Kimberley Marine Research Program

WAMSI Project 1.1.2

Key ecological processes in Kimberley benthic communities: recruitment and herbivory

Researchers from five separate institutions have joined forces with the Bardi-Jawi Land and Sea Rangers to provide the first detailed look into the process of fish and coral replenishment and the importance of marine plants to herbivore (or "vegetarian" marine animals) and vice versa in sustaining the health of the Kimberley's marine ecosystems.

Background

The health of marine ecosystems is underpinned by the continuous replenishment of marine organisms.

For corals and fish, this process is called "recruitment" and entails baby fish and corals making their way from the open ocean back into shallow coastal waters, often close to where they were first conceived.

Similarly, the role of "herbivory" in marine animals is critical to how coastal ecosystems work because it provides a foundation through which primary production (plant material) makes its way up the food chain and helps maintain populations of marine animals like fish and sea turtles.

Understanding the nature of these essential ecological processes underpins effective management by providing a yardstick by which to forecast and monitor ecosystem health and integrity.

In the Kimberley, very little was known about these processes and how they influence and characterise the region and we could only speculate on how a challenging macrotidal (tidal range >4 m) environment might complicate them.

Figure 1. Mangrove Jack (AIMS)

Clearly, a better understanding of the nature of these processes was needed; with the Kimberley coming under increasing pressure from a range of sources and the pressing need to provide baseline knowledge to inform and support decisions by Indigenous and non-Indigenous management agencies.

As a start, very basic questions needed an answer, such as:

- When do corals and fish recruit into coastal habitats?
- How many are there?
- Where do they go?
- Are there important "nursery" habitats or areas that need particular protection?

For herbivory, the questions were equally simple in concept:

- Who is responsible for eating the majority of plant material?
- How much do they eat?
- Do they have a preference for particular types of plants?

Despite these seemingly simple questions, the dynamic and complex Kimberley environment provided a challenge to the traditional ways in which western science usually gathers this information.

With advice and guidance from the local Bardi Jawi community and Marine Rangers, trials, development and testing of new or modified methods to get at these questions were a necessary first step.

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Research Objectives

Scientists from the Australian Institute of Marine Science (AIMS), CSIRO, Department of Parks and Wildlife WA (Parks and Wildlife), The University of Western Australia (UWA), Department of Fisheries (DoF) and Western Australian Museum (WA Museum) worked in partnership with the Bardi Jawi Land and Sea Rangers, Traditional Owners (TO's) and the Kimberley Marine Research Station to provide the first quantitative estimates of coral and fish recruitment and herbivory in the Cygnet Bay / Sunday Island group of the southern Kimberley region.

The core goal of the project was not only to provide a firm baseline of primary information on these processes but a blueprint on the appropriate techniques needed to do this to facilitate future studies and monitoring.

What we've found

In total, 24 field trips were conducted to answer these questions over the 2015/2016 period; 13 by the coral recruitment team, seven by the fish recruitment team and four by the herbivory team.

Coral recruitment

The mode of sexual reproduction in corals varies considerably among Western Australia's reef systems and to date, little is known about the reproductive patterns of Kimberley corals.

Sample processing is ongoing for coral recruitment, so final results are not yet available.

As part of the processing we are examining the proportion of corals that brood larvae versus those that spawn gametes into the water column.

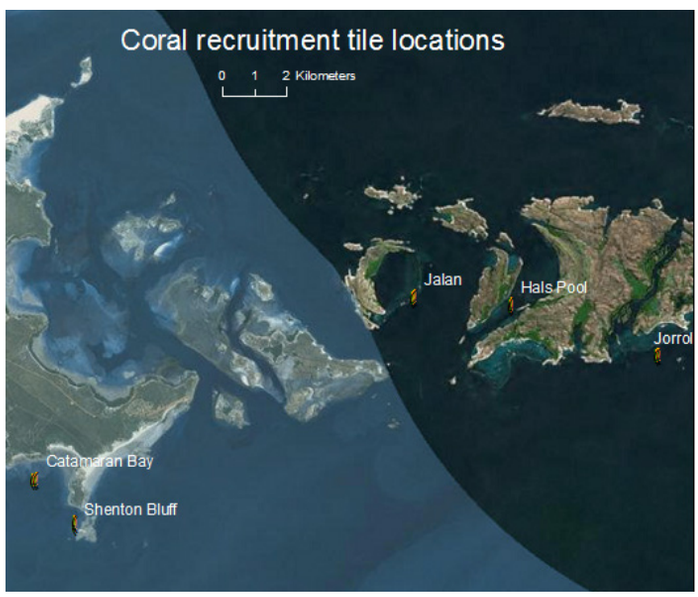

Figure 2. The locations of the coral frames in five coral-dominated areas in Western Australia's Cygnet Bay and the Sunday Island group. At each location, there are three frames each containing six tiles per month.

Initial results are highlighting that brooding corals are a significant component of corals in the Kimberley and release planula larvae each month.

Our analyses is also comparing the timing of spawning activities in corals and whether these are similar to those seen in oceanic Kimberley reefs such as Scott Reef, or more akin to those found in coastal reefs further south, in the Pilbara and at Ningaloo.

In this project, we have adapted well-known techniques for assessing coral reproduction and recruitment to suit the unique and challenging Kimberley environment.

Large tidal ranges and tidal current flows created limited windows of opportunity to access our study sites where subtidal corals were found (Figure 2).

This, in combination with limited ability for spatially and temporally intensive in situ reproductive sampling, led us to develop specialised frames housing settlement plates, which could be deployed and retrieved from the surface (Figure 3).

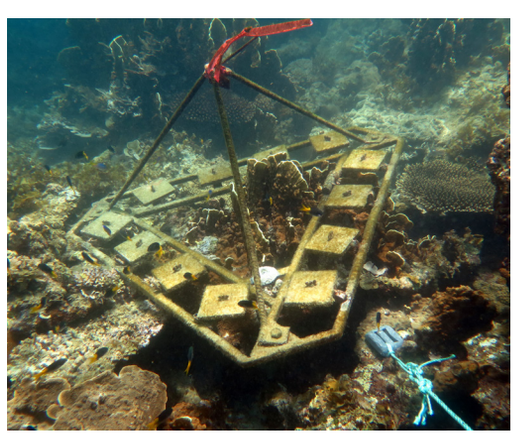

Figure 3. Sampling platform used for the three project components, the Kimberley Marine Research Station's Atlanta IV. (AIMS)

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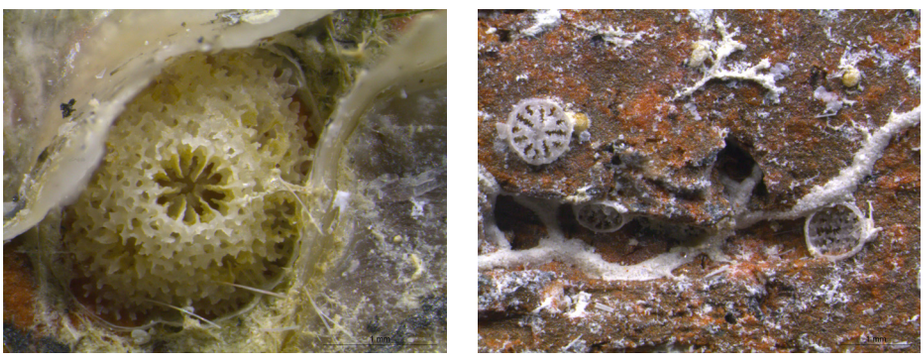

Figure 4. Isopora (left) and Porites (right) coral recruits on terracotta settlement plates. (AIMS)

These settlement plates provide a measure of coral recruitment at a range of sites to determine dominant modes of reproduction and timing.

Our monthly sampling regime was largely run by the Bardi Jawi Marine Rangers and has been designed to provide insights into spatial variation in larval supply among a host of sites.

This will help inform us of areas that retain larvae due to water movement and tidal flows, and can be described as 'sinks' for coral recruits (Figure 4).

Of note, extreme temperature anomalies in the Kimberley region between February to April 2016 encompassed the predicted dates of mass spawning by corals and caused significant stress, coral bleaching, and eventually mortality.

During other historical bleaching events, this temperature stress has been found to significantly reduce reproductive output in corals.

It is likely that this bleaching event has had a similar effect on rates of recruitment, perhaps overriding the typical seasonal patterns or recruitment and variation in spawning activities which are typically concentrated in the earlier months of the year.

The final analyses of the remaining settlement plates in the coming month will provide an indication of whether coral recruitment in the Kimberley has been affected by coral bleaching in this event, with the possibility of future work allowing insight into the recovery of these uniquely adapted coral communities from bleaching.

Fish recruitment

For the same reasons as those outlined for coral work, traditional ways to assess fish recruitment through direct underwater visual census was unfeasible prompting testing, development and refinement of a remote alternative.

Six different remote survey techniques were identified in a dedicated workshop and tested against traditional in-water techniques.

Following a pilot study, the team settled on stereo Remote Underwater Video (RUV) as the best way to remotely survey patterns of fish recruitment because of its ability to survey fish recruits in all types of habitat and its overall performance in terms of abundance, effort required, ease of deployment, precision and ability to capture a diverse group of fish species (Figure 5).

We expected that different fish species would have different nursery habitat preferences and sampled accordingly.

Mangrove, seagrass, algae, inter-tidal pools and coral reefs were all targeted at a range of sites in an effort to capture a more complete overview of patterns of fish recruitment in the southern Kimberley (Figure 5 & 6).

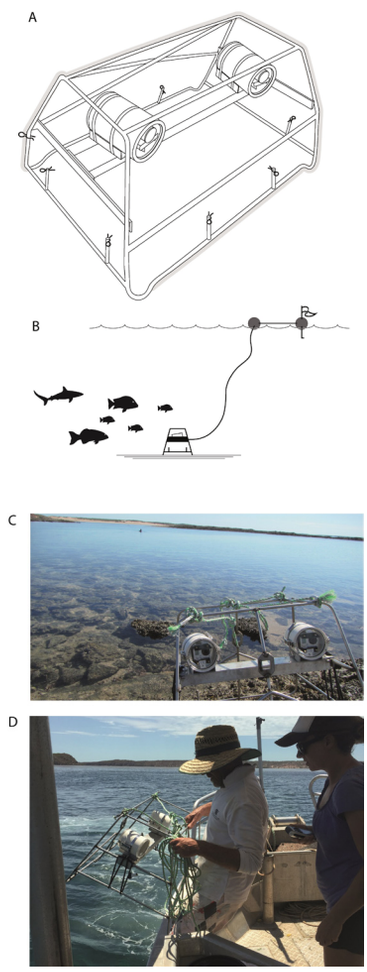

Figure 5. Diagram showing the design (a), functioning (b) and deployment of stereo-RUV units at an inter-tidal pool (c) and from a small vessel (d) in the southern Kimberley region. (AIMS)

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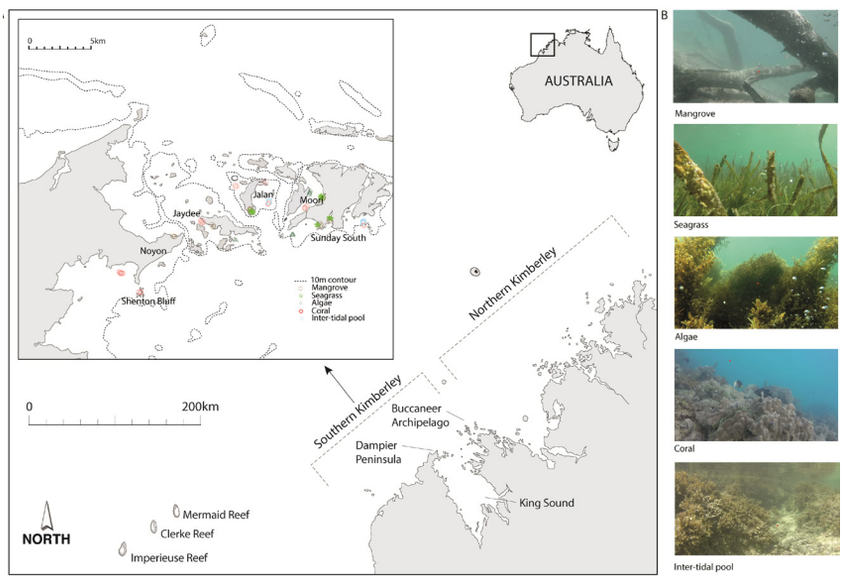

Figure 6. Map of the six study locations in the Sunday Island and Cygnet Bay area of the southern Kimberley region in northwest Australia (Jaydee= Jackson Island, Jalan= Tallon Island) (a). Stereo-RUV deployments were conducted during wet (March-April 2016) and dry (October 2015) seasons in five different nearshore habitats (mangroves, seagrass beds, macroalgal beds, submerged coral reefs, and inter-tidal pools, b), and bi-monthly at coral reefs. (AIMS)

Fieldwork produced two separate data sets. The first, targeting all five habitats over wet (April) and dry (October) seasons; the second, concentrated in coral reef habitats which our pilot study identified as supporting the most diverse fish assemblage, was gathered on field trips held every two months.

Our results firstly identified that pre-defining homogenous habitats in the Kimberley (especially remotely) was problematic. Instead Kimberley habitats are often more heterogeneous in nature, encompassing a mosaic of habitat combinations.

Generally, recruitment was stronger during the wet season, a pattern consistent with other Western Australian ecosystems (Figure 7).

Although this seasonal pattern was consistent among habitats, each habitat consisted of a unique assemblage of fishes which also varied widely in abundances.

Mangroves provide the best example. Here, although recruitment numbers were generally quite low, the habitat uniquely provided a nursery habitat for some very important species such as the snappers Mangrove jack (*Lutjanus argentimaculatus – Maarrarn*) (Figure 1) and Moses perch (*Lutjanus russellii*).

Similarly for seagrasses, the Golden-lined rabbitfish (*Siganus lineatus - Barrbal*) that provide an important source of food were found almost exclusively in seagrass habitats, a finding consistent with isotopic and gut-contents results found by the herbivory team in this project.

The bi-monthly sampling on the coral reef habitat confirmed that wet season sampling around April provides the strongest fish recruitment signal each year although we also note that our sampling period ran over a year which was unprecedentedly warm.

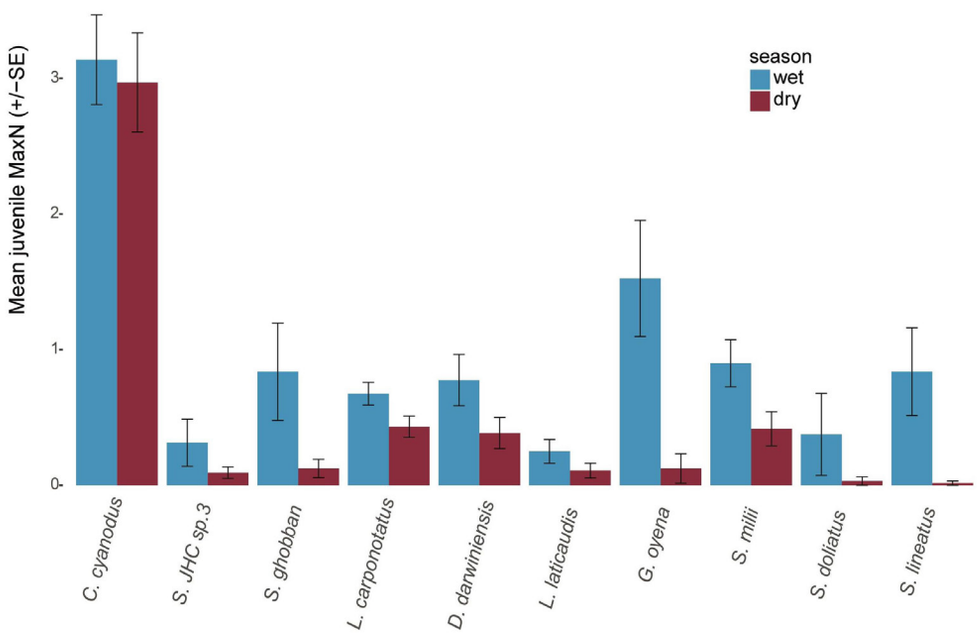

Figure 7. Average juvenile abundance (MaxN ±SE) for the ten most abundant fish species in all habitats surveyed across wet and dry seasons

Figure 8. Worker recording algal growth and consumption in the Cygnet Bay / Sunday Island group of the southern Kimberley. (Mat Vanderklift, CSIRO)

Herbivory

The research team recorded rates of grazing on seagrass that were higher in the southern Kimberley than anywhere else in the world.

Interestingly, average consumption of the seagrass *Thalassia hemprichii* (otherwise known as turtlegrass) actually outstripped growth in some areas (Figure 8).

Thalassia is one of the most abundant seagrasses in the terraced lagoons that are characteristic of the region, and the apparent contradiction of high abundance in places where we measured consumption exceeding growth is likely reconciled by a combination of fast growth rates and patchy grazing – grazing rates on *Thalassia* varied by two orders of magnitude (Figure 9).

In contrast, consumption of the seagrass *Enhalus acoroides* was on average lower than growth, and much of its production is probably not consumed by herbivores, but becomes detritus.

Further research identified two candidate species that probably account for much of the grazing. Stable isotope and gut-content analyses found that the Golden-lined rabbitfish *Siganus lineatus* – a prized table fish for the Bardi-Jawi people, who call them *barrbal*, consumed large amounts of *Thalassia*. RUV deployments confirmed that it was also one of the most abundant species inhabiting the seagrass beds.

The second significant herbivore in the area is the green turtle *Chelonia mydas*. Green turtles consumed a range of plant foods, but especially brown algae and *Thalassia*.

Satellite tags showed that they frequently tended to spend their time in places with abundant seagrass. The study revealed some evidence that different individuals might have preference for brown algae or seagrass.

Implications for Management

Differences in species assemblages vary greatly between habitats arguing strongly for targeted protection of all habitat types in (at least) the southern Kimberley.

Fish recruitment is concentrated in the wet season so any annual long-term monitoring program should concentrate efforts during this time (Figure 10).

If a more refined program is called for, then coral reef, algae and inter-tidal pools are most similar in composition and can therefore act as surrogates for each other in this regard.

With the addition of mangroves and seagrass, a wet season sampling regime would adequately capture essential information on fish recruitment processes in (at least) the Cygnet Bay / Sunday Island area of the Kimberley.

Finally, fish diversity overall was surprisingly low and well below expectations considering its closer proximity to the equator and global centre of fish diversity prompting further questions about the influence of the Kimberley's unique characteristics and how they affect recruitment processes.

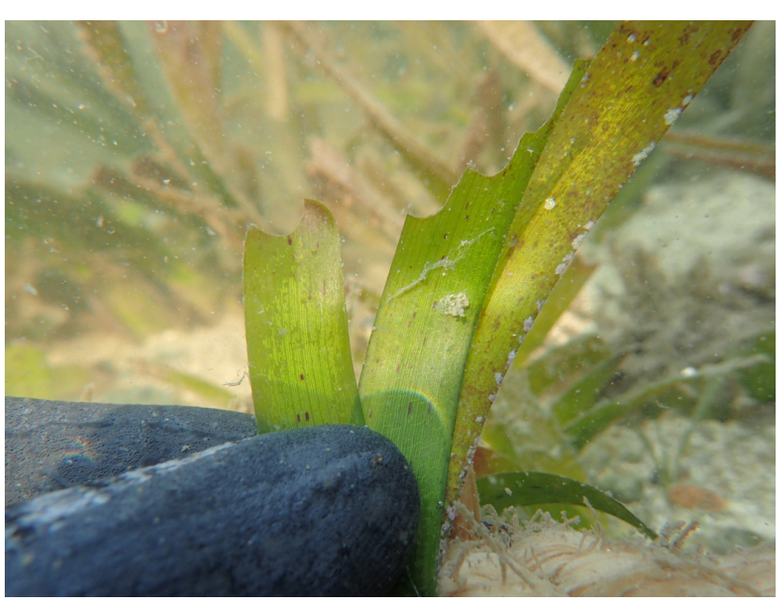

Figure 9. Grazed turtle grass (Thalassia hemprichii). Turtle grass is a fast grower but in some places grazing by herbivores exceeded estimates of production. (Mat Vanderklift, CSIRO)

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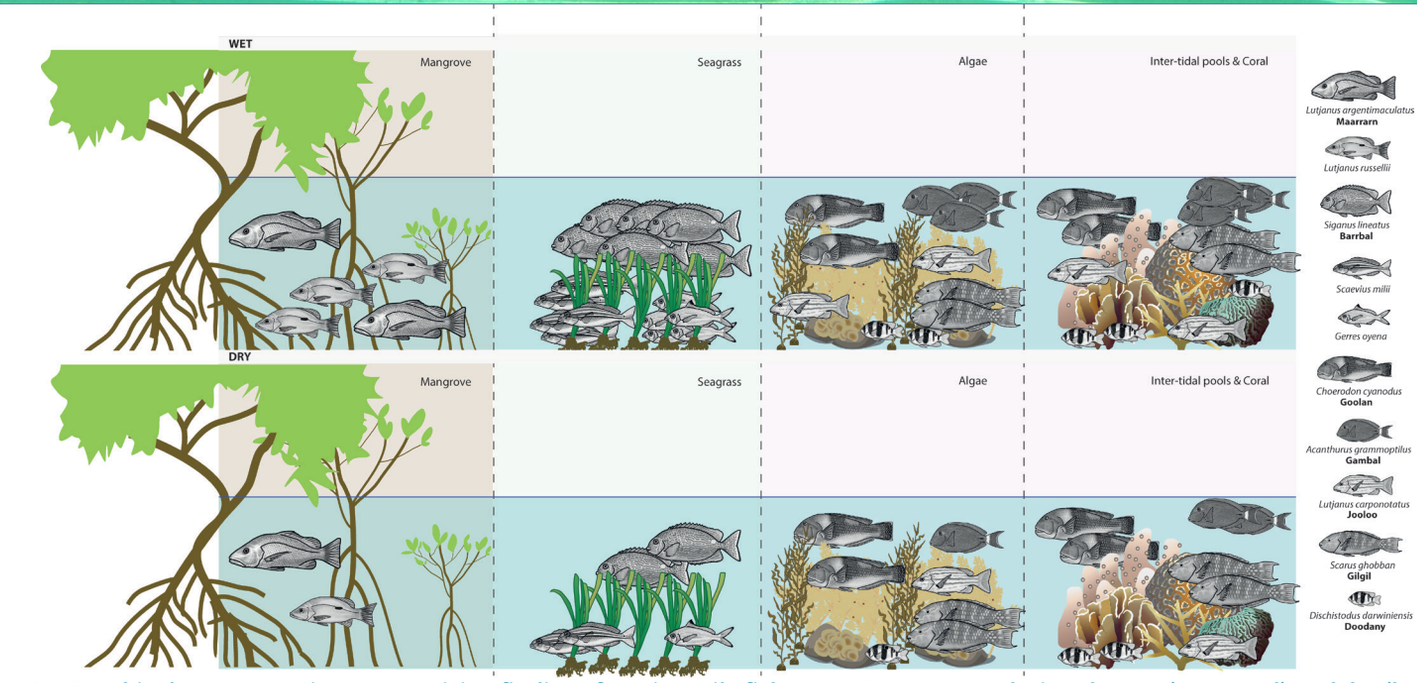

Figure 10. Graphical representation summarizing findings from juvenile fish stereo RUV surveys during the wet (top panel) and dry (bottom panel) seasons across five habitat types (mangrove, seagrass, algae, coral and inter-tidal pools; separated by dashed lines). Habitats portrayed from left to right follow a typical Kimberley habitat profile from inter-tidal mangroves to adjacent seagrass meadows and algal fields to elevated rocky inter-tidal pools and submerged coral reefs. Colour shades in the background of each habitat represent groupings based on observed statistical differences in fish assemblages among habitats (brown-mangroves, green-seagrass, and pink- algae, coral and inter-tidal pools). Each fish diagram represents a different juvenile species; key to right shows scientific and Bardi Jawi names. Only the ten most abundant and highly influential species distinguishing between fish assemblages are presented. The number of fish in each panel is equivalent to the average number of juvenile fish per RUV replicate (e.g. MaxN = 5 in mangrove habitat during the wet season).

Type of data collected

The types of data collected from this project include coral recruitment settlement plate counts of new coral recruits; temperature data, MaxN counts of fish recruits, MaxN counts of fish adults, fish species list and benthic habitat characterisation data.

Data available in:

All metadata is publically available via AIMS, CSIRO and Pawsey metadata catalogues. Data will be available after the embargo period for the project.

Project Team

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www.wamsi.org.au/key-ecological-processes

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