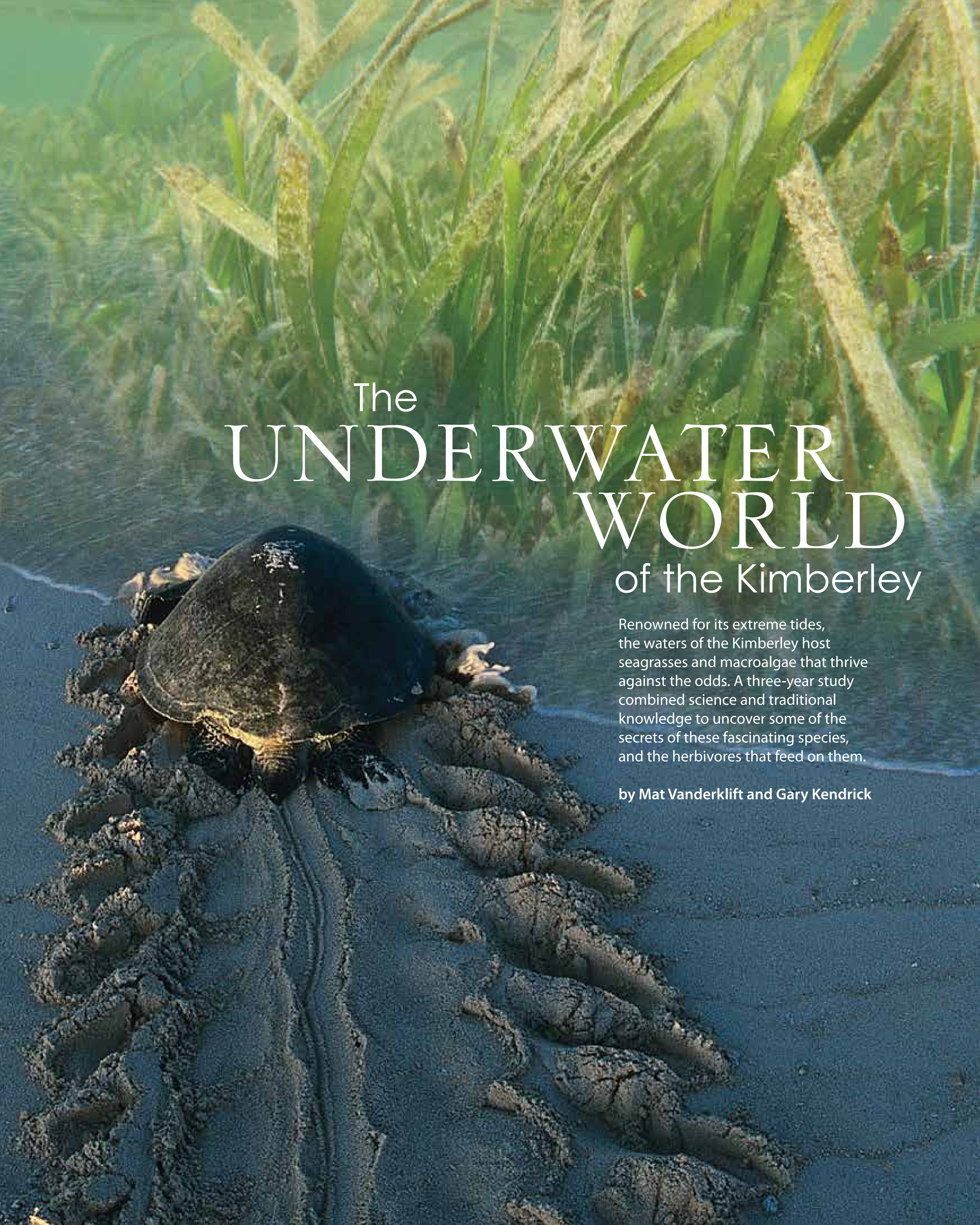

The UNDERWATER WORLD of the Kimberley

Renowned for its extreme tides, the waters of the Kimberley host seagrasses and macroalgae that thrive against the odds. A three-year study combined science and traditional knowledge to uncover some of the secrets of these fascinating species, and the herbivores that feed on them.

by Mat Vanderklift and Gary Kendrick

The Kimberley region, occupying the far north-western corner of Australia, is renowned for its wildness, extreme tides and majestic landforms. Saltwater crocodiles patrol the rivers and coasts, humpback whales give birth in its calm bays, green turtles nest on the sandy beaches, and its waters teem with fish that anglers dream of. But what sustains such richness?

AGAINST THE ODDS

Researchers from CSIRO and The University of Western Australia teamed up with the Bardi Jawi Rangers – who look after more than 250 kilometres of coast and the 340,700-hectare Bardi Jawi Indigenous Protected Area – to answer this question. Under the auspices of the Western Australian Marine Science Institution (WAMSI) which includes Parks and Wildlife, the team spent three years studying the seagrasses and macroalgae (large seaweed) that grow on the seafloor abutting the coast and islands around One Arm Point.

What they found was remarkable – the seagrasses and seaweed grow in extreme conditions that would normally pose problems. Yet not only do they survive, they thrive.

The islands off One Arm Point experience some of the largest tidal ranges in the world – at certain times of year when the moon is full the difference between high and low tide can be up to 12 metres. When the tide drops, at some places in the islands it leaves behind lagoons perched up to several metres above the water level, which are held in place by a hard reef of coralline algae (a hard, pink type of algae that uniquely takes the place of reef-building corals in the area). Water remains impounded within these lagoons for several hours, and without the cool flushing effects of the currents that twist in and out of the channels, the water gradually heats up. In the height of summer, when air temperatures regularly exceed 40°C, the team recorded water temperatures over 35°C – soaring five degrees celsius or more in the span of a few hours. But that's not all; not only do the plants in these lagoons face extreme temperatures, through their own respiration at night time they use the oxygen in the water, causing the amount of dissolved oxygen to plummet, and the water to become more anoxic.

Facing such extremes of high temperature, low oxygen and low pH water, most plants would give up, but not the seagrasses and seaweed of the Kimberley lagoons. Instead, the team found quite the opposite. The seagrasses that they measured were growing an astounding several centimetres each day – among the highest plant growth rates observed anywhere in the world. The growth rates for seaweed were similarly impressive. The team focused on one common species of large brown algae – rough-stemmed sargassum (*Sargassum polycystum*). Unlike seagrass, which tend to grow at a relatively constant rate all year, *Sargassum* has a distinct pattern of growth; for much of the year it barely grows at all, but during early summer the growth rates accelerate rapidly exceeding a centimetre each day.

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Main Surveying the diets of green turtles revealed some secrets of the area.
Photo – Alex Steffe/Lochman Transparencies
Inset *Enhalus acoroides* was one of the species studied.

Above Bardi Jawi ranger Dwayne George and researcher Monique Grol measuring seagrass growth.
Photos – Monique Grol/CSIRO

Top left The seagrass *Enhalus acoroides*, one of the species studied, often grows adjacent to mangroves.
Photo – Mat Vanderklift/CSIRO

Top A quadrat, used during the study of growth, in a meadow of the seagrass *Thalassia hemprichii*.

Above The brown seaweed *Sargassum* in a quadrat.
Photos – Monique Grol/CSIRO

Left A Bardi Jawi ranger gently brings a turtle to the surface after capture.
Photo – Mat Vanderklift/CSIRO

"What they found was remarkable – the seagrasses and macroalgae grow in extreme conditions that would normally pose problems. Yet not only do they survive, they thrive."

MEASURING GROWTH

With so much growth – a square metre of these seagrass meadows produces about a kilogram of new biomass each year – the research team set out to work out where it all goes. They used a simple but effective technique to ascertain whether it was simply getting eaten or whether something else was happening to it. They would locate an intact shoot, photograph it to digitally measure its surface area, place it back in the meadow, and return the next day to re-photograph it. This was done for two species: *Thalassia hemprichii* (otherwise known as turtlegrass), and *Enhalus acoroides*. The team found that the amount being eaten depended somewhat on where and when they did the experiment, but mostly it depended on which species of seagrass they used. Consumption of *Thalassia* was as high as 60 per cent of the shoot, and almost always higher than five per cent. In contrast, consumption of *Enhalus* was almost always less than five per cent, and sometimes did not occur at all.

These disparate rates of consumption of the two species of seagrasses contrast with their relatively similar rates of growth, which implies that they might play different ecological roles. The evidence that a large proportion of the production of *Thalassia* is directly consumed by herbivores led the team to wonder what those herbivores were. To unravel this mystery, the exchange of traditional ecological knowledge with the Bardi Jawi Rangers proved invaluable.

As they walked the lagoons together and considered the options, including green turtles and a number of different fish, one species they observed darting around them emerged as a likely candidate:

Left One Arm Point is part of the Buccaneer Archipelago.
Photo – Col Roberts/Lochman Transparencies

Above Evidence has been found that the golden-lined rabbitfish or *barrbal* is consuming vast amounts of the seagrass.
Photo – Mat Vanderklift/CSIRO

the *barrbal* – or golden-lined rabbitfish (*Siganus lineatus*). The species is highly prized by the locals for its white flesh and the fat that lines its stomach cavity. One of the rangers speared a *barrbal*, and looked inside its stomach, sure enough, it was full of *Thalassia*. Thus the next stage in the research was born. Over the next year, the team systematically collected *barrbal* from different places and during different seasons. No matter where or when they were collected, one result stood out: their stomachs almost always contained large amounts of *Thalassia*.

Yet, the team also knew that there was another prominent herbivore – the green turtle (*Chelonia mydas*), also called *goorlil* in the Bardi language. Green turtles are typically vegetarian, and in many places of the world consume primarily seagrass. Even the common name for *Thalassia* – turtlegrass – gives a clue as to the green turtle's potential role as a herbivore. Examining the diet of green turtles was not so straightforward as it was for *barrbal* – a few stomachs donated by traditional hunters showed that some had large quantities of *Thalassia*, but not all. Instead, once again the value of the partnership between the scientists and the rangers was demonstrated. The team captured turtles using a method known as 'rodeo', in which an experienced handler leaps into the water from a boat and captures it by hand – the local knowledge and proficiency of the rangers in turtle capture meant that 60 turtles were captured in this way during two expeditions. On board the boat, the research team took blood samples from the turtles before releasing them back into the wild. The blood samples were immediately placed into a centrifuge to separate red blood cells from plasma and other components of the blood. Those samples were then frozen and transported to the research laboratories in Perth. There, the researchers measured the ratios of stable isotopes – different types of atom of the same element (say, carbon) that have different numbers of neutrons, and so have infinitesimal differences in mass. This process takes advantage of the fact that different types of plants have different ways of collecting and storing energy and nutrients, and so have different stable isotope ratios. By comparing the data from the blood of turtles with those obtained from the plants, the team was able to get insights into what those turtles had been eating. What they found was intriguing. There was no single consistent diet common to all turtles, but instead they appeared to have a variety of diets. Some turtles, as the team expected, did indeed eat *Thalassia*, but others did not, and were more likely to eat macroalgae.

Three years on, the team has made great strides. The surveys have revealed that the seagrasses and seaweed of the Kimberley are living on the edge – thriving in extreme conditions that push the limits of what they can cope with – and that they support a food web that has profound cultural significance. Perhaps above all, they have shown how partnerships between researchers and Indigenous rangers can yield outcomes that neither can achieve on their own and produce enduring friendships forged during the shared experience of discovery.

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