THE UNIVERSITY OF WESTERN AUSTRALIA | Oceans Institute

# Research Strategy 2018–2021

# Strategic research vision

The University of Western Australia's (UWA) Oceans Institute Research Strategy 2018 – 2021 has been developed by the Senior Leadership Team with input from the Advisory Board and a range of Institute Members to reflect the Institute's newly refined research vision and ensure commitment to achieving its mission of providing innovative and effective solutions to challenges facing the world's oceans.

Critical aspects of our lives rely upon the seas. Transport, food, energy, recreation and the industries and livelihoods related to them inextricably link human activity with the ocean, yet centuries of overuse and neglect threaten to leave our marine environment a vast and empty blue desert.

Through collaborative, interdisciplinary research, the UWA Oceans Institute is supporting and promoting smart, sustainable and secure uses of the oceans to meet the needs of a rapidly increasing global population. Desalination, wave energy, algae biofuel research, ocean nourishment and aquaculture are just some of the ways ocean-based solutions are emerging within the Institute to safely and sustainably provide critical resources for human development, water, food, energy and bio-resources. Researchers at the Institute are equally committed to reconciling the delivery of wealth from the oceans, while conserving the biodiversity and ecosystems that support these resources.

The strength of the UWA Oceans Institute lies in its ability to call upon its breadth and depth of marine expertise. Its core disciplines are marine biology and ecology, physical oceanography and ocean engineering, but its research also reaches into the social sciences, particularly through marine environmental law, resource economics, history and archaeology. In each of these disciplines, new knowledge advances our social and economic development. Together, these capabilities have the capacity to solve major challenges and deliver significant societal benefit.

The strategic objective of the Oceans Institute is not to arrive at these solutions separately but to explore and devise approaches that connect them; these approaches balance utilisation and conservation and maximise outcomes as efficiently and effectively as possible.

By focusing on solution-oriented ocean research, there is immense scope for innovation and growth of new industries and associated businesses to address these challenges.
The success in providing smart, sustainable and secure oceans will enable governments, industries, non-government organisations and the community to make decisions that protect and sustain ocean resources for current and future generations.

*Oceans Institute Senior Leadership Team*

# The UWA Oceans Institute heralds a new era in marine research

As the world's population grows, the ocean will become an increasingly important source of food and energy, as well as continuing to provide opportunities for enhanced trade and livelihoods. However, the ocean can also be a source of danger for people and infrastructure; and anthropogenic activities can have negative impacts on the marine environment and resources. Safeguarding the health of our oceans and marine resources, as well as addressing maritime safety and security issues, is a critical need of the twenty-first century.

Marine research provides the path to address the simultaneous challenges of benefiting from, living safely with, and protecting the ocean. To address these challenges, the UWA Oceans Institute was established in 2010 to build on the University's strength in ocean research across the disciplines of engineering, biophysical sciences, and social sciences.

The UWA Oceans Institute is a large-scale enterprise with significant breadth in research activities, external collaboration, and sources of finance. Institutes are flagship units in the University's structure and the existence of the Institute helps to accelerate the quality and impact of UWA's research performance and better position the University in international affairs.

UWA is part of a groundbreaking marine science collaboration advancing ocean research in Perth and acting as a hub for researchers, industry and governments worldwide. The Indian Ocean Marine Research Centre (IOMRC), where the Oceans Institute is based, is a collaboration including UWA, the Australian Institute of Marine Science (AIMS), CSIRO and the Fisheries Division of the Department of Primary Industries and Regional Development. IOMRC is the largest research facility in the Southern Hemisphere and Indian Ocean region.

Western Australia is a unique physical and ecological marine environment. It is an area appreciated for its aesthetic and recreational values, but also one that is home to diverse industries that face significant engineering and sustainability challenges. From a base of wide experience across local ecosystems and industries, Oceans Institute researchers are engaged in expanding international partnerships and applications across the Indo-Pacific region and involving multiple disciplines and sectors.

The University is strategically located on the Indian Ocean coast of Australia, and its coastline spans the tropical north to the temperate south, with coral and rocky reef systems rich in biodiversity and endemism. The warm Leeuwin current flows along the coast, affecting both the marine ecology and the coastal climate and carrying a clear signature of climate variation. The tropical north is exposed to the impacts of tropical cyclones, including intermittent inshore flooding events, while the south is subject to extra-tropical cyclones and persistent large swell from storms in the Southern Ocean.

The Western Australian coast supports a wide range of representative maritime activity. Much of the State's recreation takes place on Perth's coast, and much of the State's most expensive property and important infrastructure is there. Half of Perth's water supply is based on coastal desalination. Australia's submarine fleet is headquartered off the WA coast with the naval base serviced by a prototype wave-energy farm. The north of Western Australia is resource-rich, with significant offshore oil and gas infrastructure and major ports shipping gas and iron ore. The south coast is shortly to become a hub for wave energy research. Along the coast there are wild fisheries dominated by rock lobster and a fledgling aquaculture industry.

The majority of the Western Australian coastline is bounded by the Indian Ocean, a diverse region that is under-researched and encompasses vast areas and resources, as well as numerous peoples and cultures. Millions of people in this region rely on oceanic industries for their livelihoods. While the blue economy agenda is strongly pertinent to the region, in many areas living and non-living resources are poorly understood. Many of the nations are developing countries with governance, food security and poverty concerns. Even though many of the challenges faced by Indian Ocean neighbouring countries are not experienced in Australia, as a developed country in the Indian Ocean region, we have an obligation to contribute to their development agenda, and most importantly on the issues focused on the blue economy through partnering on research and capacity-building projects.

The global quest for economic and ecological sustainability in coastal oceans, under the pressure of onshore and offshore development and climate change, is exemplified in Western Australia. With its local experience, disciplinary breadth and geographic location, UWA is positioned to partner with Indian Ocean, Asian and global agencies that face similar marine challenges. The UWA Oceans Institute aims to be a global leader in delivering relevant knowledge and practical solutions to the grand challenges of food and energy supply, and human health and security.

# The importance of ocean research

## Like its neighbours, Australia confronts the challenge of maintaining and improving the health, safety and prosperity of its citizens in a time of climate change, population growth, rapid technological advances and globalisation.

Many of these large national and international challenges are expressed in terms of the security of our various supply systems: defence, energy, food, water, environmental security, and human health and wellbeing. In this context, security and sustainability are synonymous. Services must be maintained in such a way that they persist into the future and are not self-defeating, cross-destructive or exhaustible at the system level.

All of these supply systems have important representation in the ocean, all have the potential to be advanced through research, and all require attention across the marine-related disciplines at UWA: engineering, biophysical sciences and social sciences.

For *maritime security,* Australia as an island nation relies heavily on its Navy for military and constabulary purposes and is poised to make multi-billion dollar investments in new patrol vessels, submarines and facilities. Surface vessels are exposed to wind and wave conditions; ships and submarines rely on acoustics, which are controlled by sub-surface ocean temperature; amphibious operations require knowledge of nearshore water and beach conditions; and naval bases are exposed to changes in sea-levels and storm events. Environmental data is critical to these operations, as is engineering and technical knowledge related to remote sensing, navigation and vessel behaviour. In addition, sociocultural and geopolitical information is critical to maintaining an effective workforce and successful operations across the regions in which the Royal Australian Navy operates. Increasingly, security operations involve other government bodies such as the Australian Federal Police as well as private security agencies.

*Energy security* is complex in a time of climate change. Offshore infrastructure, in the form of platforms, pipelines, wells and other seafloor hardware, require foundations and through-water engineering designed to survive cyclones, energetic waves and currents and corrosive seawater over structural lifetimes of decades. At the end of their field life, these structures must be decommissioned, by complete or partial removal and/or potential conversion into artificial reefs. Next-generation production facilities are more likely to float, rather than being fixed to the seabed, resulting in different environmental exposure and new engineering design challenges. Meanwhile, the imperative to transition to renewable energy is increasing. In the ocean, renewables include: the extraction of energy from waves, currents and tides, and thermal gradients; offshore wind energy; and marine biofuels. Whereas offshore wind farms are widely established in the Northern Hemisphere, there are few examples of commercial-scale energy extraction from the ocean. There are dynamic opportunities for research in this space, particularly in light of the wind and wave environment in Western Australia, government support for wave energy, and similar work being undertaken in the region. Additionally, any move to use new technology in the form of floating wind towers and marine biofuels, most likely sourced from phytoplankton, would require much more research, particularly combining engineering and science, if these examples are to become a large-scale, viable reality.

The obvious manifestation of food security in the ocean comes through fisheries and aquaculture. A high proportion of the protein in the diets of coastal communities around the Indian Ocean is sourced from fish. Wild fisheries are difficult to manage because fish stocks can only be inferred, not observed (although new technologies are enhancing our capacity to gather data) and globally many are fully or over-exploited. Expansions of wild fishery operations are problematic but do feature as part of the blue economy agenda; making it imperative to ensure that government-supported activities are well-researched.

New ocean-based aquaculture faces all of the complications of any monoculture: nutrient supply, disease, environmental impact, genetic vulnerability, escapees and an often hostile and hard-to-predict environment in which to contain and manage the species. All disciplines have a role to play, including engineering for efficient operations, social science research around consumer choice (such as labelling and certification), and business logistics (port facilities, transport solutions and supply chain management). Another aspect of food security is understanding the role of the ocean in climate, especially rainfall, for onshore food production. Aquaculture offers opportunities beyond fish and food security as products may be farmed for industrial applications; research is required to explore opportunities in this area for Western Australia.

*Water security* requires knowledge of both the seasonal and multiyear rainfall variability. At these timescales, rainfall prediction depends on knowledge of the ocean, which stores many times more heat than the atmosphere. For cities like Perth that source groundwater, the ocean is implicated in saltwater intrusions as the freshwater volume declines. Perth also relies on desalination plants. Such plants are necessarily located on the coast, and will be subjected to changes in sea-level and storm-occurrence over their operating lifetimes. Their main environmental impact is the release of concentrated brine, and they require clean seawater for their intake. They are also energy-intensive but do not necessarily require electricity to operate. For example, the direct use of wave-pumping is a possibility.

*Environmental security,* more often called environmental sustainability, is a consideration in most maritime activity. Marine sanctuaries are established primarily to protect habitat and fish populations from over-fishing, and operate in conjunction with fisheries management regimes. Such areas provide opportunities for marine-based tourism which is economically valuable and also plays an important role in raising community awareness about the value of our oceans. Construction and maintenance of ports and other coastal or offshore installations cause loss of habitat, but dredging and construction can be undertaken in ways to minimise impacts. The planned or accidental release of pollutants from the shore, ships or platforms, has the potential to damage marine organisms, as does runoff from land-based activities. International shipping may carry exotic marine species, creating biosecurity challenges; and vessel antifouling is often toxic. Increasingly, attention is being drawn to the effects of plastics in the ocean. Marine conservation requires deep knowledge of ecological systems, the cumulative nature of many of these impacts and implementation of efficient, effective monitoring programs.

*Human health and wellbeing* in the ocean is often an issue of safety. The dangers associated with maritime activity, including fishing, transport and sub-surface activity like drilling, can be significantly reduced with accurate forecasts of winds, waves and currents and appropriate cessation or avoidance under predicted adverse conditions. Threats to humans and property at the shoreline, caused by breaking waves and beach erosion, can be alleviated by good coastal planning and warning systems, as well as engineered and nature-based solutions. Dangers from marine species and the ocean environment itself are likely to be reduced by better understanding of animal and ocean behaviours, and the identification of ways and means to minimise negative interactions. Populations will be healthier if nutritional seafood is made more widely available through improved aquaculture and fishing practices.

The ocean is also likely to be the source of base chemicals for pharmaceuticals and nutraceuticals through so-called bioprospecting – that is, the massive collection and screening of marine organisms for their biochemical properties. Further, a healthy coastal ocean promotes a healthy coastal community through its role as an aesthetic and recreational amenity. Beyond this, interactions with oceans, coasts and estuaries are part of the cultural heritage of indigenous peoples and both traditional and contemporary coastal communities. Humans have always interacted with the oceans, and many traditions, practices, knowledge and beliefs, of both tangible and intangible heritage, are associated with ocean areas.

# UWA Oceans Institute's Mission and Vision

The UWA Oceans Institute is committed to research that has positive and clearly articulated outcomes.

To maximise these outcomes, it will fully utilise the multidisciplinary marine research knowledge and expertise available within the University of Western Australia.

Between 2018-2021 the Institute will:

- continue to grow strategic local, national, regional and international collaborations;
- establish partnerships with government agencies, non-governmental organisations, industry and communities; and
- deliver the highest quality research, and ensure this research is adopted and applied for the benefit of Australia and the global community.

## Mission

To provide innovative and effective solutions to challenges facing the world's oceans.

The Oceans Institute's mission reflects its ambition to use marine research to tackle issues of national and global significance.

## Vision

To be the leading global oceans research and training centre focused on the Indian Ocean.

The Institute's vision demonstrates its ambition in relation to marine research and dissemination through training and capacity building.

# Multidisciplinary marine research at the UWA Oceans Institute

The strength and potential of the UWA Oceans Institute resides in its ability to call upon its breadth and depth of marine expertise. Its core disciplines are marine biology and ecology, physical oceanography and ocean engineering, but its research reaches into the health and social sciences, particularly through marine environmental law, resource economics, history and archaeology. In each of these disciplines, new knowledge advances our social and economic development and wellbeing. Brought together, these multidisciplinary capabilities have the capacity to solve major challenges, delivering significant societal benefits.

## Marine species, ecosystems, impacts and management

Healthy marine environments are at the core of sustainable global development. To sustainably manage complex marine ecosystems, it is critical to understand biological and ecological processes.

Researchers study the marine environment at the species and ecosystem levels and work in the tropical and temperate waters off the Western Australian coast, as well as nationally and internationally.

Using the latest techniques such as stereo-video cameras, animal tagging and specialised laboratories, researchers study the physiology, ecology and behaviour of marine species. This research includes coral reef health, fish biodiversity, benthic microbiology, plant ecology and marine neurobiology as well as research on seabirds, reptiles and invertebrates.

Researchers also examine marine food-web interactions, nutrient cycles and the impacts of climate change including ocean acidification and global warming. Based on multidisciplinary expertise, researchers at the UWA Oceans Institute can create a holistic understanding of marine ecosystems, which leads to better strategies to safeguard marine conservation and restoration as well as to manage human activity. Our researchers are involved in key, global research projects to support, promote and improve the development of sustainable management of marine resources.

## Ocean engineering, innovation and enterprise

The Blue Economy is a promising sector for economic growth. The UWA Oceans Institute brings together researchers from offshore, geotechnical and coastal engineering as well as resource economics and business to develop innovative and multidisciplinary solutions for a sustainable blue economy.

Using world-leading testing facilities and numerical models, Oceans Institute members conduct research on offshore fixed and floating structures, fluid-structure interactions, seabed characterisation, waves, extreme hydrodynamics and asset management. Specific areas of research address the performance and risk factors of offshore foundation systems, hydrodynamic load on structures, scour around structures and pipelines, port development and logistics.

In collaboration with industry partners, our researchers deliver applied solutions for marine renewable energy, oil and gas, and coastal infrastructure and operations. Examples include the development of novel anchoring systems for wave energy devices, assessment of the integrity of offshore and deep-sea structures, as well as the design of floating liquefied natural gas (FLNG) facilities and electric and autonomous vehicles for ocean operations. Researchers in the UWA Business School work on innovation and enterprise, optimum governance structures and strategic leadership. If technological developments are to be commercialised then efficient and effective business solutions are critical.

## Ocean dynamics, coastal processes, observations and hazards

Reliable marine forecasts and knowledge of the physical marine environment are vital to all human activities in the oceans and coastal zones. The UWA Oceans Institute hosts a range of academics who conduct research into the fundamental physical, biological and bio-geochemical processes occurring within the oceans and the coastal zone. Scientists use the latest field instrumentation, physical laboratory experiments, remote sensing as well as computer models to understand the impacts of climate change, sea level rise and extreme events across a range of scales from the nearshore zone to larger-scale studies of shelf systems and ocean basins. Researchers are investigating the implications of global change such as marine heat waves and ocean acidification, oceanic and coastal responses to tropical cyclones and storm surges, and the dynamics of large-scale currents. They are also studying the transport of key material along the coast by ocean processes (e.g. contaminants, larvae and nutrients).

Research conducted at the Oceans Institute improves computer models to better predict the role of the ocean in climate models, wave and sediment processes in reef environments, and marine hazards such as storm surges and tsunamis. The improved prediction of present and future ocean conditions is critical to support a wide range of ocean applications, from forecasting ocean climate change variability, to the risks and impacts of contaminant spills and ocean hazards, as well as assessing the resilience of marine ecosystems.

## Human health, biomedicine and water quality

The oceans host a range of opportunities for human health, beyond nutritional benefits of seafood. Unlocking the genome of marine organisms has opened the door to ground-breaking developments in a range of industries such as food, cosmetics and biomedicine. Researchers at the UWA Oceans Institute explore how living marine resources – from entire organisms to molecules to genomes – can benefit human health and wellbeing. This involves biomedical engineering focusing on better diagnosis, treatment and prevention of disease, as well as translational engineering and medicine.

Climate change will have further impacts on human health as disease vectors change and medical researchers focus on predicting and addressing these challenges. Other researchers also focus on the adverse impacts of human activity on the oceans and human health such as contaminants, pollution and diseases. Examples of this research include transport of decomposing seagrass wrack in coastal waters, groundwater nitrogen plumes in coastal waters and water quality management. Water quality issues are critical for coastal and estuarine health, to support opportunities for aquaculture and to ensure sustainable use of the ocean for recreation and tourism.

## Maritime histories, coastal communities and ocean values

Human culture and history's inherent links with the coasts and oceans affect our relationships with the ocean today as well as our approaches to managing it. The UWA Oceans Institute involves academics from various disciplines who explore the human dimension of the oceans. Researchers in this area of expertise are social scientists from the fields of maritime archaeology, environmental history, Indigenous cultural heritage management, anthropology, maritime crime, coastal zone management, marine ecosystem management as well as recreational and commercial fisheries management. Their research interests concern the human relationship with the ocean over time and seek to identify how social interactions and values can be harnessed to benefit people, coasts and oceans.

This area of research explores the human interactions with the ocean addressing contemporary issues such as management of the land-water interface, imperatives of marine management in Small Island Developing States, identification and protection of tangible and intangible heritage, and the drivers of negative human behaviour such as piracy.

## Oceans governance, economics and buisness strategy

Sustainable management of the oceans requires good governance, policies and economic incentives. The UWA Oceans Institute involves a range of academics from various disciplines working in these areas. Predominantly, these scholars are social scientists in fields such as law, justice and regulation, public policy, international relations and politics, economics, human geography, business management and workforce planning, and psychology.

Specific areas of governance expertise include law of the sea, marine environmental law, fisheries regulation, energy law and tourism regulation. The Oceans Institute covers a wide range of topics in marine policy and economics. They include optimal management of marine systems, cost-benefit analyses, community preferences and values, social licences, market analyses, policy evaluations, market based incentives, and productivity and risk analyses. In this context, economic frameworks and models provide a platform to integrate multidisciplinary data from the natural and social sciences to quantify outcomes. This is particularly useful when providing advice on the performance of a project, policy or management plan.

# Integrated Research Themes

The UWA Oceans Institute will pursue solutions to major socioeconomic and environmental challenges by establishing large projects that utilise the full breadth of its disciplinary skills. In these projects, it will work closely with industry, government and community partners who are able to adopt and apply research to achieve long-term impacts.

The Institute's cross-disciplinary research over the next four years will be grouped under five integrated themes:

- Energy from the oceans
- Maritime security, safety and defence
- Fisheries, food security and aquaculture
- Marine conservation, ecology and climate change
- Coasts and communities

# Theme 1: Energy from the oceans

The UWA Oceans Institute will continue to improve the safety and efficiency of, and play a part in leading, the development of the offshore oil and gas industry in Western Australia, nationally and internationally. It will seek to support and grow a significant marine-based renewable energy industry, both locally and internationally. It will also develop engineering, legal, economic and ecological frameworks to support new initiatives to provide energy solutions from the ocean and to guide potential decommissioning of offshore structures at end-of-life.

The UWA Oceans Institute has a significant record and reputation for the design of anchoring systems and sea-floor structures, and for the analysis of forces on fixed and floating structures resulting from ocean waves and currents. This work combines expertise in seabed dynamics, fluid dynamics and wave dynamics through a combination of civil, structural and mechanical engineering. The offshore oil and gas industry faces certain engineering challenges as it moves to deeper and more remote offshore reserves. It is also challenged socially by community concerns about climate change, energy security, and accidents that lead to oil spills. The UWA Oceans Institute has the disciplinary breadth to address both the engineering and social feasibility of the industry's planned activities.

Meanwhile, across the world, established oil and gas installations are approaching the end of their operating lifetimes. Under many regulatory agreements, companies are required to remove such structures entirely. Removal is a potentially dangerous activity, both for humans and ecosystems. It also ignores the potential benefit of a structure beyond its utility for the oil and gas industry. Even during its operational phase, a subsea structure will become a thriving artificial habitat for colonies of marine creatures that could be (preferably) maintained. A platform may be retained as a site for long-term environmental data collection and could become a point of tourist activity. As an alternative to complete removal, a structure can be transitioned to other uses by removing components that may endanger other maritime activity, and decontaminated to eliminate the possibility of long-term damage to local ecosystems.

Decommissioning of offshore oil and gas infrastructure is a multidisciplinary challenge the UWA Oceans Institute is uniquely positioned to address. From an engineering perspective, the structure may require partial removal, decontamination and stabilisation, and understanding of the possibility of future corrosion and collapse. Across the disciplines of ecology, fisheries and resource economics, particularly, the costs and benefits of full or partial removal, and *in situ* decommissioning must be quantified and compared. Legal frameworks must accommodate the range of decommissioning options and determine how long-term benefits and responsibilities are to be apportioned. Additionally, through social engagement, the broader community must be kept informed and comfortable about decisions that are made on a case-by-case basis.

There are ageing platforms in Australia that will provide case-studies for the UWA Oceans Institute, working with local industry and government. The decommissioning issue is international and the Institute will play a critical role in regional capacity building.

While work with the oil and gas industry will continue, the renewable energy industry is opening new research opportunities and challenges. Options include the extraction of energy from waves, winds, tides, currents and from vertical thermal gradients as well as biofuels.

Energy extraction from tides and waves has been under consideration for decades with many devices suggested and prototyped. However, there are few economically viable installations anywhere in the world. Economic viability depends on the costs of construction and

maintenance, the consistency and predictability of the energy source, the environmental impact, the cost of connecting to the electricity grid and the regulatory environment. Devices will often be large and visible from the coastline, and will need to be socially, as well as environmentally and economically, acceptable.

UWA is recognised as a global leader in ocean engineering and recently received $3.75 million from the Western Australian State Government to establish the Wave Energy Research Centre (WERC) in Albany. A team of over 20 researchers, including those from the Oceans Institute will be based at both Albany and UWA Perth, creating a multidisciplinary research hub for wave, tidal and offshore wind energy industries. Researchers will work closely with Carnegie Clean Energy Limited in their development and deployment of a novel 1.5 MegaWatt wave energy converter device. This prototype will make Australia the first in the world to deliver wave energy to an onshore power station at this magnitude. WERC will also partner with other developers of wave energy technology and extend existing infrastructure to serve the entire marine renewable energy community.

Across its expertise in economics, wave dynamics and engineering, the UWA Oceans Institute will be able to assess the combination of wave climate, device efficiency, and scale and cost of operation that would make wave energy viable off the Australian coastline and overseas. It can also assess community attitudes to potential wave farms and the sociolegal and socioeconomic issues and concerns. The Institute can explore alternative utilisation of wave energy, including testing if wave-energy extraction can be incorporated directly into offshore desalination-plant designs, both to pump saltwater through membranes and to move freshwater onshore.

In contrast to direct energy-extraction from the ocean, offshore wind-farm design and construction is well established. UWA Oceans Institute engineers and oceanographers are well placed to contribute to research on floating wind towers that will be larger, more easily serviced and deployable in deeper water than towers built on the seabed. Planning for establishment and operation of floating wind farms will stimulate legislative and resourcing questions similar to those for wave farms.

Marine biofuel production is a form of aquaculture. The farmed organisms are phytoplankton (microalgae), and potentially macroalgae (seaweeds), that require nutrients (nitrogen and phosphorous) and micronutrients (e.g. iron) to thrive. While equivalent to biofuel production on land, marine production does not displace food crops from farming land. The scale of marine production must ultimately be large, and the containment, environmental, economic and social-acceptance challenges are significant. As with seafood aquaculture, the UWA Oceans Institute has the breadth of skills to address challenges presented in offshore farming. In the context of biofuels, the Institute has particular expertise in ocean primary production – that is, in the ecology of phytoplankton, macroalgae and seagrass.

Beyond existing clients, financial support for renewable energy research could be expected from federal government agencies, resource companies exploring diversification and international agencies such as development banks that are looking to new energy (and water supply) opportunities for poorer coastal communities and small island nations.

# Theme 2:
# Maritime security, safety and defence

The UWA Oceans Institute will help protect the health and safety of Australians by delivering research outcomes and practical advice to agencies responsible for managing people and property along our coastline, military agencies and private security forces involved in defence, and industry involved in ocean-related activities. Issues in focus will include not only traditional defence, but international criminal activities such as piracy, illegal fishing and trafficking of people, drugs and weapons.

To improve the national security and safety of the Australian community, the Royal Australian Navy is in the process of commissioning a new fleet of surface and submarine combat and patrol vessels. The vessels will be comprehensively instrumented with sensors for measuring physical parameters in the near-surface atmosphere and ocean. The UWA Oceans Institute will work with the broader Australian research community to support the Navy's deployment of these vessels. While the Institute is positioned to deploy its science and engineering skills, its interpretation and communication expertise can also ensure knowledge is delivered to the Navy in its most accessible and usable form.

Illegal maritime activities are conducted with vessels that authorities attempt to track using on-board vessel motion sensors (VMS), and remote techniques including radar, satellites and aerial photography from manned and unmanned aircraft. Identification of illegal activity is a research interface between law and technology, with a range of possible challenges including, for example, image processing and admissabiity of evidence.

Vessel movements are not mandated and tend to follow patterns determined by factors such as trade routes, fish stocks and territorial boundaries. Illegal activity will often be distinguished by vessel routes that are outside expected behaviour. Vessel tracks associated with illegal fishing may, for example, be apparent to an expert in "normal" fishing fleet dynamics. However, data sets, particularly from radar and satellite surveillance, will be too large for analysis by eye. There is scope for fisheries scientists to work with algorithm developers and researchers in international law to create automated detection and response techniques.

There is broader opportunity for social, biophysical and legal researchers to investigate and address the causes of illegal maritime activity. Piracy, trafficking and illegal fishing may, for example, result from the collapse of traditional industries and livelihoods, or environmental degradation and marine pollution. Poor governance will also be a contributing factor. While punitive responses may be necessary, the affected community will need the restoration of alternative livelihood to replace illegal income. Obvious maritime alternatives are fishing, aquaculture and tourism. Each case would require identification of opportunities, and establishment of operations that sustain resources (such as fish or tourist attractions). Importantly, sustainable industry requires appropriate administrative arrangements, subject to national and international law.

Many illegal maritime activities are transnational, in the sense that they take place across international boundaries and affect communities in different countries. Any response to such activities must involve international cooperation. Responses include both restricting opportunities to commit illegal practices and establishing sustainable alternatives. This must be done in the context of international law, but also with international agreement on how 'sustainability' is to be defined and monitored, and how appropriate governance is to be set up and maintained. Target countries will not necessarily have the most stable governments, good governance or the rule of law. International engagement across the research disciplines will need to be creative and persistent.

Within the Australian context, funding for research on security and community safety is most likely to come from the Department of Defence and the Department of Foreign Affairs and Trade. Internationally, it will be supported by trade organisations and development banks. The UWA Oceans Institute will work in partnership with such agencies, acknowledging their priorities, and establishing the best internal and external collaborations to address their research needs.

# Theme 3: Fisheries, food security and aquaculture

The UWA Oceans Institute will support government and industry to ensure sustainability of fish stocks and enterprises at all scales that depend on them: commercial, recreational, community and co-operative fisheries. It will also seek to drive sustainable growth in the national and international aquaculture industry. Australia ranks only 46th in world rankings of seafood industry size, yet the size of its marine estate suggests scope for growth, particularly in high-value aquaculture products. By virtue of its developed economic and educational base, Australia has the potential to play a major role in the development of aquaculture, as well as build capacity for sustainable fisheries management practices, across the Indian Ocean and Southeast Asia.

Seafood has important nutritional value, particularly because of its high protein levels, low saturated fat content and minimal use of fresh water in its production. It is a primary source of protein for many Indian Ocean region communities, traditionally supplied through artisanal and small-scale fisheries. In Australia, despite a significant commercial fishing industry, seafood consumption falls below dietary recommendations. In both developed and developing nations, limited seafood supply is reflected in high prices, preventing greater nutritional benefits from being realised. Opportunities must be identified to increase seafood production and bring greater supplies to markets without impinging on marine environments and wild stocks.

Catching and consuming seafood is a significant economic and cultural activity for all coastal communities. The sociocultural foundation can be harnessed to engage people in fishing enterprises; however, as coastal populations grow and pressures on the coastal ocean increase, the livelihoods and lifestyles associated with fishing may be threatened. Sustainable fisheries management is a challenging area, made more complicated by difficulties in monitoring as well as non-compliance including illegal fishing. Furthermore, the impact of climate change, both in the form of increased sea surface temperatures and increased storm frequency, may require the reassessment of many aquaculture locations.

Seafood comes in the form of a variety of animals, particularly finfish, shellfish and crustacea, and some plants such as seaweed. All may be harvested from the wild, and all probably have the potential to be farmed. The UWA Oceans Institute has considerable expertise in marine flora and fauna and so has a crucial role to play in developing viable techniques for aquaculture. It also has the expertise to assist in protecting and building the Western Australian fisheries brand, and preventing seafood fraud in Australia and abroad through better research into fishery supply chains and the role of labelling regulations.

Internationally, both wild fisheries and aquaculture tend to have problems with sustainability; many wild fisheries are in decline or abandoned

because of overfishing by locals or by foreign vessels, often fishing illegally or in unpoliced ways. Aquaculture ventures fail for reasons familiar in land-based farming, such as disease, irreparable damage to the local environment, or unanticipated external impacts like storms or ocean-warming, as well as supply chain and logistics limitations.

In Western Australia, wild fishing is dominated by the rock lobster industry. This was the first fishery in the world to receive international Marine Stewardship Council certification for sustainability and provides a model for other seafood production. Meanwhile, Western Australia accounts (in financial terms) for only just over one per cent of Australia's aquaculture, despite occupying about one-third of the coastline. Western Australia's clean ocean environment presents opportunities for marine aquaculture based on high-value products, but new ventures must accommodate generally low water nutrient content, highly exposed shorelines, lack of local populations and infrastructure at many coastal locations, and vast geographic distances requiring complex supply chain management. Australia can play a leading role in demonstrating the sustainable expansion of aquaculture in this context. Furthermore, fisheries for economic development feature prominently in the blue economy agenda throughout the Indian Ocean region, which demonstrates a pressing need for research in relation to the potential scaling-up of activities associated with capturing wild fish stocks as well as aquaculture.

Both commercial and recreational fishers remove fish from the ocean. Fisheries are managed by a combination of restrictions on vessels and their gear, and numbers, size, gender and age of fish caught, together with limitations on the length of the fishing season. Fisheries regulation must balance the expectations of both commercial fishers, who supply food to the non-fishing population, and the large recreational fishing community. If the sociocultural issues are not addressed, then any attempt to restrict catch becomes controversial, with the potential to become confrontational if not managed socially as well as scientifically.

Most marine creatures have a larval phase in their life cycle, during which they drift with currents. For example, in Western Australia's dynamic ocean environment, with longshore currents and cross-shore swell, it may be difficult to establish the source stock for a fishery. Fish biologists, larval ecologists, physical oceanographers and geneticists are all presently engaged in interpreting larval movement. Other disciplines may well become involved, for example through tracing the history of fishing efforts and returns. Similar knowledge and interpretation will be required in other fisheries around the Indian Ocean.

In Australia, fisheries management agencies tend to be strong in fish biology and stock assessment skills, employing some of the most sophisticated modelling available to natural resource managers. The UWA Oceans Institute offers complementary research skills across the range of biophysical and socioeconomic disciplines to assess, tune and improve these models to predict the impacts of different management options on fish stocks and human communities. Improvement of empirical (statistically-based) models requires access to, and analysis of, specialised observational data on both fish-community and human-community dynamics.

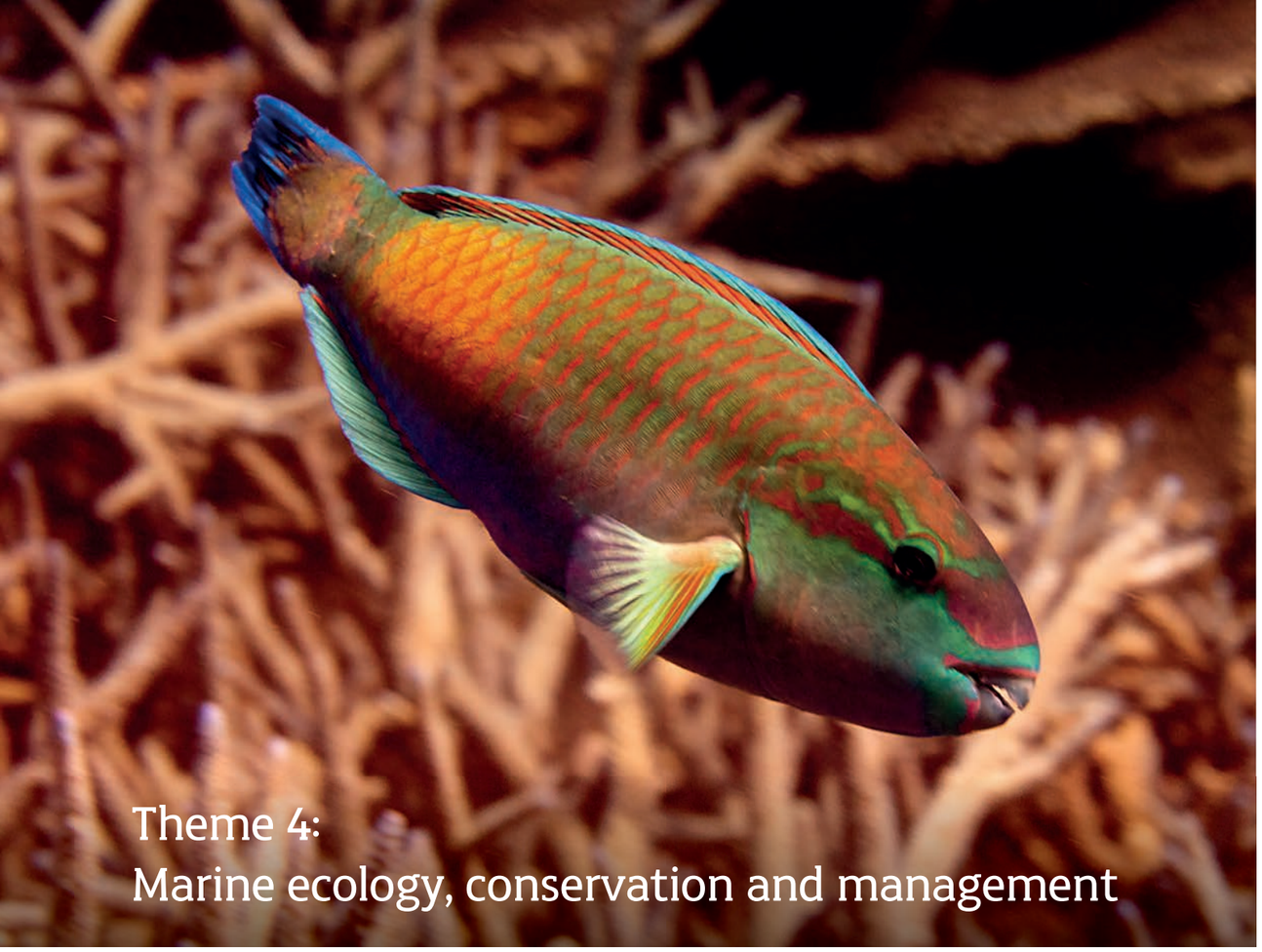
The UWA Oceans Institute also has a comprehensive range of skills relevant to aquaculture: engineering for design and anchoring of cages, and the development of monitoring systems; insight into wind, wave and current conditions; knowledge of the biology of species with farming potential, including their nutritional requirements; critical experience in the identification of novel sustainable food sources; understanding of possible environmental impacts of the facility, including on the farmed species themselves; site selection for higher production with minimum impact in the ecosystem; ability to conduct cost-benefit analyses; and an appreciation of governance arrangements, including permitting systems and environmental standards.

With appropriate political support, and working with industry and management agencies, the UWA Oceans Institute can contribute to a new approach to aquaculture in Western Australia, at the same time establishing a template for new regional and international protocols. The Institute can apply its multidisciplinary perspective to assessing past ventures and exploring the opportunities and risks associated with different species and locations. It can position itself to make recommendations for the improvement and expansion of existing operations, and to advise on new prospects.

Critically, the UWA Oceans Institute has the multidisciplinary strength to focus on species selection and management, but also on the economic and social viability and attractiveness of aquaculture. Coastal aquaculture can be controversial. It is seen to occupy valuable nearshore real-estate and is regarded by some as aesthetically undesirable, creating local environmental damage to the seabed and shoreline. In response, the industry is increasingly moving its cage operations further offshore. The UWA Oceans Institute is perhaps uniquely placed to lead development, through its experience in the design of anchoring systems and floating structures. Its links to maritime and sub-sea engineering industries, developed through work with offshore oil and gas, provide a route to exploit new high-technology options for aquaculture.

Similarly, the Institute can provide leadership and advice on regulatory frameworks that will both enhance the uptake of aquaculture and introduce appropriate safeguards. Significant private investment in aquaculture is only likely if the regulatory framework is perceived as sensible and stable. To encourage such a framework, the Institute would work with state and federal fisheries and development departments. Potential investors are highly likely to be from overseas, seeking reliability and quality of supply both for domestic and overseas markets. To work with international investors and agencies, the Institute will also partner with the Department of Foreign Affairs and Trade.

Seafood aquaculture is widespread around the Indian Ocean and in east Asia. Much of this farming is based right on the shoreline, alienating other activity and causing significant adverse environmental impacts. The UWA Oceans Institute's capability, once refined locally, will be relevant to the entire Indo-Asian region.



# Theme 4:
# Marine ecology, conservation and management

The UWA Oceans Institute will provide both fundamental knowledge and practical conservation and management approaches to ensure that Western Australia's unique marine cultural assets and ecosystems are preserved for future generations. Research at the Institute will provide marine conservation and management guidance for the benefit of the broader Indian Ocean and Southeast Asian regions.

Marine conservation is a feature of many national and regional agendas, as well as a significant aspect of most maritime activity. Blue economy goals can only be achieved if ocean environments and resources are healthy; therefore conservation must be balanced with sustainable use. Ocean biomass and biodiversity, and sites of natural and cultural heritage, may be damaged or diminished by: fishing and aquaculture; physical destruction, for example by dredging; contaminants introduced by runoff, outfalls, dumping and spills; exotic species introduced or translocated by shipping; erection and dismantling of offshore structures; and climate change. Ultimately, conservation requires a compromise between preservation, or restoration, of an existing ecosystem and disruption caused by human activity. Decisions on conservation will depend on social and ethical values, which should be guided by the best environmental, economic and sociocultural research. UWA Ocean Institute's social and scientific research is fundamental to informing and educating government, industry and communities on conservation challenges, and to ensuring that conservation outcomes match community expectations without unduly hampering economic activities.

One mechanism for ecosystem protection is the establishment of Marine Protected Areas (MPAs), in which human activity is restricted, and no-take Marine Reserves (NTRs), in which fishing and destruction of habitats is prohibited but science, educational and recreational activities are encouraged. MPAs and NTRs have an important role to play, alongside fisheries regulation and other marine management tools, in conserving and managing our oceans. Despite the best science, predicting the future for the marine environment is difficult. Because of this, adaptive management approaches are preferred, whereby the impacts of marine activities and conservation tools, including the designation of MPAs and NTRs, are carefully monitored. If the impacts are different from those anticipated, the activities and management regime are modified appropriately. However, such approaches present a challenge for legislative and regulatory frameworks which seek to create certainty. Facilitating effective adaptive management requires careful design, taking into account social, scientific and developmental consideration and approaches to operationalisation that are participatory and transparent.

The UWA Ocean Institute's marine biology and ecology expertise includes understanding species and marine ecosystem processes, enhancing marine conservation and restoration, and addressing anthropogenic impacts – particularly climate change. Studies of individual organisms or species are ultimately scaled-up to provide a description of how whole ecological systems function and how they respond to specific threats. In most cases, the aim is to quantify and minimise damage to the ecosystem or assist its recovery. Work on fish and lobster, for example, provides fundamental new knowledge with relevance to industry and government.

A particular strength of the Institute is its work on coral reefs and seagrass beds; the conservation of both is important for marine ecosystem health and also to underpin economic development goals associated with tourism, for example. The UWA Oceans Institute will also use its skills to provide advice on climate change responses, marine geohazards and the transport and mixing of nutrients, sediment and contaminants, alongside species conservation and sustainable utilisation, bio-fouling and invasive species.

Similarly, the Institute's social sciences assets make a significant contribution to marine and coastal conservation and management. Geographers, environmental management scholars and anthropologists ensure that conservation works for, rather than against, those who utilise and depend on coastal resources. This work contributes to best practice marine and coastal management and also the sustainability of livelihoods at the land-water interface. Heritage sites add to the understanding of indigenous peoples' migration and lifestyle over tens of thousands of years, and to the description of exploration and settlement over the last few centuries. The differing patterns of settlement and use of coastal and marine areas inform conservation and management efforts for the future. Engineers and biophysical and social scientists work together to protect and stabilise these windows into our past behaviour and present values. Regulations and management activities must reflect the values, practices and lifestyles of the diverse range of stakeholders whose support is essential for the long-term success of conservation activities.

Monitoring is essential to ensure that marine assets and systems continue to exist and function for both their intrinsic and practical value. The design and implementation of cost-effective monitoring requires multidisciplinary skills in ecosystem understanding, mathematical modelling, sensor engineering, human resources and policing. Monitoring must encompass the time and space scales of an ecosystem's variability, and be focused on key locations and

species. Ideally, monitoring will minimise labour and vessel costs, and include strategies that utilise technologies such as remote sensing, combining physical inspections and air and satellite surveillance.

Sensor design is an advancing field, as is automated processing for imaging techniques such as video and radar; these are areas of strength for the UWA Oceans Institute. Social science engagement will ensure that policies, legislative frameworks, industry and community acceptance keep pace with technological developments. UWA Oceans Institute researchers with expertise in these areas confirm that the Institute is well-placed to address the cross-cutting nature of these challenges through interdisciplinary research.

Climate change presents a special challenge to conservation. Mitigation is a global issue, rather than one that can be locally controlled, whereas successful adaptation tools and activities must be tailored to the specific local environment. Climate change will manifest in the ocean in many ways: in ocean temperature, salinity and acidity, to which different organisms will have different sensitivities; in ocean currents, which may change patterns of connectivity; in storm frequency and intensity, which may cause physical damage and limit recovery; and in sea level, to which reef and shoreline habitats may have to adapt. These changes may affect the ability to achieve blue economy goals and also violate the stability and security of coastal areas including heritage sites. The role of research at individual ecosystem levels is to determine the impact of climate change and to foresee its implication beyond the ecosystem, including for human well-being. Thereafter, adaptation solutions must be directed towards lessening the effects of climate change. Research projects on engineering, as well as nature-based solutions to mitigation, are a focus for UWA Oceans Institute researchers, as are innovative and integrated approaches to marine and coastal zone management for climate change adaptation.

Based on its fundamental research on the properties and function of marine systems, the UWA Oceans Institute will harness its multidisciplinary expertises to design and implement effective monitoring programs, to demonstrate and promote adaptive approaches to conservation management, and to advise on the manifestations of climate change. Critically, it will integrate new scientific knowledge into advice on legal and policy frameworks. It will demonstrate the environmental and social implications of human activity in the ocean, and ensure these are communicated to policy-makers and the broader community.

In general, regulatory agencies of the federal and state governments will guide Australia's priorities and provide financial support for marine conservation research, although non-governmental organisations have a significant role to play. Internationally, the Australian experience will be relevant across the Indo-Pacific region. Here, intergovernmental organisations and treaty secretariats will play a critical and coordinating role in defining research priorities. International development banks and aid agencies are likely to support deployment of expertise in stressed marine environments around the Indian Ocean region. Commercial beneficiaries will include the fishing and tourism industries, which comprise mostly relatively small individual operators who depend on conservation for their long-term success, as well as governments and corporations engaged in ocean-going trade. More broadly, Australian and regional communities benefit through protection and increased appreciation of their maritime environment and heritage.

# Theme 5: Coasts and communities

The UWA Oceans Institute will help protect the health and safety of Australians by developing key knowledge and practical solutions in relation to people, property and heritage along our coastline. It will collaborate with researchers, communities and management agencies in the Indian Ocean region to enhance the livelihoods of coastal communities among our neighbouring nations.

As an island continent populated by waves of migration, Australia is a distinctly coastal-focused nation. Historically, populations settled on estuaries that provided access to fresh water, food from the ocean, recreational activities, shelter for boats supporting trade, and a climate mitigated by the ocean. Beyond its economic value, the coast has deep aesthetic appeal as the dynamic interface of land and water and unique marine and terrestrial flora and fauna. Over time, history, knowledge and cultural heritage evolve. Particular locations or geographic features achieve cultural significance, and remnants of human activity, ranging from rock art to ship wrecks, connect us to our past and help explain our present.

The UWA Oceans Institute will continue to explore the practical and cultural connection between coastal communities and their environment. It will build the stories and histories that derive from our coastal heritage, including new knowledge gained from archaeological sites and evolving connections with coasts and oceans. It will seek to elucidate the priorities that the community places on environment and heritage in a rapidly changing world. It will particularly link social science with knowledge about the dynamic changes occurring along our coasts, in recognition that the changing physical environment profoundly affects peoples' cultural and economic wellbeing.

Storm systems and extreme events such as tsumanis arriving from the ocean pose the most severe threats to human life and property on the coast, but large swells caused by distant storms are also dangerous and damaging. Between storms, beaches and habitat usually recover when sufficiently resilient to changes. However climate change is causing sea levels and the frequency and intensity of storms to change. It is already clear that climate change is causing permanent modification of our beaches and poses an increased threat to coastal property and structures. Climate variability is likely to alter nearshore habitats such as coral reefs, seagrass meadows and mangroves. The loss of these habitats may, in turn, reduce the natural coastal protection provided by these ecosystems and result in greater impacts of storms on coastlines.

At the scale of beaches, there are complex interactions between waves, water levels, currents and sediment transport. Some of the most productive marine habitats are within the wave-affected coastal strip. In southern Western Australia, the physical and biological cycles are closely integrated. For example, storms wash seagrass and seaweed wrack onto the coast, where they both bind the sand and decay, releasing nutrients back to the nearshore habitats. The decaying wrack has an appearance and odour that can inconvenience coastal residents, pointing to the need for education to raise public awareness of how valuable to the ecosystem this process is.

Coastal science and engineering must accommodate how the coastline changes over multiple timescales from hours for storms, through weeks and months between storms, to years for climate variability and decades for climate change. Coastal management authorities need advice at all timescales to cover their responsibilities for the safe recreational use of the coast, the protection of coastal infrastructure, and planning approvals for long-duration coastal development.

As coastlines change, and coastal property and heritage is increasingly threatened, authorities are faced with the ultimate decision of whether to abandon coastal assets or invest in engineered coastal protection. These are often decisions with severe social, legal and financial implications. They are not only important for Australia, with its major coastal cities, but

they are urgent in other parts of the world with communities concentrated on low-lying islands and river deltas.

The nearshore zone is a complex jurisdiction, administered by multiple departments across all levels of government. Effective coastal-zone management, integrated across maritime activity and government agencies, requires a supportive law and policy framework, institutional responsibility and administrative processes. The multidisciplinary nature of the UWA Oceans Institute is well-equipped to contribute to research in these areas.

The Institute has the expertise to address the multidimensional nature of alternative management options directly, using economic frameworks to weigh up and trade off the social, environmental and economic outcomes of different options. The capabilities of these frameworks enable the intangible importance of the coast to the community to be measured and compared with the tangible benefits. This will ensure that it is not just the market value of aquaculture products, the costs of engineered solutions to coastal hazard management, or the loss of economic growth due to conservation efforts that are at the forefront of decision making, but also the values that people place on the existence of healthy marine ecosystems, the amenity of the coast, or the recreational opportunities it offers.

The UWA Oceans Institute can focus the full force of its multidisciplinary strength for the benefit of coastal communities across Australia and the region. We can apply climate projections down to individual urban beaches, and consider scenarios for nearshore biophysical dynamics and shoreline change. The Institute is uniquely placed as a single Australian research agency in the region that can explore not only the coastal engineering options, but also assess the social, legal and financial merits of alternative responses. It can keep local and regional communities informed and raise awareness about the changing physical and cultural environment, and help to ensure that people are equipped to express well-founded opinions and priorities.

With its national partnerships, the Institute can show leadership in the establishment of an Australian coastal observation network that would deliver nationally consistent data to support research and management. The network would need to deliver research-quality data while being cost-effective, and would require close liaison with other researchers and coastal authorities.

Coastal studies are relevant and valuable in Australia, and the most significant promoters are likely to be local and state governments. The UWA Oceans Institute is positioned to play a critical, coordinating role in that regard. However, across the region key players will be the World Bank, regional development banks and aid agencies. There is a need for both generic methodologies and geographically targeted projects that cover the breadth of cultural and environmental dynamics. While the physical and engineering aspects of coastal management are universal, social, economic, developmental and legal frameworks will differ enormously from country to country. The UWA Oceans Institute has an exciting challenge to demonstrate its multidisciplinary capability on the Western Australian coastline, and to then adapt it to other regional and cultural settings.

# The way forward

The University of Western Australia recognises the potential for ocean research to deliver significant socioeconomic benefits locally and globally. Through the UWA Oceans Institute, UWA is responding to the national imperative, as articulated by the Australian Research Council, that university research should not only be internationally acknowledged through peer review, but should also have tangible positive impact. This imperative is enshrined in the University's mission: to provide world-class education, research and community engagement for the advancement of the prosperity and welfare of our communities. The University recognises that the deepest impact will be achieved from projects that fully exploit its disciplinary breadth and that engage from the outset with agencies able to fund and adopt the research.

The University acknowledges that for many researchers the emphasis on 'impact' requires significant cultural realignment. Research directed at impact requires advance planning and agreement with the agencies that will take up and apply the results, and thus requires clearly articulated objectives and outcomes. Importantly, this kind of impact can only be achieved by teams of researchers who share a common sense of purpose, who communicate well, who understand one another's roles, and who exhibit mutual respect across disciplines and levels.

The UWA Oceans Institute is a flagship research entity for the University, created to enhance impact oriented research. The present Research Strategy suggests potential in the areas of ocean energy, maritime security, aquaculture and marine conservation. At the beginning of the 2018 to 2021 period covered by the strategy, some of these areas are more advanced than others, in terms of cross-disciplinary maturity and engagement with external partners. Inevitably, at the end of the four-year period some will be more successful than others, while other unanticipated opportunities will have arisen.

In the journey through the strategy period, the UWA Oceans Institute will, on behalf of the University, develop crossdisciplinary graduate courses in marine studies, broaden its collaborative reach, expand its partnerships and significantly enhance its reputation nationally and internationally for the quality and impact of its research.

Most importantly, the UWA Oceans Institute will live up to its mission: to provide innovative and effective solutions to challenges facing the world's oceans.

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