The status of Murray Crayfish in Talbingo Reservoir, Yarrangobilly River and Wallace Creek in June 2024

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Report to Snowy Hydro

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Disclaimer

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Contents

Background

Murray Crayfish *Euastacus armatus* (von Martens 1866) is one of 53 described species within the genus *Euastacus*. This genus contains high levels of cryptic diversity (Austin, Whiterod et al. 2021) however, *E. armatus* is the most widely distributed with an estimated extent of occurrence >150,000 km^2. The species is endemic to Australia and is the second largest freshwater crayfish worldwide, with a maximum documented occipital carapace length of 174 mm. It is long-lived (~28 years), slow-growing (K = 0.0933), late-maturing (~8–9 years) and has low fecundity (up to 2000 eggs per mature female each breeding event) (Gilligan, Rolls et al. 2007, Furse and Coughran 2011). It spawns annually and utilises a winter-spring brooder strategy (Morison 1988, Gilligan, Rolls et al. 2007).

Murray Crayfish prefer relatively cool, oxygenated (dissolved oxygen (DO) concentrations >2 mg L^{-1}) water with physical structure (Geddes, Musgrove et al. 1993, McCarthy 2005, Gilligan, Rolls et al. 2007). Freshwater crayfish are considered intolerant to pollutants and pesticides, yet no thresholds have been defined for Murray Crayfish (e.g., Gilligan, Rolls et al. 2007). It is capable of short-term emersion to avoid adverse conditions, although mortality can result from extended periods out of the water (McKinnon 1995).

Murray Crayfish is an iconic species endemic and once widespread in the waterways of the southern Murray-Darling Basin (MDB). This species has experienced substantial declines in range and abundance over the second half of the twentieth century (Gilligan, Rolls et al. 2007, Furse and Coughran 2011). Recent population decline across sections of its range (McCarthy, Zukowski et al. 2014, Noble and Fulton 2017, Whiterod, Zukowski et al. 2018) indicate that the species is experiencing a declining trend in population status, fostering concerns over its long-term sustainability. Murray Crayfish is considered *threatened* in Victoria under the *Flora and Fauna Guarantee Act 1988*, *vulnerable* in NSW (*Fisheries Management Act 1994*) and the ACT (*Nature Conservation Act 1980*) and protected in South Australia under the *Fisheries Management Act 2007*.

In response to species decline, there has been dedicated research and monitoring focusing on the following:

- sustainability of recreational fishing (Zukowski, Curtis et al. 2011, Zukowski, Watts et al. 2012, Zukowski, Whiterod et al. 2013),
- the impacts of extreme hypoxic blackwater (King, Tonkin et al. 2012, McCarthy, Zukowski et al. 2014, Whiterod, Zukowski et al. 2018),
- habitat degradation (Noble and Fulton 2017),
- a comprehensive genetic assessment (Whiterod, Zukowski et al. 2017), and
- the development of a stochastic population model to provide a framework to address management and conservation scenarios (Todd, Whiterod et al. 2018, Whiterod, Todd et al. 2020).

In addition, translocations undertaken over five years on the Murray River, near Echuca, have resulted in the establishment of a translocation method (Whiterod, Asmus et al. 2021) and assessment of conservation translocation feasibility for the entire genus (*Euastacus*) has been undertaken, with specific reference to priority 2019-20 bushfire-impacted species (Zukowski, Whiterod et al. 2021).

This collaborative research and monitoring has improved the wider understanding of the species and facilitated effective conservation management. It has also emphasised the requirement for research and monitoring to conserve known populations of this threatened species, particularly for populations with potential to be impacted by disturbance.

The species was historically abundant in the region of the Tumut River, which is artificially impounded by Talbingo Reservoir (Gilligan, Rolls et al. 2007). Whilst a flow specialist, Murray Crayfish has persisted following the construction of the reservoir and the species is protected from recreational fishing in the reservoir. The population has been shown to be genetically distinct from a broad, interbreeding lowland population across the wider Murray-Murrumbidgee region (Whiterod, Zukowski et al. 2017). Targeted annual surveys within Talbingo and Blowering Reservoirs during the period 2008–2010 provided the first assessment of the status of the species in these reservoirs (Zukowski, Whiterod et al. 2013). In Talbingo Reservoir, Zukowski *et al*. (2013) demonstrated a healthy population with a 1:1 sex ratio, and good population structure (including regular recruitment and long-term

survival). Whilst sampling of a single site in 2013 in Talbingo Reservoir (NSW DPI, unpublished data) demonstrated a similar abundance, a considerable reduction in catch was observed in 2018 surveys (Cardno 2019), raising concern about the status of the species in the reservoir.

In the winter of 2019, 2020, 2021, 2022 and 2023 surveys were undertaken to resolve the status of Murray Crayfish populations in Talbingo Reservoir to better inform considerations for the species in the Snowy 2.0 project. Fourteen sites were sampled within the reservoir (7 existing sites previously surveyed and 7 new sites) at which 19, 14, 18, 33 and 6 individuals were recorded, respectively (Zukowski and Whiterod 2019, Zukowski, Whiterod et al. 2020, Zukowski and Whiterod 2022, Zukowski and Whiterod 2023, Zukowski and Whiterod 2024). This project used a repeat spatial monitoring design in 2024 to determine and compare the numbers of Murray Crayfish one, two, three, four and five years on from the 2019, 2020, 2021, 2022 and 2023 surveys and determine presence of Murray Crayfish within Talbingo Reservoir in 2024.

In February 2023, and January 2024, additional surveys targeting Murray Crayfish were undertaken to determine the status of Murray Crayfish populations in Yarrangobilly River (3 sites) and Wallace Creek (2 sites) to further inform considerations for the species in the Snowy 2.0 project. During this sampling, two crayfish were sampled in 2023, one in Yarrangobilly River and one in Wallace Creek and one Murray Crayfish was sampled in Wallace Creek in 2024. Six Murray crayfish were previously detected at two sites (one in Yarrangobilly River and five in Wallace Creek) during Environmental Impact Statement (EIS) surveys. Backpack electrofishing was selected for the survey method as it is a very effective technique for collecting crayfish in a variety of freshwater habitats, and is particularly effective for shallow, slow flowing streams and for drawing crayfish out from sources of instream cover (e.g., logs, boulders). It is restricted to use in shallow (<1.25 m) water with low turbidity and a conductivity of 10–1500 µS cm^{-1}. In June 2024, the sites were again sampled and results outlined in this report.

Project objectives

The specific objectives of this project were to:

- Undertake a comprehensive repeat survey in 2024 of sites surveyed in 2019/2020/2021/2022/2023 in Talbingo Reservoir.
- Undertake a repeat survey of Murray Crayfish in the Yarrangobilly River and Wallace Creek.
- Record habitat (physical structure, aquatic vegetation, water depth and location (GPS coordinates) for each net deployment and site-based water quality parameters).
- Collect data on population abundance and demographics (length, weight, sex ratio, reproductive stages of individuals).
- Consider (a) the spatial trend in abundance and demographics, and (b) presence in southern areas of Talbingo Reservoir, Yarrangobilly River and Wallace Creek.

Field surveys (Talbingo Reservoir)

Study region

Talbingo Reservoir (Figure 1) occurs within and adjacent to the Kosciuszko National Park just south of Tumut in the Murrumbidgee Valley on the Tumut River, south-eastern Australia. The reservoir, completed in 1970, creates a head storage for the operation of the Snowy Hydro Tumut 3 hydroelectric pump-storage project. Water released from the reservoir is used to supply irrigation and industry, hydro-power and environmental flows. The reservoir is also used for recreational activities including waterskiing, sailing, boating, and fishing. It is primarily fed by releases from Tumut 2 power station tailrace at the southern end of the reservoir. Other waterways provide additional inflows, including Tumut and Yarrangobilly Rivers, and Long, Honeysuckle, Plain and Middle Creeks. The study region was severely affected by bushfires in January 2020.

Figure 1. Talbingo Reservoir location (left), images of reservoir (top middle and right) and works associated with Snowy 2.0 project (bottom middle and right).

Survey sites

The targeted surveys of Murray Crayfish in Talbingo Reservoir were undertaken 3rd to 15th June 2024. Repeat sampling of the 14 sites surveyed in 2019, 2020, 2021, 2022 and 2023 was undertaken to allow spatial comparison (Table 1 and Figure 2). The seven existing sites (sites 1–7) of Zukowski et al. (2013), including site 3 – Honeysuckle, also sampled previously (NSW DPI, unpublished data; and Cardno 2019), and seven additional sites (sites 8–14) were sampled to assess areas that may be subjected to disturbance from Snowy 2.0 Main Works. Particular attention was given to the Yarrangobilly River and Middle Creek arms of Talbingo Reservoir (Figure 2).

Table 1. Summary of sites sampled across Talbingo Reservoir in 2024

Site no.	Site description	Date sampled	(Zone 55)	
			Easting	Northing
1	Adjacent to car park	11/06/2024	618230	6056485
2	Near swimming area	12/06/2024	617167	6056496
3	Honeysuckle Creek arm	8/06/2024	617645	6050419
4	Landers Creek arm	8/06/2024	620251	6053220
5	Lick Hole Creek arm	3/06/2024	620413	6048075
6	Long Creek arm/Cascade Bay	3/06/2024	620126	6044117
7	O'Hares Campground (Sue City)	4/06/2024	623186	6036163
8	Plain Creek arm	4/06/2024	621316	6041933
9	Opposite Tumut and Yarrangobilly Rivers	7/06/2024	623129	6041915
10	Middle Creek arm	6/06/2024	623942	6041691
11	Yarrangobilly River upstream	6/06/2024	624124	6040423
12	Yarrangobilly River middle	5/06/2024	624445	6040388
13	Yarrangobilly River bottom	5/06/2024	624840	6039835
14	Open site at rivers junction	7/06/2024	622498	6042056

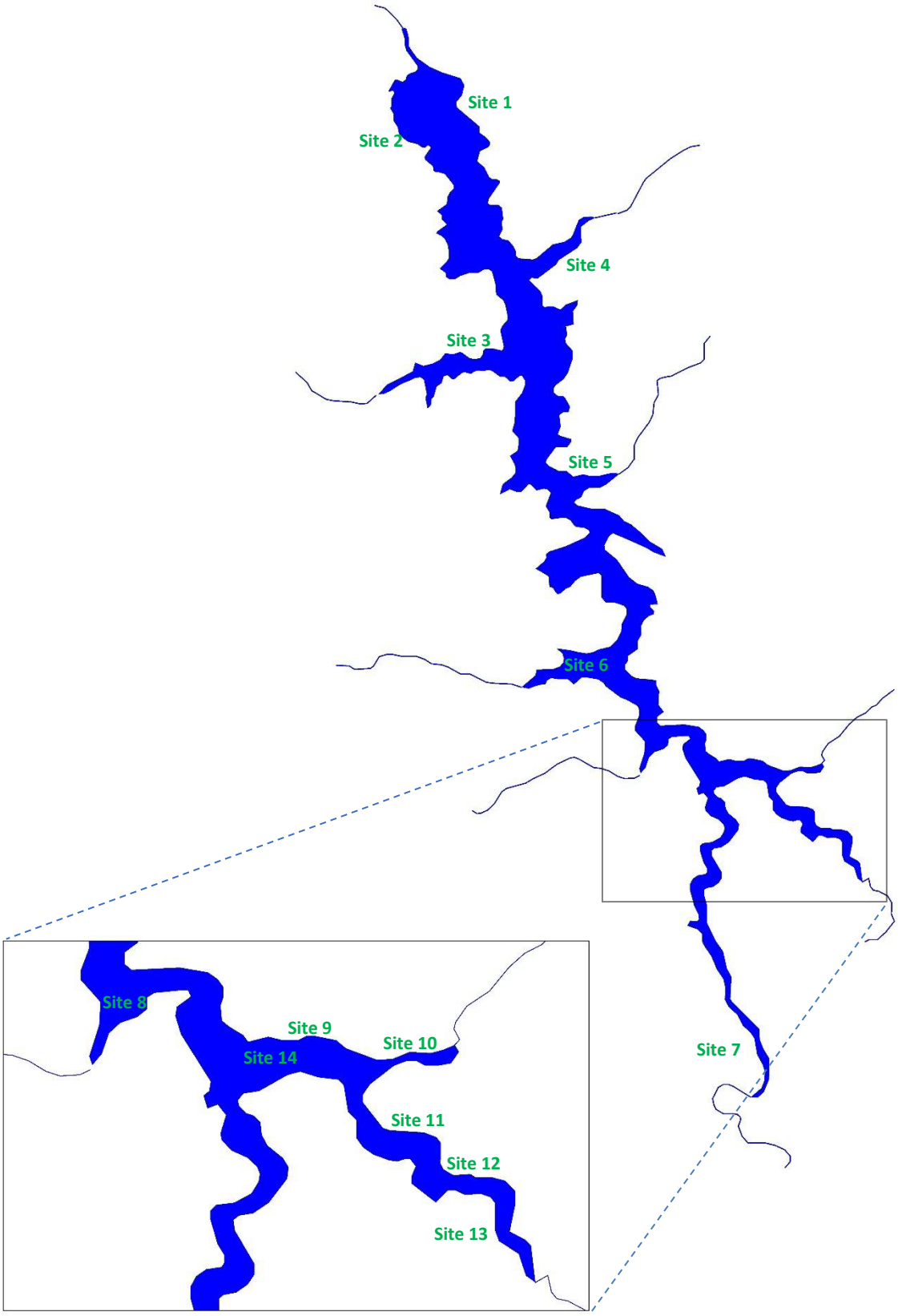


Figure 2. Sites sampled across Talbingo in the present study.

Survey methods

In Talbingo Reservoir, the field survey employed hoop and Munyana nets (Figure 3) to maximise the probability of detection. The standardised hoop net sampling protocol was employed at each site (sites 1–14), with 20 replicate single hoop nets (700 mm diameter with a mesh size of 13 mm) baited with approximately 300 g of ox liver set and checked hourly (and deployed at the same location) for a total of three hours (60 hoop net hauls per site) during daytime hours (0800–1700) (Zukowski, Whiterod et al. 2013, McCarthy, Zukowski et al. 2014, Whiterod and Zukowski 2017, Whiterod, Zukowski et al. 2018).

Munyana nets, a type of commercially available crab net (Munyana net, Wishart, Queensland: 60 mm mesh, two 0.76 m diameter steel hoops and two 0.18 m × 0.12 m openings), were used in addition to hoop nets at all sites to increase the rate of capture (see McCarthy 2005). At each of these sites, nets were baited with approximately 300 g of ox liver and set overnight. This type of method is designed to have greater retention of crayfish unlike hoop nets from which crayfish can enter and exit.

For each net, location (easting, northing), time set and retrieved, sampling level (in metres above sea level, mAHD, to account for variation in reservoir level), water depth, and habitat descriptors was recorded. Water quality parameters (water temperature, pH, dissolved oxygen concentration and electrical conductivity) (YSI 556 multi-probe) and percentage cover of submerged aquatic vegetation was recorded at each site.

Data collection

Sampled Murray Crayfish were sexed, weighed (W, in g) using waterproof scales (A&D weighting, Tokyo, Japan) and occipital carapace length (OCL, measured from the rear of the eye socket to the middle of the rear of the carapace, to the nearest 0.1 mm) was measured using Vernier calipers (Kinchrome, Scoresby, Victoria, Australia). The stage of maturity (stages 1-3: following Turvey and Merrick 1997) was recorded for females as was the presence of eggs. Additionally, each crayfish was marked using a Uni PAINT PX-20 marker (Mitsubishi Pencil Co. Ltd, Milton Keynes, UK: see Ramalho, McClain et al. 2010) to identify potential recaptures (during sampling events) before being returned to the water at the point of capture. These marks persist for months (potentially until the next moult which occurs

annually in adult crayfish) and have been employed successfully for a medium-term mark-recapture study on the species (Zukowski, Asmus et al. 2018).

Figure 3. Munyana (left) and hoop (right) nets with Murray Crayfish sampled from Talbingo Reservoir.

In addition to this current report, the following data is maintained in an Excel spreadsheet.

- Data on surveys completed (date, method);
- Descriptive information (GPS location, sampling level and water depth, bank habitat) for each hoop and Munyana net deployment;
- Number of individuals caught; and
- Demographic information (length, weight, sex and life stage) for all sampled crayfish.

Results (Talbingo Reservoir)

Catch summary

In total, 21 Murray Crayfish (14 females, 7 males) were sampled from 840 hoop net retrievals (3 crayfish) and 70 Munyana net retrievals (18 crayfish) in Talbingo Reservoir during June 2024 surveys. Most Murray Crayfish sampled appeared in good health with no obvious deformities, disease, or parasite infestations apparent (Figure 4). Fourteen females were recorded, and all were sexually mature. Of the sexually mature females, eight were carrying eggs (i.e. berried). Individuals were recorded from seven sites during the present survey (Table 2, Figures 5 and 6), compared to records from three sites in 2023, eight sites in 2022 and five sites in 2021.

Table 2. Summary of Murray Crayfish sampled during 2024 surveys at 14 sites in Talbingo Reservoir (Occipital Carapace Length (OCL)); (Net type H=Hoop net, M=Munyana net).

Site	Net type	Net no.	Sex	OCL (mm)	Weight (g)	Maturity	Crayfish notes
1	H	11	M	115	550		
1	M	1	F	129	720	Mature	Berried
1	M	2	F	111	415	Mature	Berried
1	M	4	M	134	827		
1	M	4	F	118	557	Mature	No eggs
3	H	20	F	88	250	Mature	Berried
4	M	1	M	140	1030		
5	H	8	M	133	777		
5	M	3	F	127	760	Mature	Berried
5	M	3	F	147	950	Mature	No eggs
5	M	3	M	130	530		
5	M	3	F	132	757	Mature	No eggs
7	M	2	F	89	269	Mature	No eggs
8	M	4	M	111	566		
8	M	4	F	102	386	Mature	No eggs
9	M	3	F	135	699	Mature	Berried
9	M	5	F	143	930	Mature	Berried
14	M	1	M	135	785		
14	M	2	F	151	989	Mature	Berried
14	M	4	F	134	748	Mature	Berried
14	M	5	F	136	679	Mature	No eggs

Figure 4. Murray Crayfish captured in Talbingo Reservoir in June 2024.

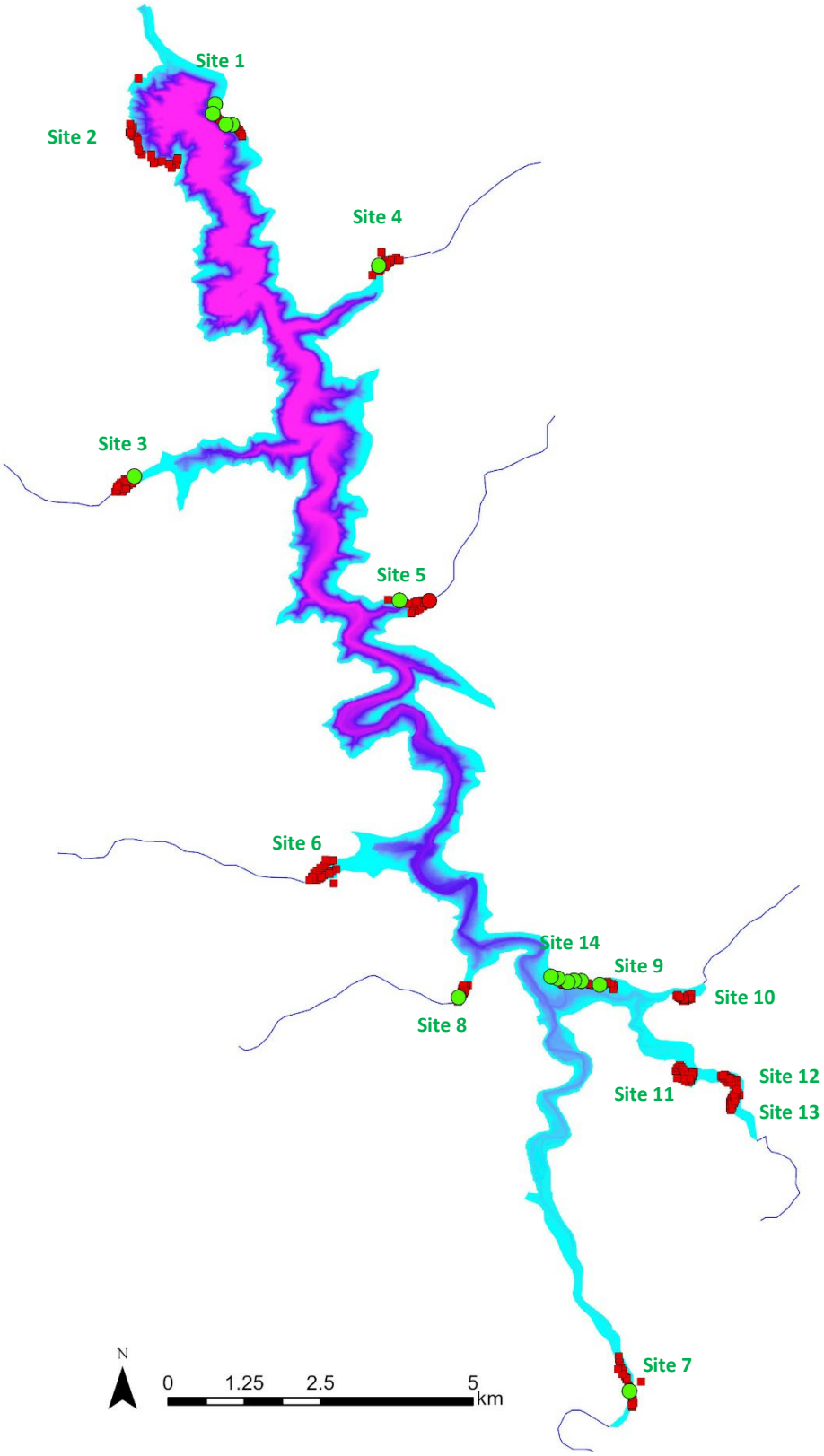


Figure 5. Individual net deployments (red circles) and captured crayfish locations (green circles) in Talbingo Reservoir June 2024. The bathymetry of the reservoir is also shown, with shallower (<20 m) areas indicated in light blue).

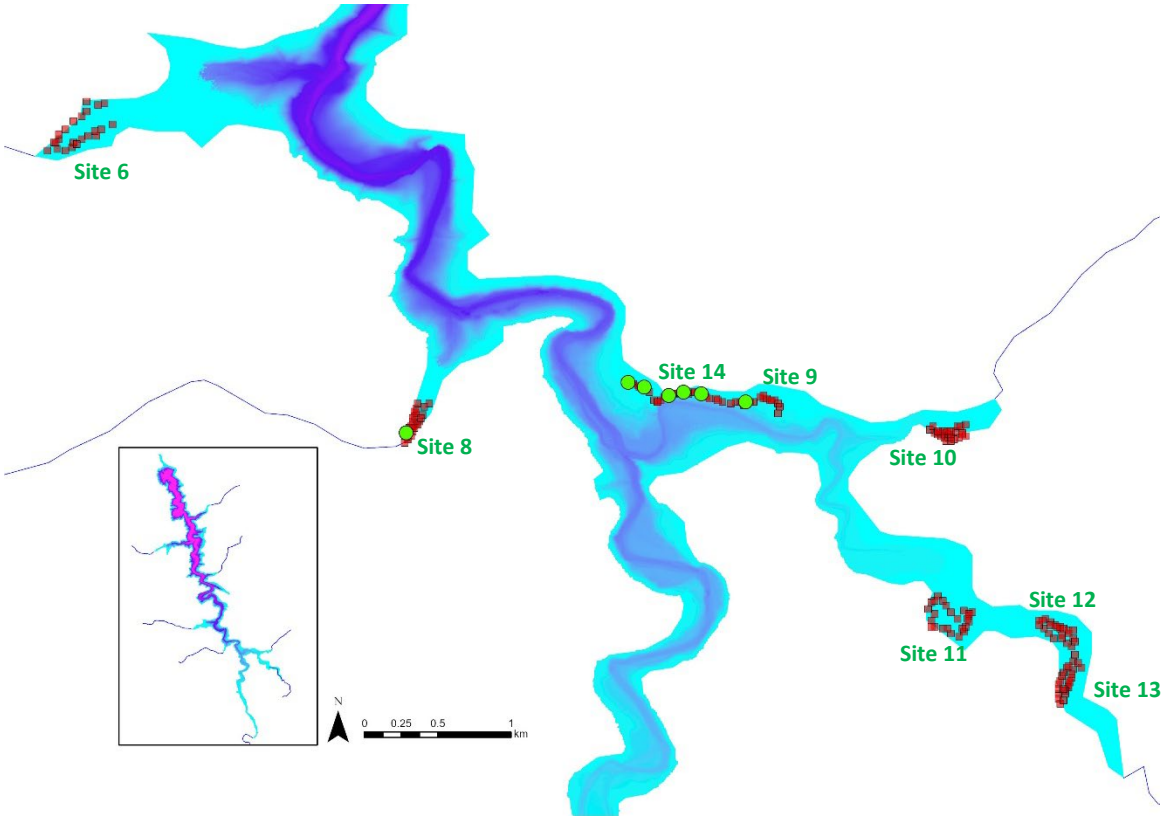


Figure 6. Close up map of the locations of net deployments and crayfish captures in the southern section Talbingo Reservoir in 2024. The shallower (<20 m) areas indicated in light blue.

Changes over time

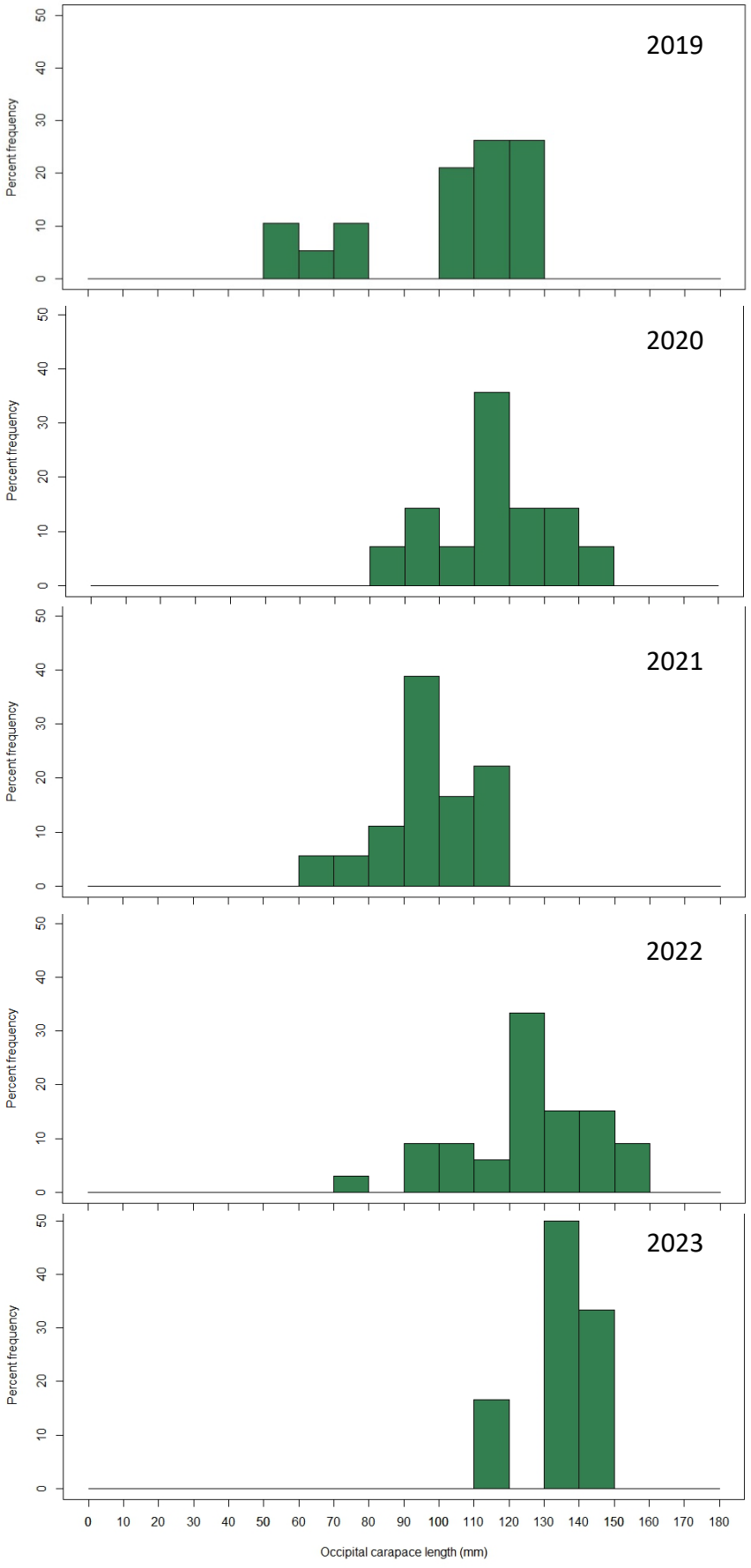
In total, 21 Murray Crayfish (14 females, 7 males) were sampled in Talbingo Reservoir during the June 2024 surveys. For comparison, 19, 14, 18, 33 and 6 individuals were recorded during the 2019, 2020, 2021, 2022 and 2023 sampling, respectively, and a total of 188 individuals (95 females (13 berried), 93 males) were recorded over the three years of sampling between 2008 and 2010 (Table 3; Table 4). Murray Crayfish were detected at seven sites (sites 1, 3, 4, 5, 7, 8, 9 and 14) during the 2024 sampling. In comparison, Murray Crayfish were detected in at three sites in 2023, eight sites in 2022, five sites in 2021, six sites in 2020 and in 11 sites in 2019.

Table 3. Summary of Murray Crayfish numbers across the 14 sampled sites from combined 2008–2010 (Zukowski et al 2013) data, 2019, 2020, 2021, 2022, 2023 and 2024 survey data. HN=Hoop Net, MN=Munyana Net.

Site	2008–2010 HN	2019 HN	2019 MN	2019 Total	2020 HN	2020 MN	2020 Total	2021 HN	2021 MN	2021 Total	2022 HN	2022 MN	2022 Total	2023 HN	2023 MN	2023 Total	2024 HN	2024 MN	2024 Total
1	19	3		3	1	1	2	1	7	8	2	5	7	1		1	1	4	5
2	3	1		1								2	2						
3	13	1		1	1	2	3										1		1
4	73							1	1	2		1	1					1	1
5	47				1		1										1	4	5
6	12		1	1								4	4		3	3			
7	21							1		1								1	1
8			3	3	2		2	1	5	6	2	4	6					2	2
9		2	3	5	1	1	2		1	1		1	1		2	2		2	2
10		1		1															
11		1		1								1	1						
12			1	1															
13			1	1															
14			1	1	2	2	4					11	11					4	4
TOTAL	**188**			**19**			**14**			**18**			**33**			**6**			**21**

Length structure

All sampled Murray Crayfish were adults and ranged from 88 to 151 mm OCL, and 250 to 1030 g (Figure 7). All sampled individuals, apart from two, were above 100 mm OCL in size in 2024. All the Murray Crayfish sampled in 2023 were above 120 mm OCL in size. Larger Murray Crayfish fish were mainly found in 2022 and the majority of smaller individuals were sampled in 2019 (Figure 7).


2019
2020
2021
2022
2023
Percent frequency
0
10
20
30
40
50
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
Occipital carapace length (mm)

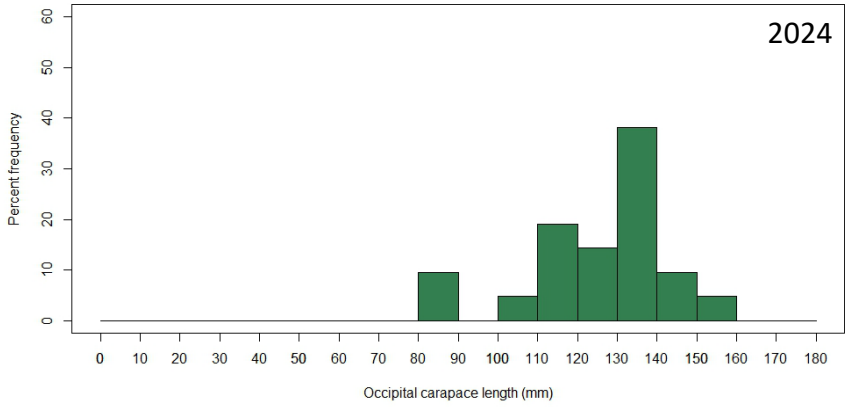


Figure 7. Length structure of Murray Crayfish in Talbingo Reservoir in 2019, 2020, 2021 2022, 2023 and 2024 top to bottom, respectively.

Habitat and Site Characteristics

Nets were deployed at depths between 530.9 to 542.5 mAHD (0.7—12.5 m) with Murray Crayfish recorded at depths between 533.5 to 538.7 mAHD (5—10 m) (Table 4). Of the sampled crayfish, three were found using hoop nets and 18 individuals were detected in Munyana nets (Table 4). Meso-habitat varied between sites and included irregular bank with rock or wood, matted bank and presence of large wood or rock (Table 4). Murray Crayfish were sampled in areas with irregular bank, matted bank and with the presence of large wood. The percentage presence of aquatic vegetation was similar to that found in the 2023, 2022, 2021 and 2020 sampling throughout most of the reservoir. At the time of the 2024 sampling, all sites had submerged aquatic vegetation present in low concentrations (≤15% cover) (Table 5). Aquatic vegetation was a mixture of Canadian Pondweed *Elodea canadensis*, *Potamogeton* sp. and *Chara* sp..

Table 4. Summary of net type, sampling level and water depth and meso-habitat present where Murray Crayfish were captured in June 2024.

Site	Net type	Net no.	Sampling level (mAHD)	Water depth (m)	Meso-habitat	No. of crayfish
1	H	11	538.191	6	Irregular bank	1
1	M	1	534.191	10	Irregular bank	1
1	M	2	534.191	10	Irregular bank	1
1	M	4	537.191	7	Irregular bank	2
3	H	20	533.639	10	Irregular bank	1
4	M	1	533.639	10	Large Wood	1
5	H	8	538.722	5	Matted bank	1
5	M	3	534.722	9	Matted bank	4
7	M	2	536.769	6.7	Irregular bank	1
8	M	4	535.769	7.7	Irregular bank	2
9	M	3	537.384	6.1	Irregular bank	1
9	M	5	535.484	8	Matted bank	1
14	M	1	537.484	6	Irregular bank	1
14	M	2	535.484	8	Irregular bank	1
14	M	4	533.484	10	Irregular bank	1
14	M	5	535.584	7.9	Matted bank	1

Water Quality

Water quality parameters varied across the 14 sites (Table 5). Salinity (EC) was relatively fresh throughout the reservoir and ranged from 20 μScm^{-1} (Site 7) to 40 μScm^{-1} (Sites 13). This was similar to EC noted in 2019 (25–76 μScm^{-1}), 2020 (27–80 μScm^{-1}), 2021 (30 –56 μScm^{-1}), 2022 (24–58 μScm^{-1}) and 2023 (26–40 μScm^{-1}). Water temperature ranged between 9.4 and 11.6°C and was similar to water temperature sampled in 2023 (8.14—10.19°C) and 2022 (7.60–12.98°C), where surveys were also undertaken in June. Water temperature was lower than that sampled in 2021 (11.5–15.8°C), reflecting the later sampling time in the year in 2021, and slightly higher than that found in 2019 (4.15–11.82°C) and 2020 (4.4–10°C). The pH was generally near neutral in 2024 with a range of 6.78 to 7.62. The pH was similar in 2023 (6.01 to 7.03), 2022 (6.11–7.18) and in 2021 (6.13–7.21). In 2020, an alkaline pH above 8 was found at all sites (8.05–8.53) and a mostly slightly acidic pH found in 2019 (6.35–7.09). Dissolved oxygen concentrations (measured during the day) (6.8—8.2 mgL^{-1}) were similar to that sampled in 2023 (7.3–8.9 mgL^{-1}) and 2022 (5.4–8.6 mgL^{-1}) but lower than that sampled in previous years (2019 >11 mgL^{-1}, 2020 >10 mgL^{-1}).

Table 5. Summary of water quality parameters and percentage submerged aquatic vegetation cover at the 14 sampled sites in Talbingo Reservoir in June 2024.

Site	Temp (°C)	pH	EC (µScm^{-1})	DO (mgL^{-1})	Submerged aquatic vegetation cover %
1	11.2	7.35	30	8.1	13
2	11.1	7.35	30	8.1	10
3	11.5	6.86	30	7.35	15
4	11.5	7.05	28	6.8	5
5	11.5	7.62	28	7.5	5
6	11.5	7.31	31	7.4	10
7	9.4	6.99	20	7.6	10
8	11.5	7.15	22	7.4	10
9	11.5	6.83	29	8.1	5
10	11.6	7.19	30	8.0	10
11	11.4	6.78	38	8.2	20
12	11.3	7.19	38	7.4	10
13	9.5	7.43	40	7.9	10
14	11.4	7.27	31	7.7	10

Field surveys (Yarrangobilly River and Wallace Creek)

The Yarrangobilly River, located in south New South Wales, flows in a general southwest direction. The river commences at an elevation of 1490 m near Kennedy Ridge and flows into Talbingo Reservoir (573 m), downstream of Lobs Hole. The Yarrangobilly River drops approximately 935 m over its 50 km course. Wallace Creek, a major channel that flows into Yarrangobilly River in New South Wales starts at an elevation of 271 m and drops to an elevation of 157 m. Flows into Wallace Creek and Yarrangobilly River are generally year-round with higher flows occurring during late winter and early spring.

Survey sites

Three sites in total were sampled in the Yarrangobilly River (n=1) and Wallace Creek (n=2) (Table 7, Figure 8) in June 2024. YR1 and YR2 were not surveyed due to technical issues. Sites were chosen based on previous sampling, accessibility, and available Murray Crayfish habitat. Sites are labelled as YR1-3, WC1-2. These sites were previously known as 1A, YR1, TR-18-232 (Yarrangobilly River), 2B, 2A/TR-18-231 (Wallace Creek), respectively. One Murray Crayfish was sampled in Wallace Creek (WC1) in 2024 Jan, and two Murray Crayfish were sampled in February 2023, one in WC2 and one in YC1. Six Murray crayfish were previously detected at two sites (YR2 (n=1), and 2A/TR-18-231 (n=5)) in Yarrangobilly River and Wallace Creek, respectively, during the Environmental Impact Statement (EIS) surveys.

Table 7. Summary of sites sampled in Yarrangobilly River and Wallace Creek and Volts and Hz used at each site during backpack electrofishing in June 2024.

Site	Date	Start Easting	Start Northing	End Easting	End Northing	Volts	Hz
YR3	10/06/2024	626856	6038169	626843	6037990	500	60
WC1	10/06/2024	627746	6038072	627892	6037942	500	60
WC2	10/06/2024	627592	6038205	627759	6038346	500	60

Figure 8. Three sites sampled across Yarrangobilly River and Wallace Creek. Top left site WC1, Top right site WC2, bottom row YR3.

Survey methods

In the Yarrangobilly River and Wallace Creek, field surveys employed backpack electrofishing methodology due to the shallow and flowing nature of the water body (Figure 9), to maximise the probability of detection. Standard operating procedures (Mossop and Whiterod 2018) were utilised as follows: Backpack electrofishing uses a pulsed DC current to attract and temporarily immobilise crayfish which were then collected by fibreglass dip nets. Surveys used a Smith Root LR24 backpack electrofishing unit (output settings range from 50-990 volts, 40 amps peak current, pulses from 1-120 Hz and maximum continuous power output of 400 watts). Low settings were first used, then gradually increased to ensure a satisfactory catch rate while minimising potential injury to fauna.

Electrofishing was conducted with one operator (wearing the electrofisher) accompanied by one netter (carrying fibreglass-handled dip nets). The team moved in an upstream direction to avoid working in disturbed, stirred up water. Periodically the electrofisher was engaged to

stun crayfish, then disengaged when fauna was spotted and subsequently netted. Each site covered 8 x 150 seconds of 'on time'.

For each site, the location (easting, northing), start time, water depth, and habitat descriptors was recorded. Water quality parameters (water temperature, pH, dissolved oxygen concentration and electrical conductivity) (YSI 556 multi-probe) and percentage cover of submerged aquatic vegetation was recorded at each site.

Data collection

If detected, sampled Murray Crayfish were sexed, weighed (W, in g) using waterproof scales (A&D weighting, Tokyo, Japan) and occipital carapace length (OCL, measured from the rear of the eye socket to the middle of the rear of the carapace, to the nearest 0.1 mm) was measured using Vernier calipers (Kinchrome, Scoresby, Victoria, Australia). The stage of maturity (stages 1-3: following Turvey and Merrick 1997) was recorded for females as was the presence of eggs. Additionally, each crayfish was marked using a Uni PAINT PX-20 marker (Mitsubishi Pencil Co. Ltd, Milton Keynes, UK: see Ramalho, McClain et al. 2010) to identify potential recaptures (during sampling event) before being returned to the water at the point of capture. These marks persist for months (potentially until the next moult which occurs annually in adult crayfish) and have been employed successfully for a medium-term mark-recapture study on the species (Zukowski, Asmus et al. 2018).

Figure 9. Backpack electrofishing used to sample for Murray Crayfish in Yarrangobilly River and Wallace Creek.

Results (Yarrangobilly River and Wallace Creek)

Catch summary

No Murray Crayfish were sampled during the backpack electrofishing in June 2024. As bycatch, six Brown Trout and one Redfin Perch were sampled at YR3. Five Brown Trout, two Rainbow Trout and one Redfin Perch were sampled at WC1. Seven Brown Trout, one Rainbow Trout and one Redfin Perch were sampled at WC2.

Water Quality and site characteristics

Water quality in 2024 was similar to that sampled in 2023 and consistently suitable for Murray Crayfish at all sampled sites (Table 9). The slightly alkaline pH ranged from 7.85 to 8.02, the water was fresh with electrical conductivity ranging from 74 to 80 μScm^{-1}, and dissolved oxygen levels were high ranging from 8.95 to 9.56 mgL^{-1}. Water depth ranged between 0.1 to 0.5 m across sites. There was a lack of submerged aquatic vegetation at the sites, with rock, boulder and bedrock making up most of the instream substrate. Sedimentation and silt was noted at the sites similar to that observed in 2023. Flow past the Yarrangobilly gauging station was lower on the sampling day in June 2024 (0.9 m^3/s) than previous sampling occasions (January 2024; 1.9 m^3/s, February 2023; 1.5 m^3/s).

Table 9. Summary of water quality parameters and percentage submerged aquatic vegetation cover at Yarrangobilly River and Wallace Creek in January 2024.

Site	Temp (°C)	pH	EC (μScm^{-1})	DO (mgL^{-1})	Depth (m)	Submerged aquatic vegetation cover %
YR3	8.8	8.02	74	9.56	0.1-0.4	1
WC1	8.9	7.85	79	8.94	0.2-0.5	1
WC2	8.9	7.85	80	8.95	0.2-0.5	1

Discussion

The present survey provided an assessment of the status of the Murray Crayfish population in Talbingo Reservoir and in Yarrangobilly River and Wallace Creek in June 2024.

Talbingo Reservoir

By utilising the same monitoring design over the past six years, a robust and comparative assessment has been undertaken of the ongoing presence of the species in the reservoir and of key metrics (abundance, length structure, evidence of recruitment) of Murray Crayfish as well as assessments of the habitat and water quality parameters associated with Murray Crayfish.

Murray Crayfish were found in low numbers (n=21) during the June 2024 survey in Talbingo Reservoir, however numbers were higher than that sampled in 2023 where only six individuals were sampled. Prior to 2023, the number of Murray Crayfish sampled in the reservoir had increased over the past three years with 14, 18 and 33 individuals sampled from 2020 to 2022, respectively. Although these numbers were significantly lower than those sampled from 2008 to 2010 (n=188), the increase in numbers was a positive indication that Murray Crayfish were persisting at a sustainable rate in the reservoir.

In 2024 Murray Crayfish were sampled at eight sites, including four individuals sampled at site 14, one of the future disturbance impact sites, where most crayfish were found in 2022. In 2023, Murray Crayfish were only sampled at three sites (1, 6 and 9), and no individuals were sampled at site 14. In 2024, 14 females were recorded, and all were sexually mature. Of the sexually mature females, eight were berried with bright red healthy eggs present which is a positive sign of ongoing reproduction occurring in Talbingo Reservoir. In comparison, three berried females were sampled in 2023, 14 in 2022, eight during 2021, and five in 2019 and 2020. Juvenile crayfish were again not sampled in 2024 with all recorded individuals classified as mature (> 85 mm OCL). Although juveniles less than 50 mm OCL are rarely sampled in crayfish surveys, individuals between 50 to 120 mm OCL are frequently sampled. Thus, the ongoing survival of juveniles and recruitment in the reservoir is uncertain.

Measured water quality parameters including low electrical conductivity and water temperature were suitable for Murray Crayfish at the time of sampling. Dissolved oxygen concentrations (measured during the day) were above 6.5 mgL^{-1} at all sites in 2024. The pH

was found to be slightly acidic at four sites and was again low at site 3. Levels of pH at or below 7 could cause problems for calcification, molting, growth and reproduction (e.g., Haddaway, Mortimer et al. 2013, Beaune, Sellier et al. 2018).

The microhabitat characteristics in which Murray Crayfish were found in 2024 included physical structure such as irregular banks, matted banks and the presence of large wood. These habitats provide shelter and refuge and are near clay banks which are believed to be necessary for burrowing (Gilligan, Rolls et al. 2007, Zukowski 2012, Noble and Fulton 2017). Murray Crayfish were only sampled in water depths less than 10 m which is deeper than that found in 2023 (8 m) but shallower than found in previous years (< 13 m). This depth may reflect the preferred depth and habitat as guided by environmental parameters such as dissolved oxygen levels, proximity to available burrows, habitat availability and food source availability.

In 2024, as in the previous three years, the majority of Murray Crayfish were sampled in Munyana nets (n=18) with three individuals sampled in hoop nets. Interestingly, in 2019 and 2020 similar numbers of crayfish were captured using both methods. However, since 2021, using Munyana nets has shown to have higher sampling rates.

Yarrangobilly River and Wallace Creek

Murray Crayfish were surveyed using the backpack electrofishing methodology in Yarrangobilly River and Wallace Creek in June 2024 during lower flows than in previous sampling events. Decreased flow and water levels led to better visibility during the current sampling, however some areas were too shallow for crayfish to habitat. Electrofishing for Murray Crayfish at Yarrangobilly River and Wallace Creek is recommended below 1.5 m^3/s for future events to ensure best conditions and maximum sampling success. Increased sedimentation and silt at sites decreased visibility during January 2024 and this sampling event.

No Murray Crayfish were sampled in June 2024. All sampled sites had good water quality and flows suitable for Murray Crayfish, however, increased sedimentation and silt were observed indicating that habitat conditions were not optimal for the species. High numbers of trout and presence of redfin detected during this and past surveys could also be contributing to

the low numbers of Murray Crayfish found. Predation by these fish species is likely a common occurrence.

Ongoing annual monitoring of the five sites is recommended through backpack electrofishing, following the methodology described in this report. Further, eDNA analysis as part of the monitoring could test for the presence of Murray Crayfish at each of the sites if no crayfish are detected in future monitoring events. The past presence of Murray Crayfish at these sites demonstrates that that the species have persisted in these sites following the bushfires, albeit in low numbers, and populations may increase with time without further disturbance.

Conclusion

The number of Murray Crayfish sampled in 2024 was lower than historical surveys but higher than 2023. The presence of berried females provides a positive indication of ongoing species recruitment and anticipated persistence in Talbingo Reservoir. The continued use of a robust repeat sampling methodology, as outlined in this report, allows the comparison of numbers of Murray Crayfish over time and space and allows for the detection of the presence of individuals throughout Talbingo Reservoir, including within the potential impact area associated with Snowy 2.0. The continued low numbers of individuals detected during more recent surveys, combined with and the lack of juvenile crayfish records, highlights the importance of ongoing habitat and water quality management for the long-term viability of the remaining population in Talbingo Reservoir, and the wider distribution of the species in general. Ongoing monitoring and translocations to boost declining populations remain an essential component in the conservation management of this species.

In June 2024, the third round of backpack electrofishing surveys targeting Murray Crayfish were undertaken to determine the status of Murray Crayfish populations in the Yarrangobilly River and Wallace Creek. No Murray Crayfish were sampled, however previously low numbers have been detected. The inclusion of these sites in annual monitoring can be challenging due to variable river heights and flow, however, it is important when considering changes in the status of the overall population over time and space.

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