Uncovering the secrets of saltwater country

Kimberley's marine ecosystem

A $30 million, five-year research project has seen more than 200 scientists from 25 organisations work with traditional owners and Indigenous rangers from seven saltwater country groups, across 23 projects, to gain a better understanding of the unique marine ecosystem of Western Australia's Kimberley region. This work will inform a balance in protecting one of the world's few remaining near-pristine coastal and marine environments, while supporting the region's social and economic development. It could also help answer some global questions about environments that live on the edge of extreme conditions.

by Kelly Waples and Aleta Johnston

Western Australia's tropical Kimberley region, which extends 12,000 kilometres from Eighty Mile Beach to the Northern Territory border, is well known for its outstanding natural features, vast and remote landscapes and cultural significance for its Indigenous people.

This physically complex inshore environment supports a diverse range of habitats that include seagrasses and coral reefs, many islands, extensive intertidal mudflats and sponge-dominated filter-feeding communities with high levels of biological diversity. The region also supports large and iconic marine fauna including whales, dolphins, dugongs, turtles and estuarine crocodiles.

ANCIENT ENVIRONMENT

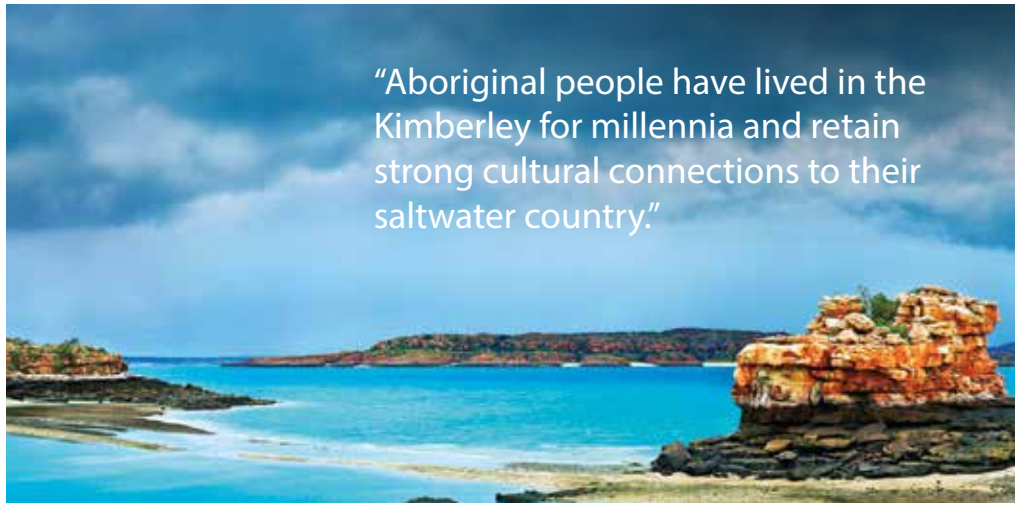
Aboriginal people have lived in the Kimberley for millennia and retain strong cultural connections to their saltwater country. In more recent years, this coastal and marine environment increasingly supports other activities, such as tourism, commercial and recreational fishing, pearling, aquaculture and major port facilities associated with resource industries.

Despite this growth in activity, anthropogenic impacts remain low compared with many other parts of the Western Australian coast, and disturbance to much of the Kimberley marine environment is considered to be minor. However, the region is likely to be increasingly affected by a number of pressures, including climate change-related impacts such as coral bleaching; regional development and growth; and increased human access and use of the region.

Being located close to the equator means the Kimberley experiences two seasons: wet and dry, with the dry season taking up most of the annual cycle through the cooler months. When it arrives in January, the wet season brings heavy rainfall and tropical storms, which result in significant flows of fresh water and land runoff into the coastal habitats.

The Kimberley also experiences huge tides that range up to 12 metres during spring tides. The impact of these tides on this structurally complex coastline creates intricate hydrodynamic patterns and is one reason the inshore waters of this region are typically turbid. These features influence patterns of productivity, energy flows and the many key ecological processes that support the Kimberley region's diverse marine biodiversity.

While there are some unique differences between other coastal systems, the average levels of nutrients and productivity in the Kimberley are comparable to those recorded across northern waters of Australia, including the Great Barrier Reef.



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Main The spectacular marine environment of the Kimberley supports a range of species including lyretail fairy basslets.
Photo – Clay Bryce/Lochman Transparencies
Inset Flatback turtles nest on the beaches of the area.
Photo – DBCA

Above Bonaparte Archipelago.
Photo – David Bettini

Right Seaweed collection in Bardi Jawi Indigenous Protected Area.
Photo – Mat Vanderklift/CSIRO

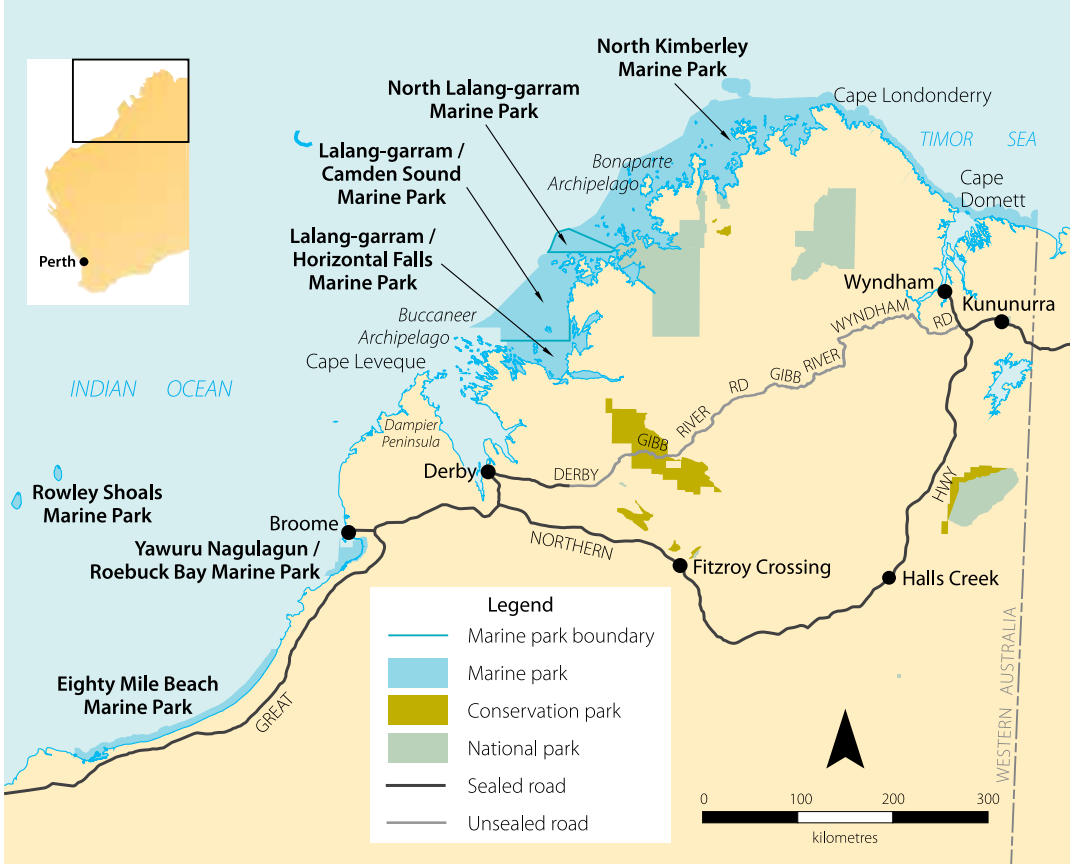
UNCOVERING THE SECRETS OF WA'S NORTH-WEST FRONTIER

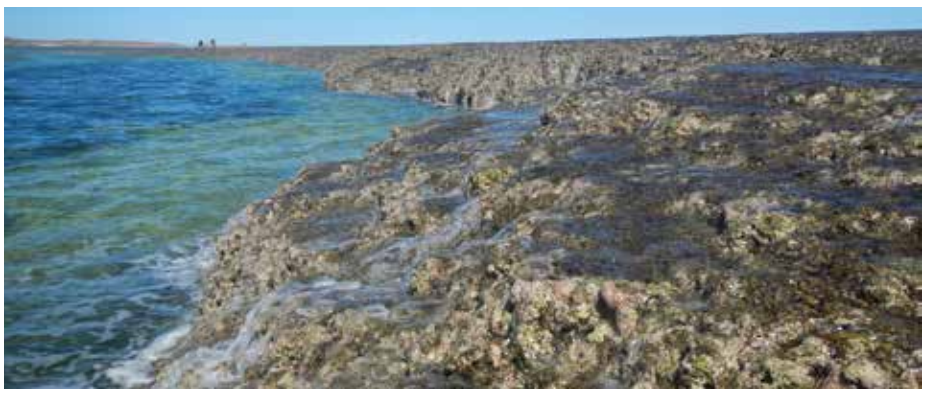
The Western Australian Government's commitment to develop a network of jointly managed marine reserves across the Kimberley highlighted that there was limited information about the marine physical environment, its biodiversity and the various human interests and activities that could assist conservation reserve planning and management.

The Western Australian Marine Science Institution (WAMSI) proposed an integrated program of 23 research projects to fill this knowledge gap and support the development and management of the marine reserves.

Supported by government and managed by WAMSI from 2012 to 2018, this cohesive and integrated $30 million research program drew on the expertise of more than 200 scientists from 25 organisations who worked with traditional owners and Indigenous rangers from seven saltwater country groups.

The key aim of this program, known as the Kimberley Marine Research Program (KMRP), was to get insight into the region's biophysical and social aspects by building foundational datasets and developing an understanding of the key ecosystem processes that support the





marine environment, including response to change. Integrating with the long and enduring cultural knowledge of traditional owners as land and sea managers, was a key aspect of the KMRP; Indigenous rangers and traditional owners took part in the science projects where possible. This has resulted in an integration of traditional knowledge with western science to better describe and understand marine ecosystems of the Kimberley.

In particular, the Kimberley Indigenous Saltwater Science Project sought to improve the integration of Indigenous knowledge and western science by producing guidelines and tools for scientists working on country as well as a pilot training program to support Indigenous rangers to continue monitoring the environment.

PLANNING FOR THE FUTURE

The KMRP has resulted in a significant increase in our knowledge of the physical and biological factors of the marine and coastal Kimberley, and a better understanding of the intricate social values and impacts of people across the region. The data have been used to develop numerous products and tools that will be useful to joint managers over the long term, including baseline datasets, standardised monitoring protocols, and models to improve future predictions of change.

The future of the Kimberley will be determined by the interaction of many pressures (economic, ecological and social processes, climate change, human population dynamics, resource extraction and others) and the effectiveness of strategies used to manage them. The insights gained through the KMRP will ensure knowledge-based management decisions are made for the region and that a sustainable compromise can be achieved, which balances protecting this precious environment for the future with supporting social and economic development in the Kimberley. The collaborations between scientists, managers and Indigenous communities also set a strong stage for ongoing joint management and working together to understand our shared country.

Above left Humback whales migrate through the Kimberley region.
Photo – David Bettini

Above Water cascading off the reef at Tallon Island.
Photo – Tubagus Solihuddin/Curtin University

Surveying fringing reefs

The Kimberley is broadly recognised as an important coral reef province, which houses extensive fringing reef around a highly indented rocky coastline with many islands, seagrass beds and mangroves. However, these habitats and the ecological communities they contain remain largely unexplored across most of this vast area.

KMRP studies focused on understanding the unique fringing coral reefs of Kimberley coastal waters, which appear to thrive, despite the extreme environmental conditions caused by large tidal movements and the prolonged exposure of extensive intertidal areas to daytime heat, cyclones, elevated water temperatures and large amounts of sediment runoff from inlets and rivers creating a turbid environment.

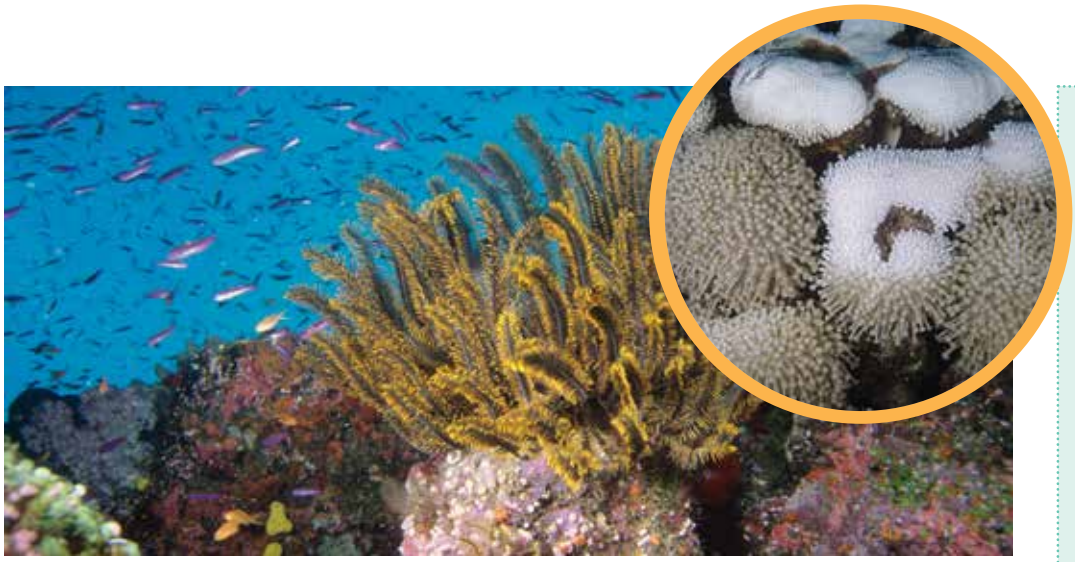
While seafloor habitats of the Kimberley are diverse, many are dominated by patchily distributed sponges and other filter feeders, where many new species are being identified. Almost 2200 species or nominal species were identified from the three areas that were sampled, with sponges, echinoderms, molluscs and crustaceans accounting for 83 per cent of these species.

The force and flow of the water (hydrodynamics) in this system strongly influence the distribution of organisms and how populations are connected. For example, there is little genetic connection between the Dampier Peninsula and Buccaneer Archipelago regions for a range of species. This is most likely due to the extreme environmental conditions, such as currents, turbidity and the periodic discharge of freshwater, at the mouth of King Sound that effectively forms a barrier to dispersal and movement.

SEAGRASS

Seagrasses, macroalgae and microalgae are important benthic (or seabed) primary producers of the Kimberley. The seagrasses *Enhalus acoroides* and *Thalassia hemprichii* (turtle grass) both grow very rapidly and can produce up to two centimetres of leaf growth a day. However, despite being abundant on nearshore reefs, scientists found that both species exist near the limit of their thermal tolerance in the harsh Kimberley environment.

Despite the pressure they are under from such extreme temperatures, these seagrasses appear to thrive and, importantly, provide food and habitat for populations of dugongs, turtles and fish, including the rabbitfish, which is a common food source for local Aboriginal communities. Remarkably, this KMRP research found that the rate of grazing on seagrass was higher in the southern Kimberley at times than anywhere else currently known in the world. In fact, the average consumption of turtle grass actually outstripped growth in some areas, demonstrating the critically important ecological role that this seagrass plays in the region.



CORAL REEF

The distinctive geomorphology of the Kimberley strongly influences how and where coral reefs form in the region. More than 850 nearshore reefs and 2413 islands were mapped as part of the KMRP, comprising 1950 square-kilometres of reef from Cape Londonderry to Cape Leveque – the largest reef system in WA and the second largest reef system in Australia. Most Kimberley reefs occur within 15 kilometres of the coast and have developed a distinctive range of geomorphologies due to underlying substrates, patterns of water movement and turbidity, which will have implications for future management of these reefs. Most importantly, their common proximity to the coast makes them potentially more susceptible to terrestrial influences caused by land use.

Like all other coral reefs in the world, those in the Kimberley are becoming increasingly susceptible to bleaching events caused by gradually increasing water temperature and episodic warm water events. While bleaching events in the Kimberley region are not as well documented as events in other areas, such as the Great Barrier Reef, we do know that coral bleaching has occurred in recent years. For example, regional-scale coral bleaching occurred on inshore Kimberley reefs during the summer of 2015–16, when most coral reefs in the southern Kimberley experienced 30 to 60 per cent bleaching.

DBCA's Biodiversity and Conservation Science marine monitoring program is being implemented as part of marine reserve management in the Kimberley, and will help managers to understand this better. Encouragingly, KMRP research found that calcification rates of Kimberley region corals have been stable over the past 100 years and similar to corals from less extreme reef environments. This suggests they can recover from such impacts. However, while it seems that Kimberley corals have a remarkable ability to thrive under extreme conditions that many other corals would not survive, they are still threatened by the increasing frequency of marine events associated with climate change.

The researchers found that adaptation to the extreme daily temperature range of the Kimberley meant that intertidal corals exhibited greater resistance to heat stress, and that intertidal corals recovered faster from the bleaching events than subtidal corals.

Research will continue to explore the physiological and genetic mechanisms underlying the exceptional heat tolerance of Kimberley corals through collaborations initiated under the KMRP.

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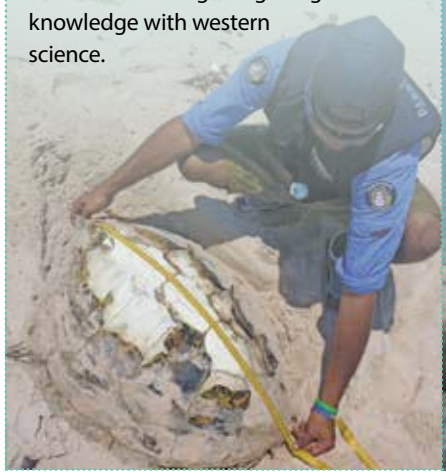
Above left Long Reef at low tide. *Photo – Col Roberts/Lochman Transparencies* **Left** Turtle seagrass. *Photo – Mat Vanderklift/CSIRO*

Above The North Kimberley is home to a myriad of coral species. **Above inset** The Kimberley has experienced coral bleaching. *Photos – Clay Bryce/Lochman Transparencies* **Right** Training activities undertaken during WAMSI field trips included data collection. *Photo – Tony Tucker/DBCA* **Far right** DBCA vessel *PV Wamdoom* at Kings Cascade, Prince Regent National Park. *Photo – DBCA*

Social research

Managing the environment relies on understanding the spatial and temporal patterns of human use, how people value the region and their aspirations for it. For the Kimberley, this recognises the strong connection to and stewardship of saltwater country held by traditional owners, along with the appreciation for the substantial knowledge they have about the marine and coastal environment. Research on social values highlighted the biodiversity and the physical landscape of the Kimberley coast and marine waters as key, with strong support for marine and coastal protection and conservation along the whole coastline. Visitor use of the Kimberley was found to have a strong seasonal influence and was focused at relatively few sites around population centres, tourist accommodation or road access to the coast. These findings can support management for the future to preserve biodiversity values and manage potential impacts.

Traditional owners were key participants in the KMRP, most notably through a project led by seven saltwater country groups to improve the ways in which research and monitoring of the natural and cultural resources of the Kimberley are planned, assessed and undertaken to include both Indigenous and western science partners. The project produced a rich legacy of strong partnerships between scientists and traditional owners as well as a set of protocols around right-way research and integrating Indigenous knowledge with western science.



Iconic megafauna

Large marine animals are valued for their biodiversity significance, contribution to marine tourism and education, and high cultural significance, including as a traditional food source in some cases. In the Kimberley, iconic species include humpback whales, coastal dolphins, dugong, marine turtles, crocodiles and shorebirds.

These species may be migratory, with wide distributions that cross national and international jurisdictions. Some are considered to be threatened and all are protected by state and/or federal legislation, or are subject to international conservation and management agreements. KMRP research focused on improving knowledge of the distribution and abundance of these species in the region and the importance of different marine and coastal habitats to them.

WHALES

Researchers used spatial models that integrated 13 years of aerial and shipboard humpback whale surveys to create distribution and density maps to better understand what drives their distribution and abundance in the Kimberley. This study confirmed that Camden Sound, and its surrounds, is an important calving area for humpback whales, particularly in August. The research also indicated that calving occurs southwards along the Dampier Peninsula. Pender Bay was found to be suitable for humpback whales across the entire breeding season, and is used for resting and transiting.

New tools for research and monitoring

Not only has the KMRP produced a wealth of knowledge and background information on the Kimberley, but it has also been instrumental in developing new tools that can be used in ongoing research and monitoring – an example of the impact of science. A new method of collecting biopsy samples from crocodiles to investigate genetic relationships within and between populations was developed by DBCA scientists. Satellite imagery was explored as a cost-effective method to count humpback whales and better understand population changes over time. A range of monitoring techniques has been developed and shared with Indigenous rangers and DBCA staff to be used in long-term and regional monitoring programs such as the use of drop cameras to assess coral and other seafloor habitats.

DUGONG

The dugong is an important species in marine ecosystems and has cultural importance to Indigenous coastal communities. The coastal waters of north-west Australia support one of the largest remaining dugong populations in the world. KMRP research estimated that about 12,600 dugongs inhabit the region, with an average density of one dugong for every four square kilometres. The highest densities of dugongs were found in areas with extensive seagrass habitat associated with sheltered shallow areas (less than 20 metres) and relatively clear water. Notably, tracking studies found that dugong can move large distances over short periods of time, which means they need to be managed on a local and regional spatial scale.

ESTUARINE CROCODILES

Estuarine crocodiles were protected in Australia in 1969 after an extended period of unregulated hunting depleted their numbers across northern Australia, including the Kimberley (see 'Snapping back', *LANDSCOPE*, Spring 2017). KMRP research found that the population and size of estuarine crocodiles in the region has increased since the 1980s when crocodiles in the area were last surveyed. More than twice as many crocodiles were counted in the Prince Regent and Roe Hunter rivers during surveys in 2015 than in 1986, and the higher number of large crocodiles (greater than 1.8 metres) seen more recently suggests the populations have a mature size structure.

This is pleasing. However, recovery in these river systems does not match that of populations in the Northern Territory in terms of density or biomass, which tells us that the recovery process is continuing.

It is likely that the unique environment and the scarcity of appropriate nesting habitat in the West Kimberley will probably limit the Western Australian populations. In addition, it is likely that the number of interactions between crocodiles and humans will increase, as the crocodile population recovers and the human population increases and expands. In order to manage this conflicting demand on habitat, more information about the amount of available nesting habitat throughout the region will be needed, and additional river systems will need to be surveyed.

MARINE TURTLES

While marine turtles nest on beaches throughout the Kimberley, the most important turtle rookeries were found to be at Cape Domett, where flatback turtles nest during winter, the Lacapede Islands, where green turtles nest during the summer, and Eighty Mile Beach where flatback turtles nest during the summer. The biggest pressure facing turtles in the Kimberley is likely to be an increase in temperature caused by climate change; warmer sand at nesting beaches can skew sex ratios of hatchlings to be predominately female, increase embryo mortality and potentially shift the distribution of nesting.

As a result, these areas have been flagged as a high priority for long-term monitoring to provide an indication of the impact of climate change on the system.

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Far left Humpback whales are known to calve in Camden Sound. *Photo – DBCA*
Inset The great knot is one of the shorebirds that occurs in the Kimberley. *Photo – Danny Barrow* **Below left** A new method of collecting biopsy samples has been developed. *Photo – DBCA*

Top left About 12,600 dugong are thought to live in the Kimberley. *Photo – Guy Skillen*
Left Saltwater crocodile. *Photo – David Bettini*
Above A flatback turtle hatchling. *Photo – DBCA*

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For more information on the KMRP and program findings and outcomes visit www.wamsi.org.au and download the final synthesis report.