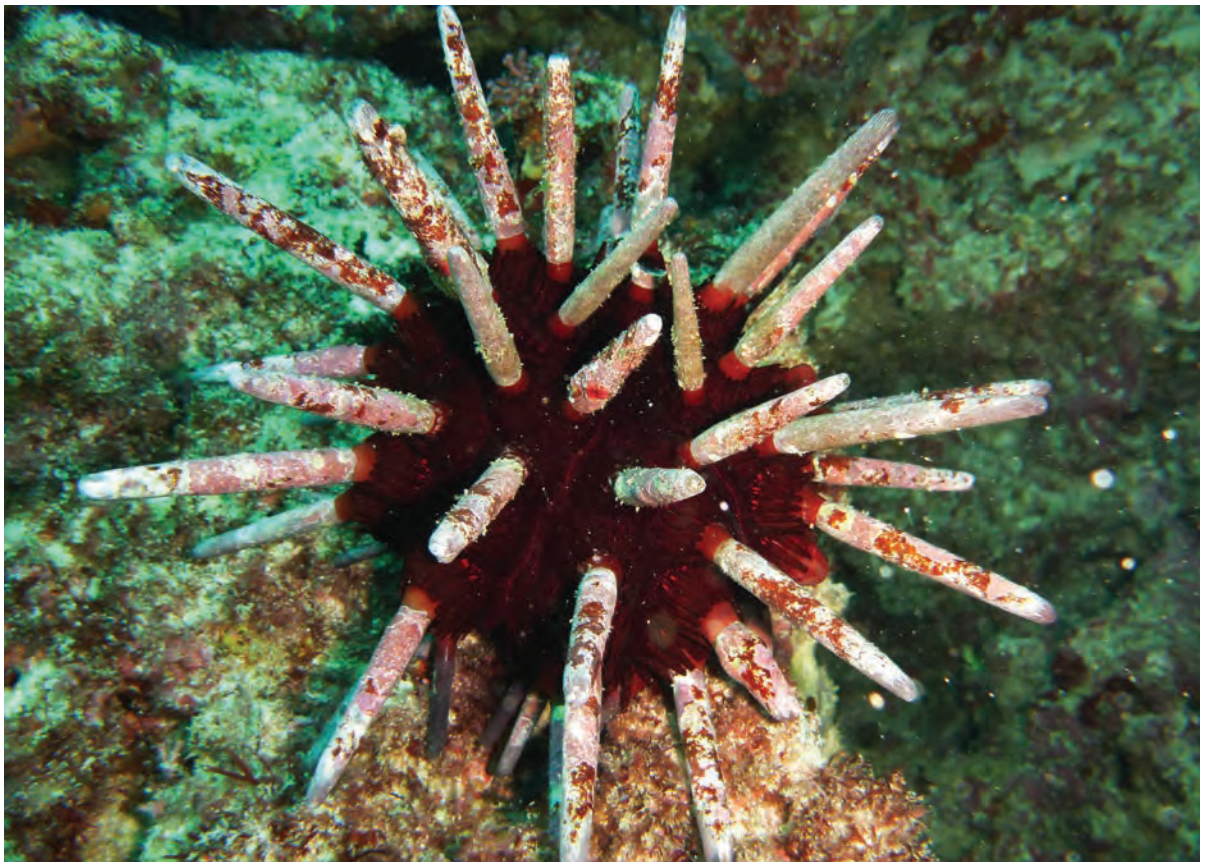
A significant characteristic of the Great Southern Reef are its extensive kelp seaweed forests. These kelp forests are some of the most productive ecosystems on the planet, and they support diverse populations of sponges, crustaceans, fish, bryozoans, echinoderms and many types of molluscs. Many iconic species living on the Great Southern Reef, like the Weedy Seadragon (*Phyllopteryx taeniolatus*) are endemic, meaning that they are found nowhere else on Earth. In places, endemism on the reef can exceed 80%.

"I was actually looking through other Mission Blue Hope Spots on social media, and it suddenly struck me that the Great Southern Reef was equally deserving and equally under threat", recounted Dr Bell.

"I almost couldn't believe it when Mission Blue came back to me and said this was exactly the sort of marine region they are looking for, and how even they were surprised that this incredible ecosystem existed without them knowing about it."

– Dr Sahira Bell
DBCA research scientist and
Oceans Institute Member

Mission Blue founder, marine biologist, and ocean activist Dr Sylvia Earle believes more needs to be done to safeguard the reef. "We need to embrace the identity of the Great Southern Reef so all can understand and appreciate this ecosystem," Dr Earle said. "There is so much that remains unknown about the life on this magnificent temperate reef".



While the reef system is a huge interconnected underwater system spanning thousands of kilometres, there are very few densely populated areas along the southern coast of Australia. It is therefore important to publicly identify this reef system. Dr Scott Bennet, the Tasmanian researcher and UWA Wernberg Lab PhD Graduate who initially defined the reef as an entity, highlighted this issue "This reef system is so immense yet towns are often hundreds of kilometres apart meaning local passion and pride is diffused across the continent. By giving these reefs an identity, our aim is to unite Australia's coastal communities along this isolated and wild coast."

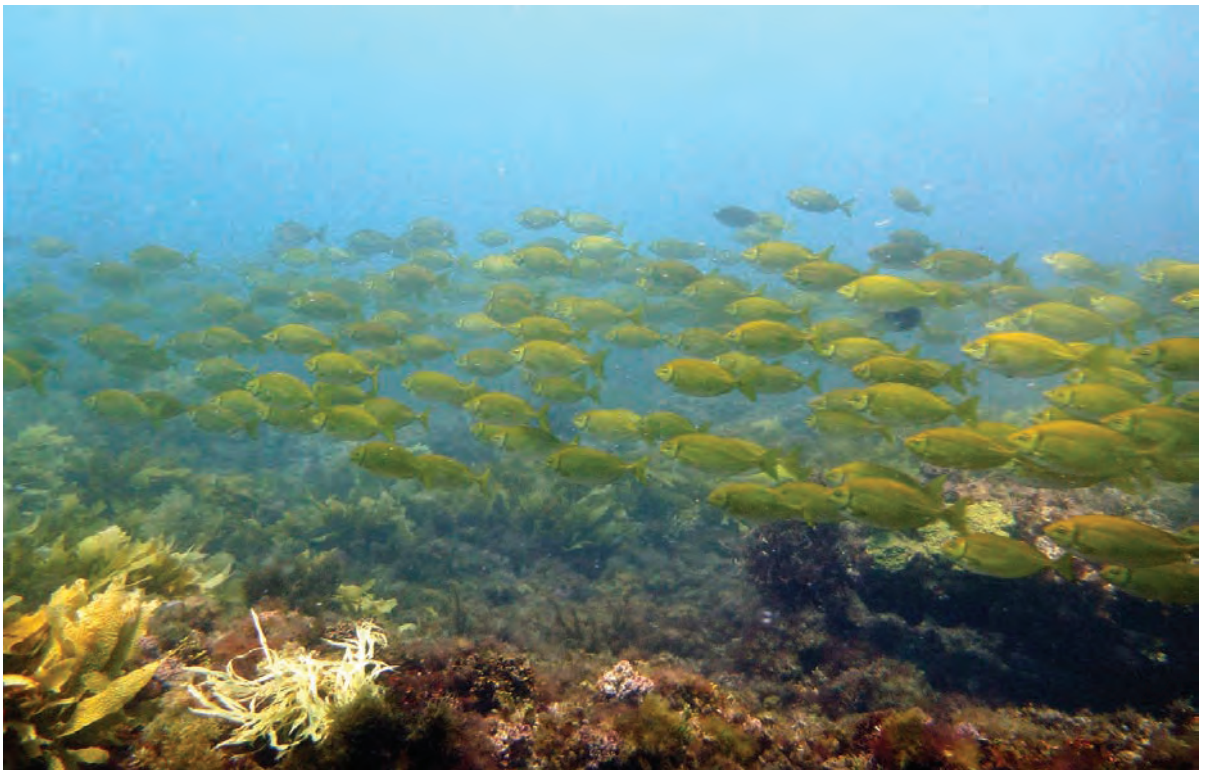
The reef also supports economic activities along Australia's southern coastline, including commercial and recreational fishing, scuba diving, surfing and other recreational tourism. These activities contribute at least $10 billion annually to the Australian economy.

GREAT SOUTHERN REEF COLLABORATORS

During 2020 and 2021, a significant amount of research was completed around the Great Southern Reef. OI members Professor Thomas Wernberg, Dr Tim Langlois, Dr Julie Trotter, Professor Ryan Lowe and Dr Karen Filbee-Dexter (to name a few) have all added to the wealth of knowledge on the Great Southern Reef, from its ecology to its importance in coastal processes.

Interesting discoveries include stunning 'gardens' of deep-sea corals in Bremer Canyon Marine Park which were uncovered during an oceanographic expedition. It was also found that a massive loss of genetic diversity in underwater kelp forests was caused by the worst marine heatwave ever recorded off Western Australia. The power of 'citizen science' is also helping add to the data banks with a new beach monitoring solution boosting our researchers capacity to make more informed scientific decisions.

Additionally, the largest assessment of marine sanctuaries in Australia has found Australia is successful at protecting many fish species, with the collaborative effort resulting in high-quality, valuable data. This data has the potential to help policy-makers and government conserve marine biodiversity by providing a blueprint for protecting Australia's marine life.



KELP - WONDER MATERIAL

The Great Southern Reef is defined by forests of iconic golden kelp (*Ecklonia radiata*). These kelp form the backbone of the reef's food chain. The Great Southern Reef is also home to Giant Kelp, Bull Kelp, and 435 unique species of red seaweed.

Kelp forests also have high economic value and support many fisheries, including the rock lobster and abalone, and do not require any fertilisers to grow.

Giant kelp is being investigated worldwide as a future source of biofuel, while red seaweed has the potential to reduce carbon emissions from sheep and cattle when used as a food additive.

Golden kelp is packed with vitamins A, B and C, iron and protein. It can be ground into granules and added to cooking as a healthy salt substitute and flavour enhancer.

History of the Concept

University of Western Australia researchers proposed the name "Great Southern Reef" in 2016 to solidify its unique identity and importance and raise awareness of the risk that climate change poses to temperate Australian reefs.

Now recognised as a Hope Spot by Mission Blue, the Great Southern Reef can prove to the world that there is more to marine environments than tropical coral reefs, and that temperate reefs are just as spectacular. A spotlight on the Great Southern Reef will hopefully motivate increased protection and research efforts for this incredible part of our ocean.

Understanding the Ocean's Behaviour

Physical Oceanography is about understanding the behaviour of our oceans. Due to the ocean's vastness, we still have much to learn about the physical processes that drive ocean circulation, transport of heat, and the characteristics of the ocean's tides, waves, turbulence, and other phenomena.

Understanding our immense oceans requires an equally immense amount of data. From citizen science to the most modern of monitoring technologies, the Oceans Institute (OI) is part of several state, national, and international initiatives that are gathering the required data sets. Thanks to these collaborative initiatives, we are increasingly able to make informed decisions about the conservation and management of our ocean's resources and provide people and communities with warnings about natural hazards such as coastal erosion and inundation, marine heatwaves, and cyclones.

INTEGRATED MARINE OBSERVING SYSTEM (IMOS) AND WAIMOS

The OI is proud to partner with IMOS, a large, diverse, and dispersed research infrastructure that gathers data about Australia's coast and open seas, making the data freely available through their Australian Ocean Data Network to Australia's scientists, students, industries, and other national and international stakeholders. This high-quality marine and climate data informs research, science, policy, and industry.

WAIMOS is the WA component of IMOS, offering ocean monitoring from the Southwest to Kimberley.

In Australia's South-West, WAIMOS monitors the Leeuwin Current, a warm ocean current that flows southwards along the coast of Western Australia. Data gathered holds valuable information about this current's influence on the climate and coastal sea levels as well as ecosystem connectivity and WA's unique biodiversity.

The Indonesian Throughflow

This ocean current is one of the largest movements of water on earth and plays an important role in the global climate. The volume of water moving in this current is so vast, that a unique measurement was developed to quantify it: a 'Sverdrup' equates to one million cubic meters of water per second. The Indonesian Throughflow is estimated at 15 Sverdrups.

In Australia's North-West, WAIMOS is focused on understanding the impacts of the Indonesian Throughflow current. The North-West is also home to significant marine-based industries, and interest in the region's natural resources is increasing. This interest signals potential rapid social and economic changes for the region, however, rich data will be required to inform management and policy decisions for this region in the near future.

WAVE BUOY NETWORK

The UWA Buoy program, run by OI members Dr Michael Cuttler, A/Professor Jeff Hansen, Professor Ryan Lowe and Dr Camille Grimaldi, includes a network of both moored and drifting surface wave buoys. The real-time data that they provide complements existing observations collected by the WA government. This real-time capability is afforded by buoy-satellite data transmission, and has been particularly valuable in remote coastal regions around WA and in the Southern and Indian Oceans.

Several buoys are supported by IMOS, while funding from other research projects and partnerships continues to expand the buoy network. Buoys have been deployed from Bremer Canyon to the Rowley Shoals. Drifting buoys have also been deployed to assimilate in wave forecast models. The wave data collected by these drifting buoys fills an observational data gap, with wave measurements within the Southern and Indian Oceans being rare.

These wave buoys provide live measurements on the state of the ocean surface, recording information on wave height, period, and direction. This information has many potential applications.

Collecting accurate observations of surface waves helps verify and improve marine forecasts. It can provide novel insights about the wave conditions responsible for coastal hazards such as erosion and flooding, as well as recent severe storms impacting WA, including Tropical Cyclone Seroja and the 2020 Perth super storm. Wave data collected off the coast of Albany has been contributing to wave energy research projects,

while also supporting research into coastal storm impacts and rock fishing safety. Data also assists with wave model development and verification, wave climate analyses, and has even been used for the calibration and validation of new satellite instruments.

Using temperature sensors integrated into the wave buoys and their moorings, UWA buoys are also monitoring marine heatwave impacts to coral reefs in a collaboration with the Minderoo Foundation and WA marine management agencies.

The UWA wave buoy team is part of a current Australian Research Data Commons project that is standardising wave buoy data from across all wave buoys currently deployed in Australia.

Beyond offering enormous research value, the data collected is also publicly available at www.wawaves.org, where it is streamed in near real time, and may be used for marine recreation by boaters, surfers, and fishers to assess near real-time safety conditions.

COASTSNAP WA

The coastline forms the energetic interface between the land and the ocean and is also used by a diverse range of stakeholders, often with competing interests. Coastal and marine ecosystems provide habitats for many organisms, from microscopic, unseen mud-dwelling infauna, to highly visible well-known animals like fish, birds and sea turtles.

Furthermore, much of Australia's coastal population lives in coastal regions. All of these coastal communities are vulnerable to flooding events, coastal erosion and destabilisation, biodiversity loss, and salinisation of aquifers, wetlands, and estuaries.

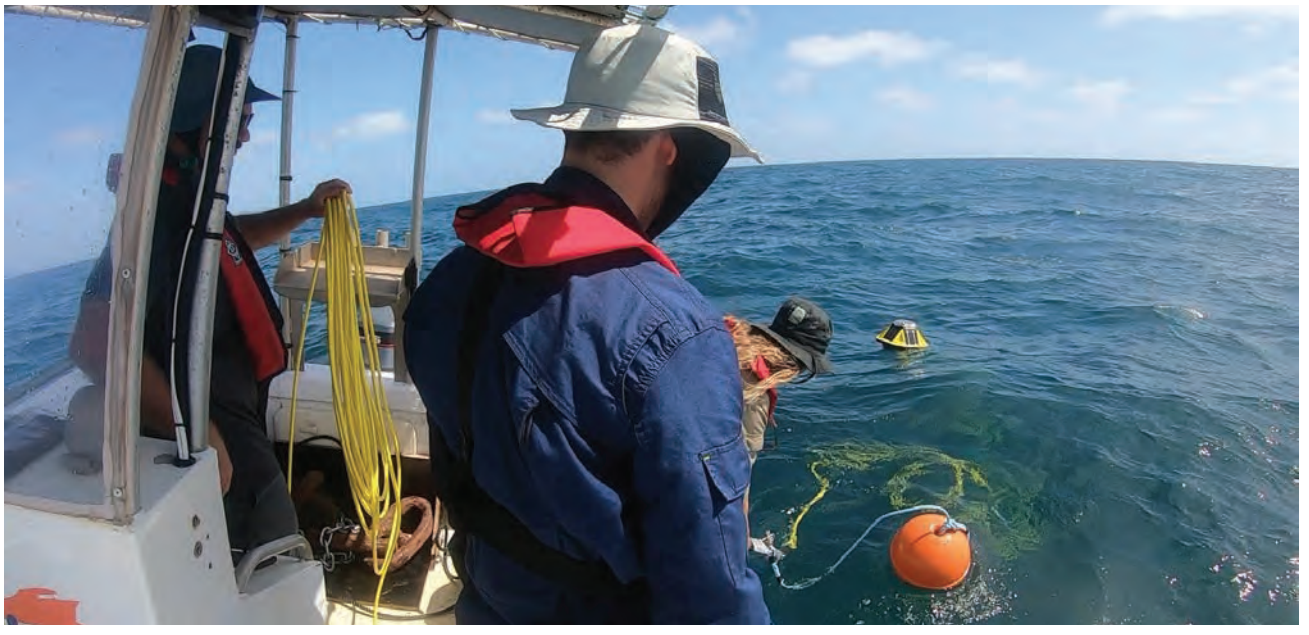
Launched by UWA researchers in collaboration with the Peron Naturaliste Partnership, CoastSnap WA invites local community members to help collect valuable data. The CoastSnap beach monitoring program, initially started by the University of New South Wales, has now spread worldwide. In Australia's Southwest, the CoastSnap WA initiative provides photo monitoring points which allow beachgoers to capture and upload identically framed pictures of the coastline at nine beaches between Rockingham and Busselton. This citizen science initiative aims to enhance understanding of coastal processes and how beaches evolve in response to changing ocean conditions.

Sustained erosion occurs due to sea level rise and other long-term changes in ocean conditions, but extreme erosion can also occur over a few days in response to storm events. Scientists' ability to understand and predict coastal changes, and therefore inform coastal management, relies on continual observations of coastal response. "With one of the largest and remote coastlines, it is incredibly difficult for coastal researchers to regularly monitor the coastline at sufficient time intervals and collect enough data to support science-based decisions on coastal management" said OI Postdoctoral scholar Dr Michael Cuttler.

"The data gathered from community members through the initiative will supplement existing coastline information, boosting our capacity to make more informed management decisions."

– Dr Michael Cuttler
Oceans Institute Postdoctoral Scholar

In 2020 CoastSnap WA received over 800 images from over 300 community members across target sites. Once received, imagery processed into time-lapse videos and re-distributed to the public via social media for visualising coastal change. Quantitative measurements on beach state (beach width, shoreline position) are also extracted from the photos, which can complement existing measurements and be used to inform coastal management by local governments.



Harnessing the Ocean's Energy

The 2021 Intergovernmental Panel on Climate Change (IPCC) report on climate change emphasised what the scientific community around the world have known for many years, "it is unequivocal that human influence has warmed the atmosphere, ocean and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred".

To address this urgent and growing challenge, transformative changes to the ways we generate and use energy will be required. Offshore wind and wave energy offer substantial resources, with all efforts governed by the needs of the marine environment. Working with international collaborators in both academia and industry, Oceans Institute (OI) researchers are making tremendous contributions to making large-scale sustainable offshore energy production a reality.

THE BLUE ECONOMY

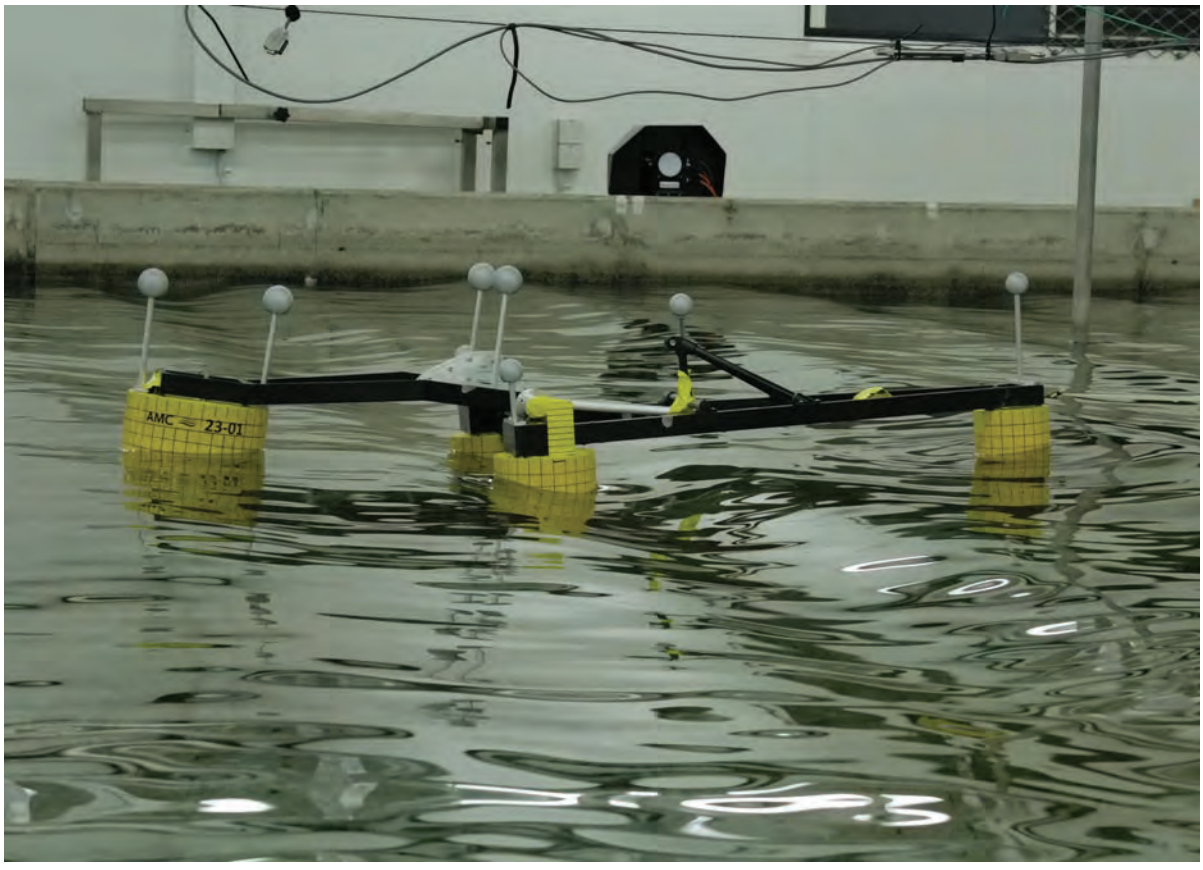
While the ocean offers many natural resources, it also requires our respect and ongoing management and support in order to continue to provide. The concept of 'Blue Economy' requires that we centre sustainability and ocean ecosystem health when using ocean resources for economic growth and societal benefit.

In 2020, UWA began working in earnest as part of the Blue Economy CRC. Researchers from the OI – A/Professor Jeff Hansen, A/Professor Scott Draper, Professor Ryan Lowe, Dr Jana Orszaghova, and Dr Hugh Wolgamot began working with an international team seeking to address the need for innovation and to facilitate a step-change in the economic value of Australia's new Blue Economy industries.

"Participation in the CRC allows UWA ocean researchers to play a critical role in three innovative projects which focus on offshore aquaculture and energy, remote monitoring technologies and multi-purpose offshore platforms."

– Professor Christophe Gaudin
Oceans Institute Director

Working with 44 member institutions from ten countries, these researchers are collaborating with industry, Government and research partners to develop an understanding of existing technologies and solutions while identifying major challenges and opportunities in renewable energy production systems.



"Research undertaken at UWA across physical oceanography, hydrodynamics and seabed characterisation will enable these developments to be undertaken in a sustainable way which benefits our communities while also protecting our ocean environment."

– Professor Christophe Gaudin
Oceans Institute Director

UWA Senior Deputy Vice-Chancellor Professor Tim Colmer believes the University's involvement in the initiative is recognition of our collective research excellence.

WIND ENERGY

Offshore wind energy is set to be a major contributor to renewable energy production. Geotechnical engineer Professor Britta Bienen has been developing solutions to safely and reliably secure offshore wind energy foundations to the seabed. This is a challenging endeavour in marine environments given the unstable sea floor and waves. Translating scientific findings into practical methods for use in industry is critical if we are to implement the robust, reliable and cost-effective renewable energy infrastructure that the planet so desperately needs.

"Our research has had quite a significant impact in practice already, with our predictive methods being used by practising engineers in the offshore energy industry," said Prof Bienen. "There are lot of opportunities to make a real difference and improve engineering solutions."

WAVE ENERGY

In August 2021, UWA built on the successes and efforts of the Wave Energy Research Centre, based at the Albany and Perth campuses, to re-brand to Marine Energy Research Australia (MERA). MERA will continue to collaborate with Australian and international ocean energy industry partners, academic researchers and Government to facilitate innovative renewable energy technology and fieldwork activities.

With support from the Western Australian Government's Royalties for Regions program and the Blue Economy Cooperative Research Centre, a key project for MERA is the full life-cycle sea trial of the deployment of a prototype

version of the M4 Wave Energy Converter in King George Sound, Albany. This will demonstrate the potential of wave energy to decarbonise the aquaculture industry, grow a regional supply chain in the manufacturing and marine operations of wave energy technology, and enable to power the aquaculture industry and enable an ecosystem of other surrounding activities. All MERA activities are underpinned by a strong commitment to training, mentoring, outreach, and inclusivity and diversity.

"This research and technology hub, based in the heart of Albany, will provide opportunities for technology developers, researchers, marine scientists and the international and local community to better understand the wave resource and conditions in Western Australia." Said Regional Development Minister Alannah MacTiernan, who opened the MERA headquarters in November 2019.

ENERGY NEUTRAL BY 2025

UWA has also re-affirmed its commitment to a sustainable future in its operation and research. As part of its Energy Smart Campus initiative, UWA set a target to be energy neutral by 2025, driven by a shift to renewables and a 'living laboratory' approach, in which everyone is invited to have a stake in the energy future of the site, from reducing consumption to developing emerging technologies.

Led by the University's Campus Management team, which includes Principal Engineer Stuart Downes and Energy and Sustainability Manager Dr Geraldine Tan, the Energy Smart Campus initiative brings together teaching, research and knowledge from professional sectors.

Dr Tan emphasised the importance of integrating the University's campus operations with its expertise in teaching, research and engagement. "There is an opportunity to use the campus as a testbed which, if done collaboratively, can benefit operations as well as enhance the teaching and research offerings of the University."

New Wave of Innovation

The Southern Ocean is one of the largest potential wave energy resources globally. Wave Energy Converters (WECs) are used to turn the kinetic and potential energy produced by waves into useful electrical or mechanical energy. When it comes to wave energy conversion however, not all ocean waves are equally useable, and bigger isn't necessarily better. Too big and wave energy converters can be damaged. Too small and not enough power is converted. Wave energy is often most efficiently converted when waves are between 1m and 4m, and consistent in their direction. This matches the wave profile of much of the Southern Ocean along the southwestern coastline of Australia, making this the potentially perfect location for wave energy generation.

Animals on the Move

MEGAMOVE

MegaMove is a global Marine Megafauna Movement project led by UWA Oceans Institute (OI) Adjunct Research Fellow Ana Sequeira. After pioneering the development of marine megafauna global distribution models, and establishing cooperative efforts to study the movement of marine megafauna on a global scale, A/Prof Sequeira now leads a worldwide team of over 400 'MegaMovers', committed to gathering and sharing the data that is required to effectively study the movement of marine megafauna. This global approach is a necessity when studying megafauna who travel freely over long distances in our vast oceans. MegaMove has members from 49 nations and 285 institutions worldwide.

The project has been endorsed by UNESCO during the UN Ocean Decade as a Decade Project from 2021-2030. The dataset generated by MegaMove is currently valued at over 50 Million USD, and includes data from roughly 15,000 tagged animals. The rich information generated by this project will be critical in understanding the impacts of humans on marine megafauna as we work to better understand our oceans, and interact with our oceans sustainably as we develop a Blue Economy.

GATHAAGUDU ANIMAL TRACKING (GAT) PROJECT

The researchers of the Gathaagudu Animal Tracking (GAT) Project led by A/Prof Ana Sequeira and Dr Matthew Fraser, collaborate to understand how a range of marine megafauna, particularly turtles, dugongs, and tiger sharks, interact and share space in the Gathaagudu (or Shark Bay) UNESCO World Heritage Area.

Tracking marine animals is a tricky proposition. Collecting location data over long periods requires catching animals and attaching a satellite tag, which takes skill, practice, and patience. Hours can be spent crossing the shallows of Gathaagudu looking for turtles, or watching the floats of the fishing lines for a shark's nibble. The hours spent on boats with colleagues fuel many stories for this tight-knit team. However, the real fun starts when an animal is sighted.

While there are many beautiful animals in the Gathaagudu region, the team must first locate an animal that is a suitable tagging candidate. Importantly, animals must be over a certain size in order to be tagged, and mother-calf pairs are to be avoided to ensure there is no separation.

The project's first turtle, a Loggerhead Turtle weighing over 100kg, was tagged in mid-2021. Catching turtles requires the team to give chase across the shallows, and working to get close to the animal without scaring it into deep water. When in position, PhD student Mike Taylor dives from the research vessel to gently "rodeo" the target, along with Dr Karina Jones, Jessica Pearce and the team, working together to carefully pull the large animal aboard.

Entering the water with a 4-meter tiger shark, however, is not recommended! In this case, a team of project members, including Dr Oliver Jewell, Dr Hannah Calich and PhD Candidate Ben D'Antonio carefully restrain the shark alongside their research vessel. When the shark is in this position, sample collection can be done and satellite tags can then be attached from the safety of the boat.

Once animals are tagged and released, it is a nervous wait until the first GPS locations come in. After this, the map of Gathaagudu begins to light up with pings showing the journey of the tagged animal.

Since the beginning of the GAT project, 12 turtles have been satellite tracked, and seven sharks. In addition to satellite tags, camera and diary tags have also been deployed on several sharks. The data collected from each species can inform what habitat types these species forage in, and how and where these species interact.

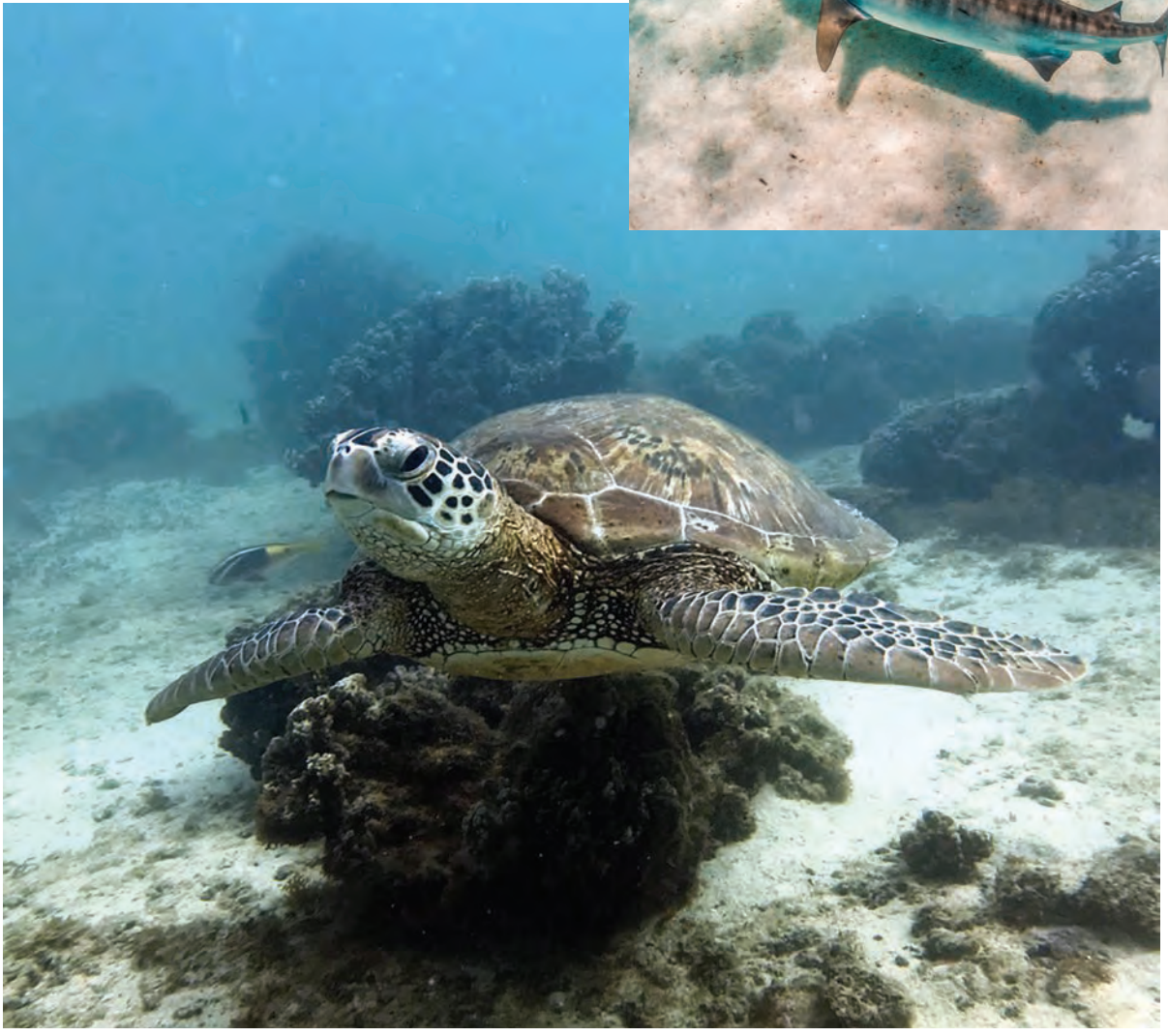
Along with the challenges of studying animal movement, the opportunity to interact up close and personal with iconic species is a highlight for the GAT team. These researchers get the chance to work with marine animals in amazing locations, and the pleasure to collaborate with the area's Traditional Owners - the Malgana Peoples and other collaborators from the OI, and around Australia.

ACTIVELY SHAPING OUR SUSTAINABLE FUTURE

The 17 United Nations Sustainable Development Goals are the blueprint for social and environmental peace and prosperity, and are designed to address the most pertinent global issues of our time. Goal 14 - Life Below Water, is at the core of all our research at the OI. A/Professor Ana Sequeira was one of fifteen editors who worked together to write an editorial piece that serves as the preface for Goal 14, and defines its scope and strategic objectives.

The piece highlights the imbalance between the extent to which we as a global community rely on the ocean, and the extent to which we understand and give back to it. We will face many challenges with regard to striking the right balance between these two things, and the editorial highlights the importance of the synergy between Goal 14, and other SDGs, such as Goal 1 – No Poverty, Goal 2 – Zero Hunger, and Goal 3 – Good Health and Wellbeing.

At the OI, we not only work towards a better future, but we also take part in shaping the roadmap that we will need in order to get there.



Did you know?

GPS tags cannot transmit positions from underwater, tagged animals must come to the surface for long enough to get an accurate read of their location.

A Focus on the North

The Oceans Institute (OI) continues to have a large research footprint in Australia's North-West. One of the continent's most diverse sub-tropical and tropical environments, the region is home to spectacular ecological features, including the Kimberley Coast, Rowley Shoals, Scott Reef, Dampier Archipelago, Pilbara Coast and Ningaloo – just to name a few.

WA's North-West shelf has been the focus of multi-disciplinary and cross-institutional research incorporating expertise across oceanography, ecology, submerged archaeology, and genetics. This work will enhance our ability manage and preserve local biodiversity, and offers insights into the management and preservation of reefs, islands and atolls worldwide. Research has also revealed rich cultural seascapes, which has improved our understanding of the culture of the local Yaburrara people.

ROWLEY SHOALS REEF

AIMS@UWA postdoctoral fellow Dr Camille Grimaldi and Professor Ryan Lowe, in collaboration with the Australian Institute of Marine Science (AIMS), leads a team of researchers modelling the hydrodynamics (i.e. wave, tide and wind processes) of the Rowley Shoal's reefs. These important hydrodynamics regulate the distribution of water and material on coral reefs, influencing key ecosystem processes such as coral bleaching and genetic connectivity of resident coral populations.

"Understanding the drivers of coral genetic connectivity and dispersal will allow robust predictions of reef health to inform management practices within one of Australia's healthiest reef systems."

– Professor Ryan Lowe
UWA Oceans Institute & Oceans Graduate School

The team discovered that coral larvae is dispersed across the atoll by both tides and wave forces, where it was previously thought that larvae dispersal was tidally driven only. This new finding has fundamental implications for the management and restoration of the Rowley reefs, as well as other reefs, by facilitating improved forecasting of larval sources and their potential dispersal sites.

The Rowley reefs have also been the site of high-tech floating laboratories in the search for heat-resistant corals that could survive ocean warming caused by climate change. This ground-breaking work by Dr Luke Thomas (AIMS@UWA Lead Research Scientist) and colleagues from the OI and AIMS has involved translocating corals into onboard floating aquaria, to test different corals' capacity to withstand future climate change conditions.

"We can now conduct high-tech experiments from the back deck of our ship while surrounded by corals on the reef."

– Dr Luke Thomas
AIMS@UWA Lead Scientist

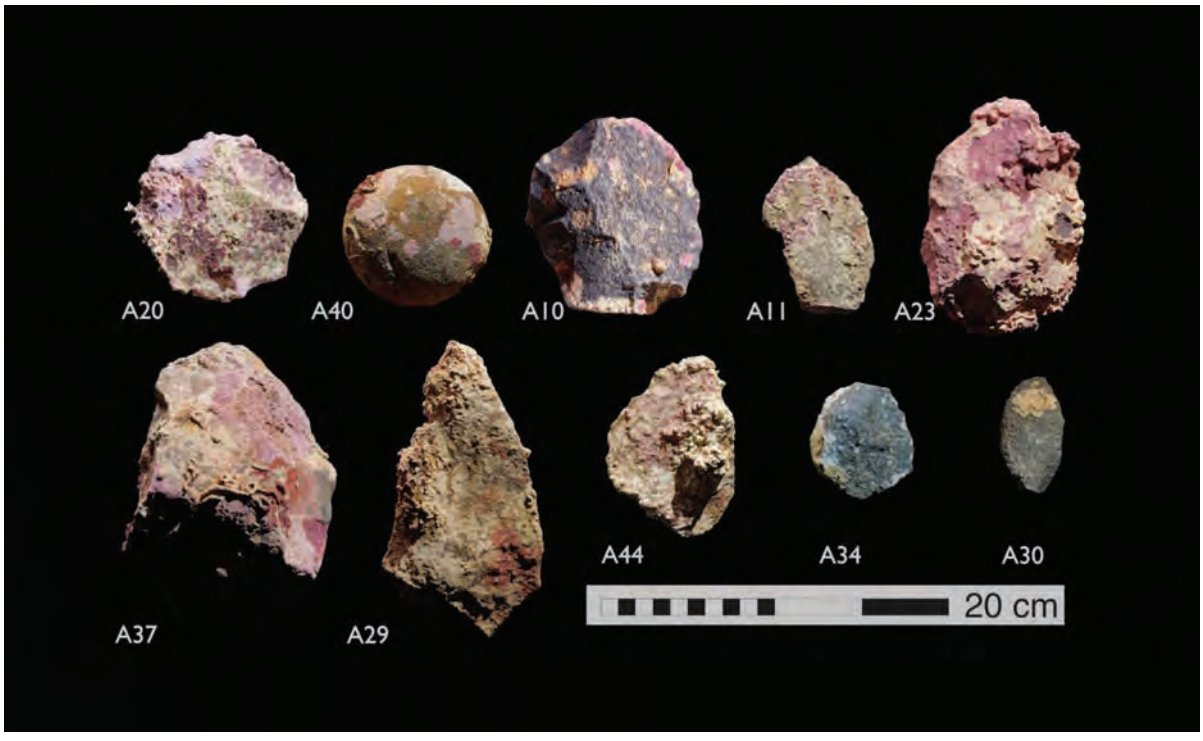
The hope is that by identifying corals with heat-resistant genes, scientists may be able to aid the restoration and adaptation of climate-impacted reefs not only within Australia, but globally.

DAMPIER ARCHIPELAGO – SUBMERGED CULTURAL HERITAGE

Off the coast of Dampier, we are offered a fascinating glimpse into submerged First Nations cultural records of the local Yaburrara people. The Dampier Archipelago region is known to the Yaburrara people as 'Murujuga', which means 'hip bone sticking out' and refers to the shape of the Burrup Peninsula.

The ARC-funded 'Deep History of Sea Country' research project involves a team of researchers from Flinders University, James Cook University and UWA – including OI member A/Professor Mick O'Leary. The team has unearthed artefacts from 2.4 to 14 meters below the sea surface, with some artefacts dating more than 7000 years old. Hundreds of stone tools, arrangements and rock art have also been found in the area.

These findings offer a window into the past, back to a time when Murujuga was an inland desert range. The artefacts provide researchers and the community at large with information on Australia's Yaburrara people, which is particularly valuable given the previous erasure of Australia's First Nations cultural groups. These discoveries also raise new requirements for the careful management of First Nations sites that are under sea water, as current Heritage Legislation does not automatically protect these areas.



EXMOUTH GULF & SOUTHERN PILBARA

In the Pilbara region, OI researchers are unravelling the mysteries of WA's more marginal marine environments. The southern Pilbara not only houses Australia's largest reef island archipelago outside of the Great Barrier Reef, but unique naturally turbid coral reefs, unlike clear-water reefs found at neighbouring Ningaloo.

The region is of high ecological and cultural value, providing critical habitat (rookeries and nesting locations) for sea turtle and sea/shorebird populations. A team of researchers, led by OI Affiliates A/Prof Mick O'Leary and Senior Research Scientist Dr Nicola Browne (Curtin University), have been assessing the sensitivity and resilience of reef islands and turbid reefs to climate pressures, and the drivers of water quality change within the Exmouth Gulf.

With expertise in coral reef ecology and geomorphology, PhD student Mr Josh Bonesso has been working in the region for over 4 years to understand how biological materials like mollusc shells and coral came to form the Exmouth Gulf islands, and how changes in reef ecology with climate change will affect how these islands are built in the future. While the findings of Mr Bonesso's work indicated that island building won't be affected by climate change in the short-term (years), long-term (decadal) impacts on reefs are likely to be greater, as the organisms that build islands may be wiped out with increased sea surface warming and ocean acidification.

Understanding how these naturally turbid reefs will respond to climate change has also been the focus of PhD student Ms Adi Zweifler. Through in-water field measurements and laboratory experiments, Ms Zweifler is studying how the physiology of resident corals, for example how they acquire nutrients, allows them to survive under such extreme, highly turbid, water quality conditions. These traits are what makes resident coral uniquely distinct to the Exmouth Gulf.

Notably, turbid coral reefs may be better resilient to the challengers of ocean warming and acidification, as their reef inhabitants (corals) are more tolerant of extreme environmental conditions. Through Adi's research we hope to learn more about whether Exmouth corals could be used for restoration for the clearwater reefs which may be more susceptible to a changing climate.

ABOVE
Aboriginal stone artefacts recovered from Murujuga

EXMOUTH TO SCOTT REEF – UNDERSTANDING OCEAN DYNAMICS

Oceans Graduate School Professor of Oceanography Dr Nicole Jones has been applying innovative techniques to estimate ocean dynamics off the NW shelf to better understand ocean mixing, near-bed wave (turbulent) dynamics and how waves mobilise coastal ocean sediments.

In a rapidly changing ocean, quantifying ocean mixing processes enables researchers to not only improve climate forecasting models under climate change, but also the prediction of how pollutants, nutrients and temperature are transported between marine systems. Prof Jones' research team have been utilising both traditional ship-based measurements such as vertical-profiling turbulence and the deployment of autonomous moorings to better estimate ocean mixing, from surface waters to a depth of up to 300 meters. Waves that occur at these depths are termed 'internal waves,' and play an important role in the ocean mixing process.

The high-resolution data obtained by the team have enabled development of new and improved relationships that describe the contribution of internal wave dynamics to ocean mixing processes in the deep ocean. It has also led to the development of next generation ocean 'turbulence closure models,' which help researchers understand and describe ocean circulation and stirring more generally.

"If we don't understand how much internal waves contribute to the deep ocean mixing, then we cannot model climate change accurately."

–Professor Nicole Jones
UWA Oceans Institute & Oceans Graduate School

Closer to the seabed, research into internal wave-driven turbulent dynamics has provided insight into ocean sediment mobilisation, or how sediments move and sit on the sea floor. This has direct implications for offshore oil and gas engineering design and operation, and provides insights for environmental management of the coastal ocean ecosystems across the Northwest Shelf.

NINGALOO COAST

Around the cape at Ningaloo Marine Park, researchers from the AIMS@UWA Alliance are advancing research in the realms of coral reef resilience and fingerprinting charismatic whale sharks. This work aims to improve the health and longevity of the reef and its inhabitants.

PhD student Shannon Duffy leads the reef resilience component of this work, using advanced experimental facilities and cutting-edge genetic sequencing techniques to understand thermal tolerance in adult and baby corals along Ningaloo Reef, particularly in response to the periodic warming conditions caused by climate change.

"With the help of molecular analysis tools, we can decode the coral thermal stress response to inform restoration efforts."

– Shannon Duffy
AIMS@UWA PhD Candidate

In March of 2022, a team, including Senior Research Scientist Dr Luke Thomas (AIMS@UWA), carried out their first successful coral spawning experiment in the newly opened Minderoo Exmouth Research Lab (MERL). In controlled tanks, the team was able to recreate the perfect conditions that allowed coral collected from the Ningaloo Coast to spawn. Given the likelihood of future yearly bleaching events, being able to spawn coral in controlled laboratory environments will be instrumental to reef management and restoration efforts.

Tracking the movement patterns of Ningaloo's giant migratory residents, the iconic Whale Shark, is the focus of Abinaya Meenakshisundaram's PhD research. Abi's goal is to generate individual genetic fingerprints of the individuals that visit the reef using sophisticated DNA barcoding technology. The aim of this work is to better improve the way scientists monitor these elusive migrating giants. Forecasting when and what demographic of whale sharks visit the reef will allow for better conservation efforts to protect them.

Did you know?

The annual coral spawning on Ningaloo Reef is one of the most extraordinary natural phenomena on the planet. In the laboratory, corals will only spawn when the conditions perfectly replicate nature.

Oceans Supporters Fund

The study of our oceans is an expensive endeavour, requiring access to boats, advance sensing equipment, and long-distance travel. Without the generous philanthropic support we receive, much of the important work conducted by Oceans Institute (OI) researchers would not be possible.

2021 was a significant year for the OI in terms of philanthropic support, seeing the establishment of the Oceans Supporters Fund. Through the generous support of 13 philanthropic donors from across Australia, the fund was established to exclusively support the research of emerging marine science leaders to address ocean issues ranging from climate change, pollution, and biodiversity loss, to regional social equity and coastal health and safety issues. It is not possible to overstate the value of this type of assistance in marine research, and the OI thanks the Oceans Supporters for their generosity.

A/Professor Mick O'Leary is using support from the fund to map the hidden and submerged rock art artefacts of the Murujuga traditional inhabitants of the Dampier Archipelago. The World Heritage Nominated Dampier Archipelago (Murujuga) hosts one of the densest concentrations of rock art anywhere in the world, with over a million petroglyphs showcasing a range of rich and complex artistic styles. The stylistic changes observed in the rock art represent a deep time record of evolving landscapes and environments brought on by climate and sea-level change.

Facilitated by the fund, Mick's project team have been digitally mapping submerged landscapes that have similar geology to the islands of the Archipelago, and recreating these submerged landscapes in 'virtual reality', to generate an immersive environment in which to experience these geological terrains and environments as it was prior to inundation.

Dr Catherine Wingate is applying her grant in the field of metabolic research. Her team are using a metabolic stress test that was first created to measure stress markers in human tissues, and applying it to aquatic species. This has the potential of adding a new non-invasive tool that aquaculture managers and conservationists can use as an early warning indicator of animal health. Pilot projects have demonstrated that the approach works for several species of fish, bivalve molluscs, and crustaceans. Understanding metabolic stress is important in maximising aquaculture production, enhancing animal welfare, and for early identification of disease. The methods are also equally applicable to wild animals, with predicted marine conservation uses including assessing the metabolic stress induced by marine heatwaves and pollution, or monitoring metabolic stress of communities over long periods, to understand the implications of increasing sea temperatures.

Dr Mike Cuttler, a physical oceanographer at the OI, received a grant to develop a remote sensing video recording platform to measure wave runup along rockfaces. This data could then be combined with in situ measurements of waves and water levels to determine the incident conditions that drive the extreme runup events that pose a danger to rock fishers.

"Fishing spots along WA's South Coast like Salmon Holes near Albany are popular but high-risk fishing destinations. We hope this research will help West Australians enjoy the coastline in greater safety"

– Dr Michael Cuttler

A/Professor Ivica Janekovic and Professor Phil Watson are using their grant to explore novel, small, low-cost, drifter buoys that use the latest communications technology. They aim to provide an attractive, relatively cheap alternative to classical current measurement methods. This application will help 'fill the gap' between single point measurement and large system monitoring, enabling local dynamics to be determined. Improving on their initial design, they hope to develop a set of 'Oceans Institute Drifters' that can be used by multiple researchers.

Finally, A/Professor Ana Sequeira is taking the impact of the Oceans Supporters Fund global with her marine megafauna bio-logging program. "Bio-logging data that is obtained by tagging animals is key to addressing global conservation challenges. However, the many thousands of existing bio-logging datasets are not easily discoverable, universally comparable, nor readily accessible through existing repositories, slowing down ecological research and effective management" said A/Professor Sequeira.

Ana has developed a standardisation framework adhering to FAIR1 and TRUST2 data principles that allow the simple files commonly used by the ecology community to be converted into sharable, machine-readable and interoperable network files. With the help of the grant, she is taking this vast archive of valuable data and creating an online database for use by researchers globally, propelling movement ecology by providing the means for the community to share and visualise the thousands of bio-logging datasets.

The Oceans Institute strives to be the ‘go-to’ marine research centre on the Indian Ocean Rim to benefit UWA, Perth, WA, Australia, and the Indian Ocean Region.

SECTION 2

Oceans Institute Initiatives

AIMS@UWA Alliance

AIMS@UWA is a collaboration between the Australian Institute of Marine Science (AIMS) and the University of Western Australia (UWA). The initiative was championed in late 2020 to develop an internationally recognised cohort of emerging leaders in marine science.

"AIMS@UWA builds on our successful past collaborations. UWA looks forward to expanding our joint research and opportunities for research student training, to address research needs in our tropical marine areas"

– Professor Tim Colmer
Senior Deputy Vice-Chancellor, UWA

Developed from the successfully established AIMS@JCU Alliance model developed by James Cook University, the AIMS@UWA Alliance is a major step in a long-standing collaboration between UWA and AIMS researchers. With an emphasis on providing support for postgraduate students and early career researchers, AIMS@UWA focuses on improving capability in topical marine science within Western Australia and beyond.

"The AIMS@UWA program will provide an unprecedented opportunity for postgraduate students and researchers in Western Australia to work collaboratively and provide a platform for world-class training in marine science" explained Research Program Director Dr Karen Miller.

AIMS@UWA prioritises undertaking research with impact, linking with the needs of local coastal communities, industry partners, and external stakeholders by providing the scientific information needed for best practice ocean governance and management, both within Australia and globally.

"The AIMS@UWA alliances provides researchers with unprecedented access to world-class marine research infrastructure and expertise, facilitating impactful research"

– Dr Luke Thomas
Senior Research Scientist leading the AIMS@UWA science program

The current cohort of researchers includes thirteen PhD candidates, alongside more established early career, and senior researchers. Set to expand even further in the coming years, the alliance has since welcomed newly appointed PhDs as part of the AIMS and BHP joint-funded Reef Song Project (Australian Coral Reef Resilience Initiative). This exciting new research venture, undertaken at Ningaloo Reef and the Great Barrier Reef, is the first to explore how attracting coral reef fishes to settle on reefs can help promote successful reef recovery

Expertise across the alliance is wide-ranging, with researchers exploring coral reef resilience and climate stressors, blue carbon ecosystems, reef-scale hydrodynamics and the migratory ecology of marine megafauna.

EARLY AND MID-CAREER RESEARCHERS

Dr Luke Thomas

Senior Research Scientist Dr Luke Thomas is the Science Lead of the AIMS@UWA Alliance. A research associate in molecular ecology at the OI and AIMS, he is interested in the physiological tolerances and adaptations of reef-building corals. His work involves studying coral DNA and RNA, as well as conducting ex-situ tank experiments such as the successful coral spawning project conducted through the Minderoo Exmouth Research Lab (MERL).

Dr Catarina Serra-Gonçalves

Dr Serra-Gonçalves' background is largely focused on uncovering the complexities of human impacts on ecosystems, mainly working with marine pollution and community-based conservation projects. Her PhD investigated the effectiveness of mitigation strategies aimed to reduce marine debris in the environment at different organizational levels (from local to national) by working closely with Australian communities and Tangaroa Blue Foundation.

Dr Camille Grimaldi

Dr Camille Grimaldi is a newly appointed post-doctoral researcher in the AIMS@UWA alliance. Her research focuses on deciphering circulation patterns that drive the connectivity and dispersal of coral across atoll reefs in North-Western Australia.

OceanWorks

The need to solve current offshore engineering challenges and support innovative research with potential for significant industry impacts was the inspiration behind the creation of OceanWorks.

This collaboration between UWA and Woodside Energy, supported by the Oceans Institute and Oceans Graduate School, brings industry together high-calibre researchers and students in oceanography, ecology, engineering, resource management and governance.

OceanWorks provides a unique portfolio of programs to seed and support applied research; a physical space to share industrial challenges and enable ideation; and a rich program of outreach and teaching activities to upskill our community.

DECOMMISSIONING FOR A BETTER FUTURE

Decommissioning of offshore oil and gas infrastructure requires collaboration between researchers, industry, regulators and the wider community to ensure decisions and approvals are underpinned by robust science. With around 3200 km of flexible pipelines and umbilicals to be decommissioned in Australia over the next 3 decades, it poses a significant waste management challenge. The limited capacity to process these products in Australia means research can play a significant role in developing and validating approaches to better recycle and repurpose decommissioned infrastructure. On a broader scale, we can redefine how industrial waste is managed in Australia.

The July 2021 Decommissioning Ideation Event was hosted by OceanWorks in response to this pressing challenge. Bringing together 54 Academics from across 14 disciplines, they worked alongside Woodside Energy personnel to identify opportunities to re-use and re-purpose flexible flowlines and umbilicals.

An impressive 55 ideas were generated at this event, with 5 now expanded into research projects. These projects span pyrolytic energy generation through to the development of new construction materials and offshore technologies. Most represent new collaborations between UWA researchers and Woodside Energy engineers. It is hoped that successful outcomes from these projects will be adopted by Woodside Energy and the wider offshore engineering sector.

IMPROVED WAVE FORECASTING

Accurate forecasts of weather conditions are vital to a range of industries operating in the ocean. In particular, many offshore operations like side-by-side offloading require sufficiently benign ocean wave conditions to be safely competed. Errors in forecasted wave conditions can pose significant risks. Unexpected increases in wave heights can result in unsafe working conditions or equipment damage.

Dr Jeff Hansen, from the School of Earth Sciences and UWA Oceans Institute, in collaboration with the International Centre for Radio Astronomy Research (ICRAR), developed a Machine Learning (ML) model to better predict wave conditions at Woodside Energy's LPG jetty in Mermaid Sound.

Their model uses real-time observations from Woodside Energy's network of wave buoys on the North West Shelf and predicted tidal conditions. This OceanWorks prototype produced a 'now-cast', otherwise known as a real-time wave forecast prediction of the wave conditions at the LPG Jetty.

A key focus of the project was to train the Machine Learning (ML) system to make predictions of the 2-dimensional wave spectrum, representing ocean wave energy as a function of frequency and direction. Predicting the 2-dimensional spectrum adds complexity to the ML model. The advantage of this approach is a much richer data set to utilise for port operations, in particular when multiple swell/sea peaks are evident, something Mermaid Sound is known for.

This project demonstrated that machine learning can provide realistic real-time wave forecasts when fed with sufficient wave observations, and has the potential to directly benefit a range of marine operations, including ship berthing and loading. This concept is now being expanded as part of the Industry-wide research hub, Transforming energy Infrastructure through Digital Engineering (TIDE), led by the University of Western Australia (UWA).

OceanOmics

OCEANOMICS CENTRE

After much anticipation, the Minderoo Foundation OceanOmics Centre at The University of Western Australia was officially opened in 2022. This new facility promises to deliver major breakthroughs in the way global ocean health is measured and understood.

The state-of-the-art centre forges the latest advances in DNA sequencing technology and analysis of environmental DNA or 'eDNA'. This eDNA, the floating fragments of genetic material found in seawater and other environmental samples, will eclipse the speed and scale of conventional methods for monitoring life in the world's oceans.

UWA Vice-Chancellor Professor Amit Chakma welcomed the investment in innovative ocean research. "This capability to identify species from traces of DNA floating in the water will dramatically improve our capacity to analyse and inform conservation efforts for life in the ocean," Professor Chakma said.

Founder of the Minderoo Foundation, Dr Andrew Forrest AO, described the importance of the Centre, which brings together the firepower of genomic technology and leading expertise of the researchers.

"This is a pivotal moment in time when we need to really understand and respond to our planet's climate emergency, and this research is key to formulating an appropriate response before marine ecosystem and biodiversity loss becomes catastrophic" said Dr Forrest.

Fewer than four per cent of marine vertebrates have had their genomes sequenced to date and the Centre will generate and openly share the largest library of marine vertebrate reference genome information available. Minderoo's Chief Scientist Dr Tony Worby said the Centre and the broader program behind it is a game-changer.

"We have created a world-first centre for marine genomics, combining a cutting-edge ocean genomes laboratory, OceanOmics laboratory and computational biology capabilities. This allows us to forensically detect what marine DNA is in the water at a speed and scale that will revolutionise the way we measure, understand and conserve life in our only ocean," Dr Worby said.

The Minderoo OceanOmics Centre will process samples, data and information from around the world, with an initial focus on the under-researched Indian Ocean, with the goal to establish biodiversity and ocean health baselines from which to analyse and interpret future changes.

"This capability to identify species from traces of DNA floating in the water will dramatically improve our capacity to analyse and inform conservation efforts for life in the ocean."

– Professor Amit Chakma
Vice-Chancellor, UWA

RIGHT
Image by Giacomo d'Orlando

Around the IOMRC

INDIAN OCEAN MARINE RESEARCH CENTRE (IOMRC)

The IOMRC is a purpose-built collaborative marine science and ocean engineering research facility. More than just a facility, IOMRC is a dynamic and high-level research partnership bringing together CSIRO, the Australian Institute of Marine Science (AIMS) and the Western Australian Department of Primary Industries and Regional Development (DPIRD), along with UWA researchers and infrastructure.

DPIRD AT WATERMANS BAY

The Department of Primary Industries and Regional Development (DPIRD) Aquatic Animal Health R&D team is providing the aquaculture and seafood industries with research services and specialist advice relating to long-term diseases of economically significant aquatic animals.

The team supports the development and sustainability of the seafood industry across Western Australia. They continue to work on a range of projects focusing on investigating health and productivity issues in commercially important aquatic animals to enhance research efforts, and fish health services to the Aquaculture industry in WA.

ICOAST

The Integrated Coastal Analyses and Sensor Technologies (ICoAST) project is a significant collaboration between marine researchers in the IOMRC, AIMS, CSIRO, DPIRD, and UWA. ICoAST promotes impactful, innovative and ambitious marine research, and strives to understand, predict and help manage WA's vast and diverse coastline that is under pressure from climate change and population growth.

ICoAST does this by focusing on three distinct research themes: Physical Drivers, Remote Sensing, and Molecular Ecology.

The theme of 'Physical Drivers' aims to improve our understanding of the physical processes in shallow marine environments and their impact on benthic habitats. "In shallow marine environments, waves, currents, and related physical processes are

strongly related to the characteristics of benthic habitats (the ecological region along the floor of the body of water). It is important to understand how climate change will impact these processes as they will directly impact the local ecology" said A/Professor Jeff Hansen. "For example, the areas suitable for seagrass may change due to increasing sea levels and wave energy. This project aims to improve our understanding of these interactions and develop novel techniques to measure and monitor processes in shallow water, which has historically been challenging."

In the 'Remote Sensing' space, the focus is on developing a greater understanding of West Australian shallow marine habitat through utilising advanced satellite data. Like the vast WA coastline, the ICoAST field activities are spread far and wide. This includes three sites currently under considerable pressure from climate change: Gutharraguda (Shark Bay), the Midwest WA coast, and the Perth Metropolitan waters near the IOMRC base. Across these three sites, data collection methods include the collection of image data from new-generation satellites and novel unoccupied aerial vehicles (UAVs), which are equipped with cameras boasting spectral ranges that extend beyond human vision. These new camera systems are quick and safe to deploy, with no blind spots thanks to their omni-directional stereo imagery. Both the understory and canopy of the marine ecosystem can be captured in one pass.

Under the umbrella of 'Molecular Ecology', researchers apply emerging molecular techniques to track the resilience of critical coastal habitats. In one experiment focusing on understanding the impacts of heatwaves, the ICoAST team took samples of habitat forming seagrass from an area starting in Shark Bay, and spanning as far south as Geraldton. Samples were processed to identify genes and associated microbes that confer resilience to climate change. These results can be compared with tank heatwave experiments to help understand the adaptation of marine ecosystems under climate warming.

THRIVING STARTUPS

Turning a research project into a commercial venture requires more than just a creative idea. Determination, hard work, and passion are essential.

For UWA Adjunct Research Fellow and ULUU startup co-founder Dr Julia Reisser, her research background in plastic pollution was a key driver to creating a sustainable material that could replace plastics on a large scale.

ULUU is a natural PHA (polyhydroxyalkanoate) or polyester polymer made from farmed seaweeds. Seaweed absorbs up to 20x more CO_2 than terrestrial forests, and unlike terrestrially farmed plants, it does not require any fresh water or fertilisers to grow. This means that using ULUU to replace synthetic polymers could mean regenerating the oceans and climate at the same time. ULUU is produced from microbial fermentation of seaweed and can be tweaked to mimic all kinds of plastics. Unlike many plastic alternatives, the material is durable and truly biodegradable, which means that even in cold, dark environments such as the ocean, it breaks down safely into harmless constituent compounds that are naturally found in the ocean.

"Being co-located at the IOMRC and Waterman's Bay Laboratories means we can better collaborate with our IOMRC partners – UWA, CSIRO & DPIRD. We look forward to continuing co-developing climate positive commodities alongside them here in this beautiful facility."

– Dr Julia Reisser
UWA Adjunct Research Fellow

The company also has input from a number of other UWA researchers, as part of the development team, as well as on the board of Advisors.

This isn't the only startup making waves in the wider community. UWA Adjunct Lecturer Luke Wheat founded Future Green Solutions, now a leading Australian producer of sustainable animal feed ingredients and agri-products for the aquaculture, pet feed and agricultural sectors. Future Green Solutions' innovative technology utilises the Black Soldier Fly to turn low-value organic waste from the food production and animal agriculture industries into a nutritional source of protein. This turns a waste product into a sustainable commercial product, reduces waste in landfills, and reduces greenhouse gas emissions associated with decomposition of waste.

Back in the ocean, UWA Research Fellow Dr John Statton is developing Australia's first commercial-scale Asparagopsis farms with the seaweed technology business Immersion Group (previously Seascape Restorations). The Asparagopsis seaweed they produce will be processed and fed to livestock to reduce methane emissions by up to 98%.

Collaboration with Industry

Given the strong presence of offshore industry in Western Australia, from oil and gas to renewable energy, the Oceans Institute (OI) remains an active participant in shaping the future of the marine resources sector.

The OI participates in formal research initiatives with local industry partners aimed at improving the effectiveness and safety of offshore operations, while reducing the environmental footprint of these projects. These close partnerships allow cutting edge research to be immediately implemented by industry partners, and have facilitated the expansion of UWA's world-leading facilities, which continue to foster success in conducting wide-reaching research. These facilities include the National Geotechnical Centrifuge Facility (NGCF), UWA's unique O-tube seabed current simulation flume facilities, a newly refurbished 50m long wave flume, ocean data collection and analysis equipment, numerical modelling facilities, and OceanWorks, which is part of the Woodside FutureLab network.

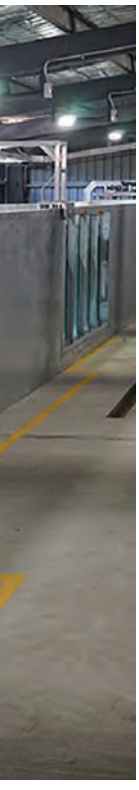
THE ARC INDUSTRIAL TRANSFORMATION RESEARCH HUB FOR OFFSHORE FLOATING FACILITIES (OFFSHORE ITRH)

The Industrial Transformation Research Hub for Offshore Floating Facilities (OFFshore ITRH), was a multi-disciplinary research initiative tackling the critical offshore engineering challenges associated with the large-scale floating infrastructure linked to offshore oil and gas projects. Commencing in 2016, and concluding in 2021, it was jointly funded by the Australian Research Council and industry partners Shell, Woodside Energy, Bureau Veritas and Lloyds Register, with the University of Western Sydney as a collaborating partner.

The OFFshore ITRH united a team of world-class researchers across all areas of offshore engineering. Key focus areas included:

1. The state-of-the-art design of risers, moorings, anchors and sub-sea foundations for offshore oil and gas infrastructure.
2. Research into improving vessel motion/ stability and offloading of recourses.
3. Predicting the longevity of offshore infrastructure to increase sustainable usage into the future.

This research combined sophisticated modelling (experimental/numerical) and field observations to tackle these monumental offshore engineering goals.



"Our collaboration with the OFFshore Hub has produced exciting innovations that have yielded significant value for our business, and for the other industry partners"

–Ms Jan Flynn
Chief Metocean Engineer, Woodside Energy

The multidisciplinary research initiative produced novel designs, new technologies, and new operating procedures that have had a positive impact on the next generation of oil and gas projects. "The OFFshore Hub has provided deep insights into advanced technical topics that have directly influenced technical content in LR's industry guidance and Rules", reported Mark Tipping of Lloyds Register.

ARC INDUSTRIAL TRANSFORMATION RESEARCH HUB FOR TRANSFORMING ENERGY INFRASTRUCTURE THROUGH DIGITAL ENGINEERING (TIDE)

Since 2021, UWA has been hosting the ARC Industrial Transformation Research Hub for Transforming energy Infrastructure through Digital Engineering (TIDE), jointly funded by industry partners Shell, INPEX, Woodside Energy, Lloyds Register, Bureau Veritas, Fugro, RPS and Wood. The project has a host of national and international partners including the University of Wollongong (UoW), the Bureau of Meteorology and the Australian Institute of Marine Science.

The goal of TIDE is to improve the management of existing offshore infrastructure, thereby making this activity more reliable and more cost effective. Researchers also hope to improve the safety and efficiency of future infrastructure.

TIDE is expanding its activities into marine renewable energy, through direct research and the upskilling of engineers to transition into this emerging sector to meet future requirements of continued development in this field.

The initiative comprises academics, operators, class societies, consultants and contractors across industry and academia. The core team works closely with industry partners to implement research findings and make immediate industry impacts.

ABOVE
Prelude FLNG (Shell Australia)

SHELL PARTNERSHIP

A partnership formed in 2013, Shell Australia and UWA established the Shell Chair in Offshore Engineering to strengthen Western Australia's position as a global offshore engineering hub. Approaching the end of its second term, the partnership has invested $40M in research, with eleven PhD graduates, 300 research publications and with a number of UWA-led research outcomes having been implemented on Shell projects globally.

The partnership's strengths encompass pure and applied research from the seabed to sea surface processes to develop technologies that can be directly transferred into real-world applications in Offshore Engineering. Examples span improving the critical safety and durability of offshore infrastructure, to developing next-generation tools to better understand how seabed characteristics influence the type of infrastructure built on it.

The Shell Chair in Offshore Engineering has supported two early career researchers, Dr Wenhua Zhao and Dr Hugh Wolgamot, both of whom have since been awarded prestigious ARC Discovery Early Career Researcher Award (ARC DECRA) fellowships.

"The last few years have been an exciting period for the Shell Chair, as we built on earlier initiatives and deliver clear value to Shell – both in Australia and worldwide," said Shell Professor Phil Watson. "With our eye firmly on a third term, we have expanded our research portfolio and see tremendous potential to support ongoing Shell projects in the region, such as Prelude, while also helping with the transition to new energy solutions."

Training the Next Generation of Leaders

In addition to connecting and hosting the world's best marine scientists, the Oceans Institute (OI) also supports the next generation of ocean leaders and researchers through awards and fellowships. These programs give PhD Candidates and early career researchers the freedom and funding to undertake the ambitious research endeavours that will turn them into the leading experts of tomorrow.

R&R AWARDS

Now in its sixth year, the annual Robson and Robertson Young Scholar Awards provides opportunities for outstanding young scholars to undertake exciting and innovative ocean research. Honouring Emeritus Professors Alan Robson and Alistar Robertson for their integral roles in the establishment of UWA's OI, the Awards are designed to encourage early career researchers across any marine discipline. With up to $15,000 of funding on offer, the annual cohort of PhD candidates can use the award to access travel opportunities (e.g. conferences), undertake fieldwork, and access key equipment to enrich and advance their research. Just like the leaders that these Awards honour, recipients contribute significantly to research into the future of our oceans.

"The R&R award provided the funding I need to access specialized equipment and training required for isolating and analysing microplastics in various body tissues from commercially important decapod crustaceans in Western Australia. It also allowed me to broaden my research scope to investigate plastic contamination across more species with larger sample sizes whilst developing an analysis protocol that will become commercially available."

– Katrina Bornt
R&R Award Recipient and UWA PhD Candidate

PhD candidate Adi Zwiefler's research benefited greatly from R&R award funding. "Thanks to the award, I have been able to travel to Exmouth Gulf four times in 2021" she reported. "The ability to visit my study sites every few months was critical to understanding how the physiology of turbid water corals varies across seasons. Importantly, it also enabled me to be on site in the Exmouth Gulf during the February to March 2021 heatwave events, when corals were exposed to ongoing thermal stress."

Award winner Josh Bonesso reflected that "The Robson and Robertson Award has been instrumental in allowing me to undertake high-precision radiocarbon analyses of coral reef island sediments to better resolve the geological development of important coral reef landforms such as islands. By doing so, it has provided insight into forecasting future island change which will inform of management strategies to protect these landforms and their ecology under future climate change scenarios" he said.

Established marine science experts from government and non-government agencies in Western Australia review and allocate the award based on the credentials of the researcher, quality of the project, alignment with identified strategic area, and the potential research impact. The Award is funded through the generous contributions of the Jock Clough Marine Foundation.

R&R FELLOW

The five-year R&R Fellowship was established to support early career researchers in pioneering global research by addressing ocean challenges in conservation, genetics and aquaculture. We sat down with Dr Matt Fraser who was selected as the inaugural Robson and Robertson Fellow in 2017.

Congratulations on your Fellowship, Dr Fraser. Could you tell us a little bit about your work?

"Thank you! First and foremost, I'm a Seagrass Enthusiast. Seagrasses are immensely important primary producers for the marine environment. I'm working to establish a 'canary in the coal mine' type warning system for better prediction, detection, and management of stress in seagrasses."

And how do you predict and detect stress in seagrasses?

"Well, most monitoring programs largely focus on measuring the above-ground stress responses of seagrasses. The downside of this is that it can take weeks or months to be noticeable, with irreversible damage done. My work aims to use molecular indicators to measure stress and reliably detect changes in a matter of days. This can involve looking at changes in the expression of key gene or metabolites in seagrass, or even shifts in microorganisms that are associated with seagrasses. Developing these molecular indicators will allow us to take a proactive approach to marine conservation, helping to future-proof our oceans from the myriad of stressors they face."

Interesting, and I assume that any trouble with an ecosystem's primary producers might have knock-on effects for the broader marine environment?

"Correct. My appointment as the R&R Fellow has provided the opportunity to collaborate on other projects, including the Gathaagudu (Shark Bay) Animal Tracking Project (GAT). Working with the Sequeira Lab, this project investigates the movement and habitat use of large marine species such as dugongs, turtles and tiger sharks. By using satellite tags and eDNA, the team can identify interactions between these large species and their habitats, such as the extensive seagrass beds."

And that's where your expertise comes in!

"Exactly. This work will further our understanding of the likely impacts of habitat loss on our iconic megafauna species. We know that interactions between habitats and animal communities have

the potential to be affected by climate change, worsening impacts to valuable ecosystem services. A balance of research into bottom-up and top-down processes gives us a more holistic and comprehensive picture as to how marine heatwaves can impact ecosystems like Shark Bay."

Sounds like important work. What else has the R&R Fellowship allowed you to do?

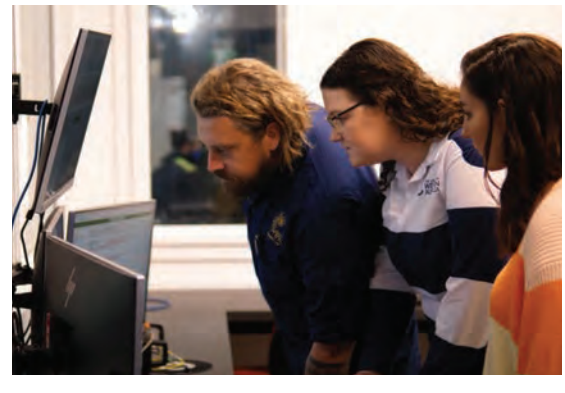
"The Robson and Robertson Research Fellowship has enabled me to undertake core research that I am extremely passionate about, while also providing freedom to explore new research areas. I've established collaborative research projects with the Traditional Owners of Gathaagudu, the Malgana Peoples. This research has allowed for two-way knowledge exchange to help understand and protect sea country. Research freedom for early career researchers is often limited, and fellowships like the Robson and Robertson Research Fellowship provide us with the opportunity and space to enhance their skillsets and conduct novel research in important areas."

MASTER OF OCEAN LEADERSHIP (MOL)

Described as the 'missing piece between fields', the Master of Ocean Leadership (MOL) was successfully launched in 2020. This new Masters by Coursework degree allows students to apply disciplinary and multi-disciplinary knowledge to real-world problems. Graduates are encouraged from any field, and students come from a range of backgrounds across the marine sciences, engineering, law, resource economics and environmental management.

"If you want to understand the ocean and how you manage it and govern it, we need to know how all of the different disciplines act together", explained Professor Chari Pattiaratchi

The MOL is contributing to multi-disciplinary marine education that will ultimately allow graduates to work across a variety of sectors and to strive towards solving the challenges at the heart of the United Nations (UN) Sustainable Development Goal 14 to safeguard 'Life below water'.



"The Master of Ocean Leadership is a degree unlike any other in Australia," said UWA A/ Professor Marco Ghisalberti. "Staff from across the world-renowned UWA Oceans Institute come together to immerse students in the challenges, language and approaches of the range of oceans-facing disciplines."

The strength of MOL graduates will be in their ability to work broadly across myriad disciplines and sectors, from industry and government to non-government agencies. These future ocean leaders will have wide-ranging knowledge, expertise, and problem-solving skills to critically analyse ocean issues, preparing them to address future challenges facing the oceans.

Recent MOL graduate Jurgen Valckenaere has found that the multi-disciplinary approach of the course aligns well with his research goals. "I completed a research project that brought international law and ocean governance into kelp forest restoration," he said. "Bringing together marine ecology, biology, ocean governance and potential commercial application within the blue economy together and seeing how we can actually improve what is already there, and how to fix some of the challenges those disciplines are facing."

Engaging with our community

The Oceans Institute (OI) is building a wide-reaching and engaged community to increase the impact and influence of our work. We have hosted events both for OI members, and for the wider community, to showcase our strengths and to attract further collaboration, partnerships and funding.

2020 EVENT HIGHLIGHTS

Oceans Week at Scitech

OI members took over the news feed at Scitech for a week, enthralling and educating the public with marine science and engineering content in celebration of World Oceans Day on 8th June.

One key content area was from the work of PhD candidate Ms Mirjam van der Mheen, who was on a mission to find out where our ocean-bound plastics end up in the seas. Instead of examining entire oceans to determine their plastic content, Mirjam works with a network of 'Ocean Drifters' which are specialised free-floating drifter buoys. Drifters can inform how items move in the ocean, floating wherever the wind and currents take them. Mirjam's work focuses on filling the data gaps in the Indian Ocean, making good use of modern GPS enabled trackers.

17 PARTNERSHIPS FOR THE GOALS

Dr Charlotte Birkmanis joined the Scitech Particle podcast to discuss rebranding sharks and the weird creatures living deep in our seas. She spoke about current environmental pressures, inspiring younger girls to pursue marine biology, and of course, everything related to sharks.

Sharing her experiences as a researcher and science communicator, Charlotte's podcast was packed full of great information and insight into the journey she embarked upon to become the shark expert she is today.

Rounding out the Scitech take over was Professor Chari Pattiaratchi, sharing his research with 'Ocean Gliders', which are automated missile like underwater vessels, and the impact this technology can have on difficult to study parts of the world. Gliders are capable of embarking on unmanned journeys for weeks at a time, help save oceanographers thousands of hours, and can explore waters too dangerous for hands-on human study. From exploring a tropical cyclone from the inside to discovering a world of hidden pollution carried out on invisible coastal tides, these ocean gliders are unlocking secrets of the sea.

City of Perth Library Series

Partnering with the City of Perth Library, the OI brought science and the scientists to the community with a series of 'Oceans Talks' presented by enthusiastic researchers.

Dr Belinda Cannell spoke on Perth's population of Little Penguins (*Eudyptula minor*) including their general biology, breeding behaviour, diet, population estimates, threats and the impacts of climate change. She also spoke about why they have a 40% 'divorce rate'!

Ms Lucy Arrowsmith led a session on whale sharks and other marine megafauna. Whale sharks are currently found in most tropical and subtropical waters around the world, but what impact will a changing climate have on the future of this ocean giant?

Mr Michael Brooker shared how researchers are investigating the habitat choices that rock lobsters make during their early life stages after they have settled onto nearshore reefs. Thanks to his work, this highly vulnerable and secretive stage of their life cycle won't be a secret much longer!

Wrapping up the talks was Dr Todd Bond, who delved into his research on artificial reefs and how decommissioned oil and gas infrastructure can play a role in providing a unique ecosystems and habitat for fish species in the area.

In The Splashzone

Despite the challenges posed by Covid-19 restrictions, the OI successfully continued its efforts to promote ocean science through a series of engaging livestream events held during the month of May. These virtual gatherings featured some of the Institute's early career scientists and guests who captivated and educated a live audience eager to learn about their ground-breaking work.

Dr Asha de Vos, an ocean educator and pioneer of long-term blue whale research within the Northern Indian Ocean enthralled the live audience who tuned in to learn about her passion for the ocean and how she founded the Sri Lankan Blue Whale project.

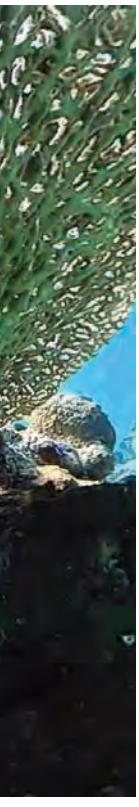
"I wanted to build something that also created space for that next generation of people who wanted to try out what marine conservation was and get involved."

– Dr Asha de Vos
UWA Oceans Institute and Sri Lankan Blue Whale Project Founder

Conservationist, photographer and author Mr Wade Hughes joined the Splashzone uncovering the surprising secret life of whales through his breathtaking photography. Hughes delved into the secret lives of whales, unravelling the mysteries of their behaviour. Viewers were treated to a visual journey into the depths of sperm whale interactions as Hughes shared some of his favourite images and the stories behind them.

Dr Sahira Bell, Ms Brinkley Davies, and Mr Stefan Andrews joined forces for a thought-provoking discussion on science communication and conservation efforts focused on the Great Southern Reef. Dr Bell emphasized the power of impactful storytelling and messages. The trio shared inspirational anecdotes and powerful stories from individuals closely connected to the Great Southern Reef, highlighting the profound impact of climate change on their local environment.

The 'In the Splashzone' series covered these topics and more, plus viewer competitions and live Q&A, bringing the best of oceans news and research to our virtual audience.



2021 EVENT HIGHLIGHTS

Minderoo-UWA Marine Heatwaves Workshop

The OI and Minderoo Foundation's Flourishing Oceans initiative co-hosted the Minderoo-UWA Marine Heatwaves Workshop at the Indian Ocean Marine Research Centre (IOMRC). Following the 2021 marine heatwave recorded along much of the Western Australian coast, this open-forum workshop assembled researchers across disciplines of physical and biological oceanography, marine ecology and molecular ecology.

Keynote speakers included Mr Peter Rive from Aqualink USA and Dr Claire Spillman from the Bureau of Meteorology (BOM). Marine researchers from the OI joined colleagues from DBCA, AIMS, DPIRD, CSIRO and leaders from Minderoo Flourishing Oceans. The group discussed the effects of the marine heatwave event on marine ecosystems, coastlines, populations and industries across Western Australia. They also explored preparedness in the face of future heatwaves, and the identification of vulnerable habitats and species that are most at risk.

Perspectives on Decommissioning

What environmental science does industry, regulators and stakeholders need to support offshore oil and gas decommissioning decisions? During this event, our panel of experts were on hand as we explored what knowledge is needed to support industry processes, regulatory requirements and meaningful stakeholder engagement to ensure future decommissioning decisions and approvals are underpinned by robust science.

Eurekamp OZ!

The OI in partnership with PEiPL (Philosophical Engagement in Public Life) Ltd co-hosted a series of 2-day camps during the school holidays at the IOMRC building on UWA's Crawley campus. The theme of the program – 'Oceans 21', aimed to get kids between the ages 10 - 14 immersed in the exciting and complex world of the ocean environment, and generating big ideas.

OI PhD candidates Ms Carly Portch and Mr Justin Geldard, along with presenters from AIMS, led a series of interactive hands-on activities that challenged the kids to explore the ocean from an environmental, conservation and biological perspective – beyond the general concepts of marine biology.

Carly, PhD candidate in Coastal Engineering, introduced students to the thought-provoking challenges faced by sea level rise through an interactive activity, 'Save the Beach.' "It was great to see how engaged and excited the kids were about saving the ocean, and was refreshing to see their perspectives on climate change priorities. I think we can learn a thing or two from kids, and the way they think through solutions." Carly said.

PhD candidate Justin followed on with the theme of coastal protection, exploring the wonderful innovation of 3D printed corals, working with the kids to design their own nature-based solutions for protecting fragile coastlines. "The curiosity of the kids and their enthusiasm to apply what they had learnt throughout the camp was incredible." Justin said, "The excitement they shared through their designs of nature-based solutions to coastal protection was a great example of this."

Perth Symphony Orchestra - SOUND & WAVES

Perth Symphony launched their 2021 Heritage Series with the immersive Sound & Waves concert, presented with the OI joining as a concert partner. The program included live music from Perth Symphony strings and guest artists, which was interwoven with stories told by individual West Australians whose connections to the ocean are deeply profound and reflect our

own experiences in this isolated but beautiful part of the world. This bespoke mix of music including classical and contemporary pieces was designed to evoke a sense of movement and awaken the spirit of the ocean. The stunning music soundtrack featured musical premieres, and works by classical greats such as Vivaldi and Gershwin and contemporary composers including Ross Edwards and John Butler.

2022 EVENT HIGHLIGHTS

City of Perth Library Series

Partnering again with the City of Perth Library, Dr Todd Bond dove into this series of Oceans talks, sharing his experience with the operation of deep sea ocean landers, including a recent expedition to the Diamantina Fracture Zone some 300km off the coast of Western Australia. Dr Bond finished off with some recent ground-breaking discoveries, including the retrieval of the deepest snailfish (*Elassodiscus tremebundus*), giving the audience a unique appreciation of this unique deep-sea habitat in WA's backyard.

Dr Ana Manero Ruiz gave an engaging presentation on the real-world values of surfing, not only to human well-being and lifestyle, but more broadly the local economic benefit to communities. Dr Manero Ruiz highlighted the importance of finding strategies for sustainable management of natural resources in a way that accounts for human values and needs, as well as environmental protection, allowing all parties to benefit.

PhD candidate Ms Isobel Sewell presented on the black soldier fly circular economy, and how it can be used to combat several growing global issues such as food insecurity and insufficient waste disposal. She focused on how this can concurrently benefit the sustainability of the seafood industry, intriguing the crowd with her exhibits.

Dr Georgina Wood shared the beauty and importance of kelps in coastal ecosystems, outlining some of the largest problems currently facing kelp forests around the world. She also shared insight into how researchers at UWA and elsewhere are taking genetic tools underwater to better understand kelp genetics, allowing

them to build new populations where they have been lost and hopefully enhance resilience to climate change impacts.

Deep Sea Wikipedia Workshop

The deep sea is often thought of the earth's last undiscovered frontier, but it is also its largest habitat. Partnering with the team from the Minderoo-UWA Deep-Sea Research Centre and Wikipedia, the OI hosted a hands-on Deep Sea Workshop. Led by Wikimedian Mr Gideon Digby, the group updated and refined Wikipedia's 'Deep Sea' page in accordance with new discoveries in deep-sea biology, oceanography, and bathymetry.

The event was great opportunity to learn and improve skills in science communication, research, academic writing, and referencing, with no previous Wikipedia experience necessary.

Seeds for Snapper

Volunteers for the 'Seeds for Snapper' initiative joined researchers from the OI to help in the dispersal seagrass seeds over Cockburn Sounds new wave attenuation reef. The event was a joint collaboration through MMA Offshore, OzFish, City of Cockburn, and UWA. Enthusiastic volunteers hit the water by kayak, snorkel, and scuba, to spread critically important seagrass seeds (of species *Posidonia australis*) over the reef constructed by MMA Offshore. UWA

Professor Gary Kendrick, and Research Officer Ms Rachel Austin were on hand at the site in Cockburn Sound, assisting volunteers with achieving an ambitious goal to disperse over 1 million seeds.

Onshore, Dr Renan Silva joined other project and community partners at the OI stall, sharing some of the research undertaken in the UWA wave flume to help design the reef, as well as the ongoing monitoring. Those too young to join volunteers on the water enjoyed the family seagrass and beachcombing session run by local marine scientists, providing the chance to get their hands (and feet) a little sandy in the pursuit of restoration science.

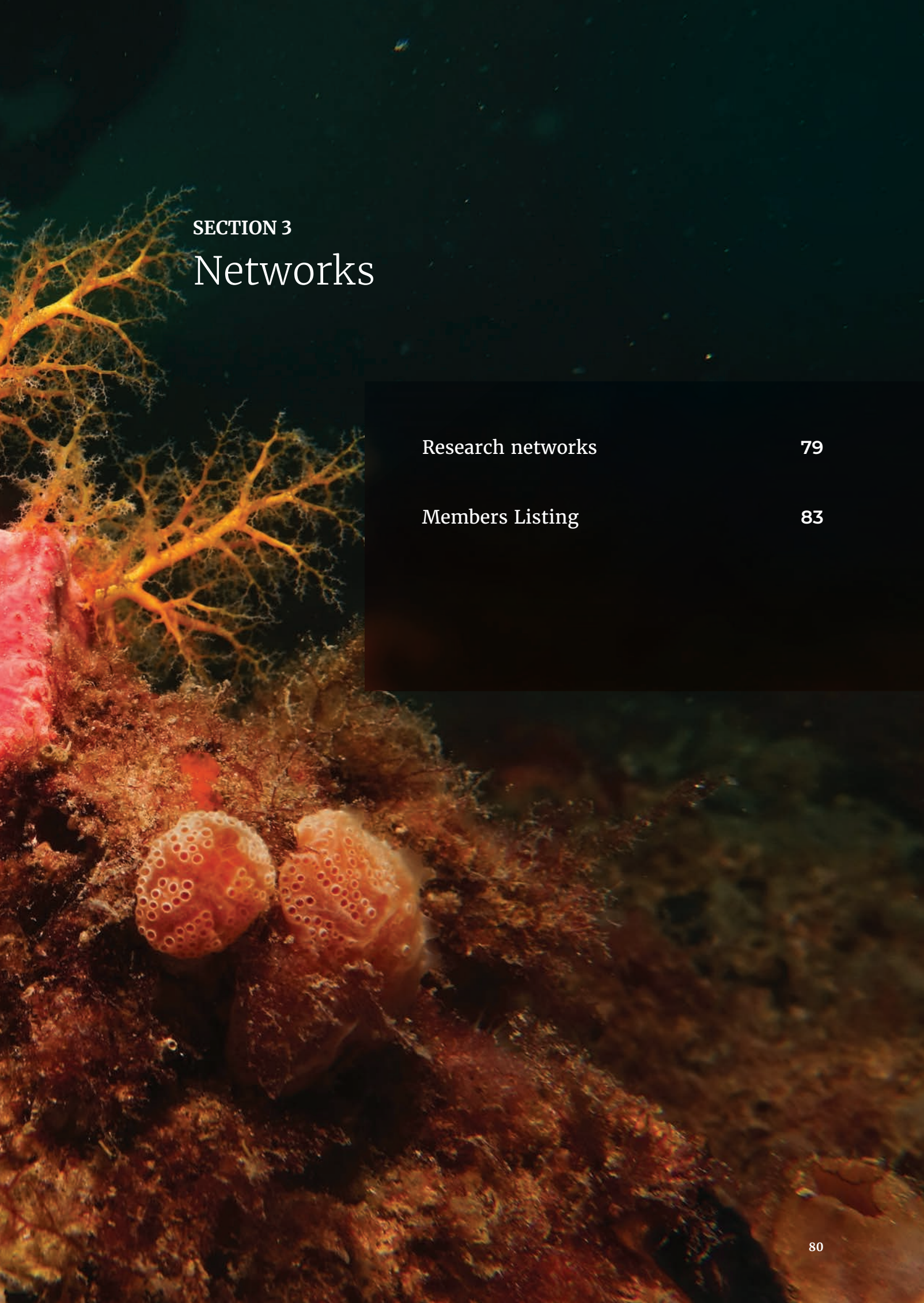
Beyond the Hall of Winthrop podcast

The OI was invited to guest host an ocean themed episode of the UWA Alumni podcast, Beyond the Hall of Winthrop. The episode, titled 'One Ocean, One Climate, One Future - Together', brought together Physical Oceanographer Dr Danielle Su, Marine Ecologist Dr Emily Lester and Ocean Conservationist Dr Emily Pidgeon.

The 3 UWA Alumnae discussed the biggest problems facing our oceans, and the solutions having the biggest impact on turning it around.

"Climate change is now the single biggest threat to the oceans. While there is a lot of work that can be done to build up the resilience of these ecosystems... the only real solution is addressing the cause, reducing our emissions, and addressing the bigger climate change issues" said Dr Emily Pidgeon.

Together, we have done extraordinary work to address the greatest challenges facing our blue planet. Invigorated by recent global events, we continue our work as a leading multi-disciplinary research hub.



SECTION 3

Networks

Research networks

740

EUROPE

United Kingdom	256
France	88
Spain	55
Norway	36

88

CANADA

912

UNITED STATES

Washington	462
California	78
Massachusetts	54

126

SOUTH AMERICA

Brazil	50
Chile	14
Ecuador	14

Region

Top countries/states/territories

353

ASIA

China	109
Japan	36
Saudi Arabia	32
Sri Lanka	12

89

OCEANIA

New Zealand	64
New Caledonia	9
Fiji	6

87

AFRICA

South Africa	47
Kenya	9
Seychelles	8

1200

AUSTRALIA

WA	456	VIC	131
NSW	202	TAS	47
QLD	181	NT	25
SA	59	ACT	99

Members Listing

Oceans Institute members span all UWA schools, centres and institutes. The OI works particularly closely with the School of Engineering, Oceans Graduate School and the School of Biological Sciences but seeks to engage all UWA marine researchers, policymakers, industry leaders and ocean allies from across UWA and partner institutions. By uniting these experts, we foster fruitful partnerships that cross disciplines, industries and national borders.

Dr Maryam Abdolahpour
Dr Greg Acciaioli
Dr Simon Allen
Prof Zachary Aman
Dr Hongwei An
Ms Vania Andreoli
Dr Prema Arasu
Mr Thalles Araujo
Miss Lucy Arrowsmith
Ms Charlotte Aston
Dr Zahra Bagheri
Dr Diego Barneche Rosada
Prof Jacqueline Batley
Dr Philipp Bayer
Prof Mohammed Bennamoun
A/Prof Paul Bergey
Dr Britta Bienen
Dr Charlotte Birkmanis
Miss Kelly Boden-Hawes
Dr Todd Bond
Dr Joshua Bonesso
Mr Mitchell Booth
Ms Katrina Bornt
Dr Bryan Boruff
Prof Farid Boussaid
Mr Carlin Bowyer
Prof Thomas Braunl
Mr Michael Brooker
Dr Rohan Brooker
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Mr Stuart De Vos
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Dr Andrew Zulberti
Miss Adi Zweifler

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RESEARCH HIGHLIGHTS REFLECTIVE

UWA Oceans Institute

The University of Western Australia
M470, 35 Stirling Highway
Perth, WA 6009 Australia

T: +61 6488 8116
E: oceans@uwa.edu.au
oceans.uwa.edu.au

CRICOS Provider Code: 00126G

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