Muscles in the mud: engaging community power to monitor Lokeri (*Velesunio ambiguus*) in the Lower Lakes

June 2026

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The CLLMM Research Centre has the objective of developing and delivering locally driven, innovative, and impactful research that reflects community and First Nations priorities to provide an evidence base to address critical needs of the CLLMM region. The CLLMM Research Centre will also bring together our First Nations, local community and scientists to create and share knowledge, and support our well-informed and engaged community and empower our future generations to be part of the solution.

The Goyder Institute for Water Research Coorong, Lower Lakes and Murray Mouth (CLLMM) Research Centre, based in Goolwa SA, was established in 2023 through funding by the Australian Government.

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Executive Summary

Freshwater mussels are integral to freshwater biodiversity and provide critical ecosystem services. As filter feeders, they are ideal indicators of water quality and ecosystems health. Globally, human modification of aquatic ecosystems threatens freshwater mussel populations. The Coorong, Lower Lakes and Murray Mouth (CLLMM) region is home to the floodplain mussel (*Velesunio ambiguus*). Freshwater mussels are of cultural importance to First Nations in Australia, including Ngarrindjeri people of the CLLMM region who know freshwater mussel as *Lokeri* (*Loker-engk* for two mussels; *Lokerar* for three or more mussels). Forgotten caches of Lokeri dated to over 8000 years old have been found on Ngarrindjeri Country thereby demonstrating its use as a food source. A greater understanding of Lokeri on Ngarrindjeri Country will provide essential knowledge to address cultural considerations and the ecological management of the species.

The citizen science 'muscles in the mud' project was sparked by community interest in the contemporary status of Lokeri in the Lower Lakes, where it was very abundant up until the early 2000s but disappeared by 2009 during the Millennium Drought. The first aim of the project was to connect with community to discuss project objectives, identify potential survey sites and increase awareness of Lokeri. The second aim was to conduct a widespread survey of Lake Alexandrina and Lake Albert to identify if and where Lokeri may be present. The third aim of the project was to examine shells of Lokeri collected from the Lower Lakes to compare three approaches to determining age and growth (counting growth increments from the umbo section and from the full cross-section, and counting external growth interruption lines).

In November 2024, more than 50 members of the Ngarrindjeri community attended two yarning circles held in Raukkan and at Point Sturt. The lead researcher presented the idea for a Lokeri project that included a survey where community members could be employed to participate in field and laboratory work. The events provided a successful way to inform community of the intention to conduct a survey on Ngarrindjeri Country and the opportunity for people to participate. After the yarns, Community members entered the water, searched for Lokerar and shared knowledge across generations. This work supported both the collection of information and the continuation of cultural practice. Many not having been in the water for years and feeling connected to the water again after being disconnected for so long. Many reporting how their mi:wi (spirit) felt happy again.

In December 2024, 34 sites were surveyed in the Lower Lakes in lake-edge habitats known to be preferred by Lokeri. Lokeri presence and abundance at each site was measured using three adjacent 10 ×10 m quadrats in a randomly chosen location that were accompanied by a wider general search up to 50 m from shore and approximately 50 m either side of the quadrats. Numbers of live Lokeri and empty shells were recorded and each live Lokeri was measured for a range of morphometric parameters including length, height and width.

A total of 76 live floodplain mussels and two river mussels (*Alathyria jacksoni*) were recorded from 9 and 1 of the 30 sites in Lake Alexandrina, respectively, but neither species was detected in Lake Albert. The quantitative surveying revealed low abundances across all sites, with temporal comparison from surveys conducted 45 years prior at Point Sturt, Lake Alexandrina, indicating the current population is <0.5% of its historic abundance. All Lokeri collected were adults ranging from 59–104 mm long. Forty-eight live Lokerar were retained for age analysis with the most feasible and reliable ageing method being the use of umbo sections whilst acknowledging ageing is yet to be validated for the species. Lokeri age estimations ranged between 5 and 13 years corresponding to recruitment spanning the years 2011–2019, with individuals present in each year class. There was apparent higher recruitment from 2015–2017 and again in 2019, however, this is not definitive due to a potential ageing error resulting from shell erosion. Notably, these dates correspond to recruitment following the Millennium Drought.

This project brought together science, community and culture to gain information that addressed cultural and community concerns, quantified the contemporary demographics of Lokeri in the Lower Lakes and highlighted key knowledge gaps for future research. It reflects the importance of Ngarrindjeri involvement in research on Country. Cultural knowledge guided how this work was undertaken, and community participation ensured it remained grounded in Ngarrindjeri priorities. Looking forward, the recovery of Lokerar is part of Ngarrindjeri responsibility to care for Ruwi. Ongoing work must continue to support Ngarrindjeri leadership in how research is designed, carried out, and applied.

Acknowledgements

We acknowledge the cultural connections to the land and connected waters, as well as the cultural significance of freshwater mussels that exist between people of the Ngarrindjeri and Boandik Nations across the Coorong, Lower Lakes, and Murray Mouth region. We recognise that First Nations peoples' spiritual, social, cultural, and economic practices come from their lands and waters, and they continue to maintain their cultural heritage, economies, languages, and laws which are of ongoing importance. We are committed to fostering and nurturing ongoing relationships with First Nations communities in the CLLMM region, as we continue to work together towards a diverse and thriving freshwater mussel population.

Thank you to the many citizen scientists who participated in the Lokeri surveys. Participants engaged through Ngarrindjeri Aboriginal Corporation were Cyril Karpany, Brayden Kartinyeri, Muffy Kartinyeri, Lalo Kartinyeri, Chase Rigney, Brad Hartman, Matt Hartman, Kirsten Hartman, Nathan Hartman, Archie Kartinyeri, Tyron Kartinyeri, Cyril Trevorrow, Jade McHughes, Jai Alick and Rhys Alick. Thank you to Tanya Rigney and Alban Kartinyeri of Ngarrindjeri Aboriginal Corporation for organising community members for the survey and laboratory days. Thanks to the River, Lakes and Coorong Action Group for their dedication to the project and the survey including Gloria Jones, Julie Jones, Grant Gibson, Christine Jackson, Ray Rootsey, Allison Rootsey, Milly Breward, Janette Brooks and Bruce Brooks. Thanks also to Charlie Zukowski, Eliza Zampatti and Lilija Zampatti for their help and enthusiasm in the field. Thanks to Jane French and Nick Whiterod of the CLLMM Research Centre for project and field assistance. Thanks to Tiffany Nay of the CLLMM Research Centre for the life cycle artwork and various tasks associated with community engagement. We also very much appreciate the maps for the interactive display and report provided by Jack Fraser of Adelaide University. A big thank you to the various landholders for access to lake edge sites and their hospitality including Ack Varcoe and Jenny Varcoe (Tolderol), Russell (Lake Cloud, Hindmarsh Island), Chris Eckert, Rick Eckert and Tony Eckert (eastern Lake Alexandrina), Paul and Anne (Point Sturt Road), and Clem Mason (eastern Lake Alexandrina). Thank you to Michael Geddes and Nicole McCasker (Charles Sturt University) for their brilliant reviews which undoubtably strengthened the quality of this report.

Finally, we would like to acknowledge that this work follows the passion Keith Walker had for freshwater mussels. Keith provides us with much of the scientific knowledge regarding freshwater mussels of the River Murray in South Australia. Since his earlier works in the 1970s and 1980s, there is very little published research. This current project is the first known for freshwater mussels in the lower River Murray in South Australia in more than 30 years. It was partly inspired by Keith's passion but also through his supervision and mentorship of several scientists on this project. Our hope is to expand on the current research project in the Lower Lakes and conduct further studies on the overlooked freshwater mussels further up the river system, which is something we know would please Keith.

This project was funded by the Goyder Institute for Water Research's CLLMM Research Centre, which is funded by the Australian Government. We thank the CLLMM Research Centre staff for project initiation, support and management. We thank the Goyder Institute for Water Research, Research Advisory Committee.

1 Introduction

Freshwater mussels are one of the most vulnerable invertebrates globally due to numerous factors related to contemporary human modifications of the environment (Walker et al. 2013; Böhm et al. 2021; Aldridge et al. 2023). This is concerning because mussels are an important component of freshwater ecosystems and provide critical ecosystem services, although generally these are poorly quantified (Vaughn 2018). The filter feeding nature of adult freshwater mussels, with their diet including bacteria, algae, detritus, zooplankton and dissolved organic matter, make them ideal as indicators of water quality and, therefore, the health of ecosystems (Aldridge et al. 2023). Freshwater mussels can be very abundant under favourable conditions, when the full extent of their benefits are realised (e.g. water purification: Vaughn 2018; Ćmiel et al. 2020). Factors influencing freshwater mussel populations are specific to a population and region, thus localised studies are required to understand influences of recruitment and abundance, and to identify local benefits and threats.

Freshwater mussels are of cultural importance to First Nations in Australia and New Zealand (Hiroa 1921; Clark & Hope 1985), being collected as food or to use the shells for jewellery, or as cutting tools for food or ceremony (e.g. Clark & Hope 1985). The Coorong, Lower Lakes and Murray Mouth (CLLMM) region is Ngarrindjeri Yarluwar-Ruwe (Sea-Country). The Ngarrindjeri word for freshwater mussel is Lokeri, Loker-engk is for two mussels and Lokerar is for three or more mussels (herein referring to the floodplain mussel *Velesunio ambiguus*). Lokeri was traditionally collected, as demonstrated by nets created in the 1840s using string made from bullrush (*Typha*) fibre (Figure 1; Jones & Hemming 2000). The Ngarrindjeri Dictionary states that historically Lokeri were dived for in Lake Alexandrina at Ngawulawara, Woodrow Point (Gale 2020). The collection of Lokeri by First Nations people also is displayed in forgotten caches on Ngarrindjeri Country dated to over 8000 years old in some cases (Wilson et al. 2012; Bourman et al. 2022). Apart from a food source, the uses of Lokeri by Ngarrindjeri people include ornamentation, tool stringing, fibre scraping, ceremony, and as food utensils (Roberts et al. 2022). A greater understanding of Lokeri on Ngarrindjeri Country will provide ecological advantage and address the cultural importance of the species.

The citizen science 'muscles in the mud' project was sparked by community interest in the current status of Lokeri in Lake Alexandrina and Lake Albert – the Lower Lakes. Landholders, scientists and the Ngarrindjeri community anecdotally recount the species being abundant up until the early 2000s and its disappearance by 2009 during the Millennium Drought (Figure 2). The contemporary status of Lokeri in the Lower Lakes remains unknown but assessments by Walker (1981) provide some historic information for a location in Lake Alexandrina where they were highly abundant. This project incorporates the knowledge and motivation of scientists, Ngarrindjeri people and the wider local community with the objective of determining the current status of Lokeri in the Lower Lakes. The first aim of the project was to inform the community of the project intentions through consultation and yarning circles. The second aim was to conduct a widespread survey of Lake Alexandrina and Lake Albert. A third aim was to examine shells of Lokeri collected from the Lower Lakes during the survey to estimate age and growth. It is envisioned that information gained from this project will address cultural and community concerns, inform management of the lakes, and highlight key knowledge gaps for future research.

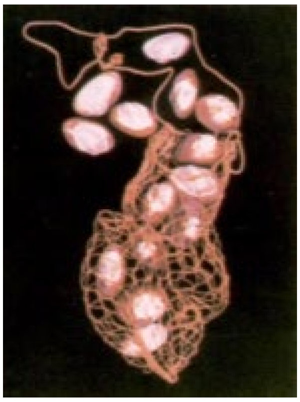

Figure 1. A netted bag from the 1840s used by Ngarrindjeri women for Lokeri collection (source of photo and information: Jones and Hemming 2000).

ONCE ABUNDANT, THEN GONE

Lokeri (*Velesunio ambiguus*) has inhabited the lower River Murray and Lower Lakes for thousands of years where archaeological evidence from middens shows they were used by First Nations peoples. A lack of historic data means it is uncertain if the consequences of river regulation and altered flow regimes in the lower River Murray and its terminal lakes has influenced the abundance of Lokeri in the Lower Lakes. In the latter decades of the 20th Century, anecdotal accounts from Ngarrindjeri elders and landholders describe Lokeri in very high abundances. One landholder recalls: "you could walk to the water's edge and fill a 10 L bucket with mussels in minutes". By 2009, during the later stages of the Millennium Drought, Lokeri in the Lower Lakes were decimated by dramatic declines in lake water levels and desiccation. There has never been a lake-wide assessment of its population status in the Lower Lakes.

Figure 2. Lokeri were stranded and desiccated, or killed by rising salinities, in the Lower Lakes by the end of the Millennium Drought including at Point Sturt, Lake Alexandrina, where the waterline had receded by March 2010.

2 Citizen science

This citizen science project involved bringing people together from the Ngarrindjeri Nation and the broader community (RLCAG) with scientists (CLLMM) to learn the current population status of Lokeri in the Lower Lakes. The exchange of knowledge between people of different backgrounds and experiences greatly enhanced the project outcomes.

2.1 Ngarrindjeri Nation

Prior to on-ground surveys in December 2024, the CLLMM Research Centre and scientists worked with Ngarrindjeri Aboriginal Corporation to hold two yarning circles with members of the Ngarrindjeri community. Approximately 40 participants, mainly from Raukkan and Meningie, attended the first Lokeri yarning circle held on 25 November 2024 on the edge of Lake Alexandrina near Terringie. The second yarning circle was held at Point Sturt on 26 November 2024 with approximately 15 participants. During the yarning circles, the lead researcher presented the idea for a Lokeri project that included a survey where community members could be employed to participate in field work. After the yarns, participants entered the water in search of Lokeri. At Terringie, only empty shells were located but participants stated how much they enjoyed getting in the water and connecting with Country during the search. At Point Sturt, most participants found live Lokeri (Figure 3).

Figure 3. Participants of the yarning circle at Point Sturt, Lake Alexandrina, on 26 November 2024.

The events provided a successful way to inform community of the intention to conduct a survey on Ngarrindjeri Country and the opportunity for people to participate. During the yarning circles, participants approached the lead researcher and expressed their interest to participate in the survey, which eventuated in most cases. There were 15 people from the Ngarrindjeri community that were employed to participate in the surveys and laboratory.

2.2 River, Lakes and Coorong Action Group

Several members of the River Lakes and Coorong Action Group (RLCAG) participated in the Lokeri project, especially in the survey design and implementation (Figure 4). The RLCAG is an independent, not for profit, Incorporated Association and Registered Charity which formed in 2006. The organisation incorporated in January 2007 to protect, conserve and enhance the biodiversity of the River Murray, Lakes and Coorong; liaise with appropriate bodies over the management of the River Murray, Lakes Alexandrina and Albert and the Coorong, and their immediate surrounds; and provide information for the community. Membership is open to community members, fishers, farmers, scientists, artists, environmentalists, educators, tourism operators and business people who endorse the objectives and purposes of the Association. The RLCAG's Vision is to achieve a fair water allocation based on science for all users including the environment. The RLCAG's Mission is to protect, conserve and enhance the biodiversity of the River Murray, Great Southern Lakes and Coorong by ensuring environmentally sustainable quantities of healthy water continue to flow to the CLLMM region and this water is managed for the benefit of the First Nations people, the environment, current beneficiaries and future generations.

2.3 CLLMM Research Centre

The CLLMM Research Centre is a collaborative partnership working to create locally-driven and inclusive knowledge creation and exchange to inform decision making in the CLLMM region. The CLLMM Research Centre supports First Nations community well-being, providing an opportunity for knowledge creation and sharing, and the incorporation of the scientific knowledge of First Nations, the community, governments and researchers into the management of the region. The CLLMM Research Centre achieves this through locally-based research in which community and First Nations can participate and lead in cultural and scientific activities, that build upon existing cultural knowledge and empowers communities to take charge of the management of their land and waters.

The muscles in the mud project is an example of meeting the principles and objectives of the CLLMM Research Centre because it is a citizen science study driven, planned and undertaken by community, scientists and Ngarrindjeri peoples. The CLLMM Research Centre was fully supportive of any approach decided by scientists and citizen scientists that ensured the project's success (e.g. planning and undertaking yarning circles). The CLLMM Research Centre also kept the wider community up to date with the project's progress through various means including the sand box display, speed dating with the scientists, regular Facebook and Instagram posts, and regular promotions through other engagement activities. The gaining of contemporary knowledge about Lokeri in the region would not have happened if the CLLMM Research Centre had not supported the current project.

3 Methods

3.1 Lokeri survey

3.1.1 Survey sites

An initial search in September 2024 by scientists, staff from the CLLMM Research Centre, and several members of the RLCAG, confirmed the presence of Lokeri in the Lower Lakes (Figure 4). Following the successful detection of Lokeri in Lake Alexandrina at Point Sturt (Figure 5), the Bremer River mouth and Terringie near Raukkan, a coordinated survey of 34 sites was conducted from the 2nd to the 20th of December 2024 (Figure 6 and Table 1). Sites were selected based on local knowledge, safety and accessibility, and historic accounts from Elders, landholders and Walker (1981). Survey effort was dispersed around the Lower Lakes whilst specifically targeting lake-edge habitats known to be the preferred habitat of adult Lokeri (Walker 1981). Thirty sites were sampled in Lake Alexandrina, and four sites were sampled in Lake Albert. Supplementary surveys by two members of the RLCAG in the southern parts of Lake Albert near Meningie failed to find Lokeri.

Figure 4. An initial search on the edge of Lake Alexandrina in September 2024 located Lokeri near Teringie.

Figure 5. Julie Jones finds the first live Lokeri at Point Sturt, Lake Alexandrina, in September 2024.

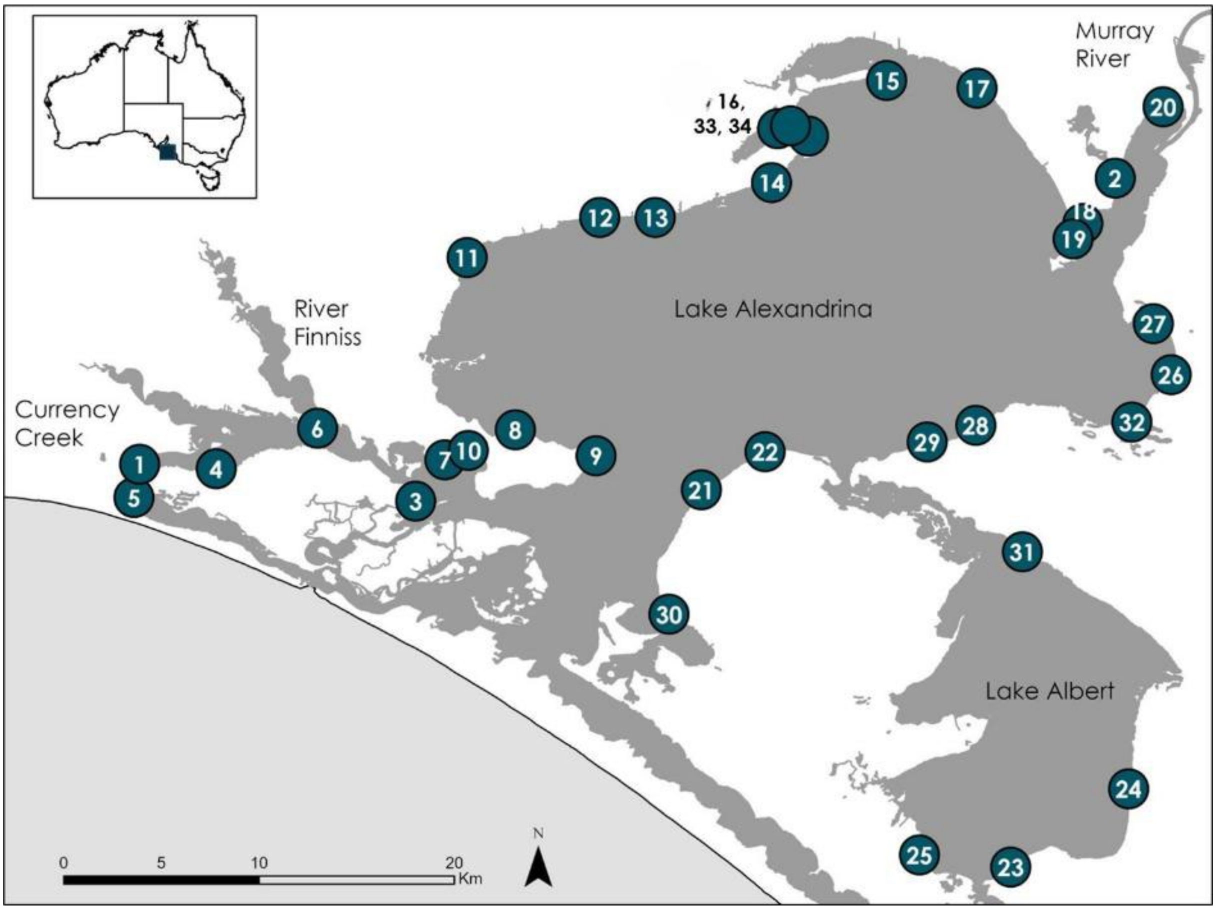

Figure 6. Sites in Lakes Alexandrina and Lake Albert surveyed for Lokeri in December 2024.

Table 1. Lokeri survey sites and locations in Lake Alexandrina and Lake Albert (UTM zone 54H, WGS84).

SITE NUMBER	SITE NAME	LOCATION	EASTING	NORTHING
1	Riverview	Goolwa Channel	0299477	6069296
2	Laffin Point	Murray Confluence	0349423	6083953
3	Lake Cloud	Lake Alexandrina	0313612	6067407
4	Monument Road boat ramp	Goolwa Channel	0303388	6069056
5	Goolwa	Goolwa Channel	0299183	6067589
6	Goolwa Channel-River Finniss	River Finniss mouth	0308581	6071139
7	Dunn Lagoon east	Clayton	0315108	6069518
8	Point Sturt Road	Lake Alexandrina	0318708	6071067
9	Point Sturt campground	Lake Alexandrina	0322845	6069728
10	Stony Point Bay east	Goolwa Channel	0316298	6070004
11	Milang Jetty	Lake Alexandrina	0316241	6079887
12	Bremer River mouth	Lake Alexandrina	0323037	6081932
13	West of Tolderol Game Reserve	Lake Alexandrina	0325874	6081930
14	Tolderol Game Reserve	Lake Alexandrina	0331835	6083724
15	Mosquito Point	Lake Alexandrina	0337720	6088957
16	Dog Lake entrance	Lake Alexandrina	0333725	6086115
17	Nalpa Station west	Lake Alexandrina	0342345	6088550
18	Nalpa Station east	Murray Confluence	0347777	6081631
19	Nalpa Station supplementary	Lake Alexandrina	0347280	6080833
20	Lake McHughes	Murray Confluence	0351890	6087596
21	Terringie	Lake Alexandrina	0328238	6067980
22	Bullrushes Raukkan	Lake Alexandrina	0331505	6069948
23	Woolshed Road Reserve	Lake Albert	0344086	6048672
24	Brown Beach Meningie	Lake Albert	0350113	6052677
25	Campbell House	Lake Albert	0339407	6049290
26	Eckert property	Lake Alexandrina	0352301	6073883
27	Cousin Tony's	Lake Alexandrina	0351376	6076500
28	Poltalloch homestead	Lake Alexandrina	0342285	6071278
29	Poltalloch pumpshed	Lake Alexandrina	0339811	6070428
30	Loveday Bay	Loveday Bay	0326584	6061607
31	Lake Albert Road in Narrows	Lake Albert	0344684	6064821
32	Masondrina Station	Lake Alexandrina	0350286	6071451
33	Dog Lake entrance south	Lake Alexandrina	0332802	6086626
34	Dog Lake entrance north	Lake Alexandrina	0332802	6086626

3.1.2 Recording Lokeri and habitat

Lokeri presence and abundance at each site was measured using two standard methods. First, between three and eight people conducted a general search of the area for between 20 and 30 minutes using bare feet to feel for Lokeri in waters up to 130 cm deep within 50 m of the shore. Second, in a location randomly chosen within the search area, three adjacent 10 m × 10 m quadrats, 1 m apart, were pegged out using 1.2 m long garden stakes and 40 m of rope stretched tightly between each garden stake (Figure 7). Each quadrat was sampled by a search line of 4–6 people walking from one end of the quadrat to the other for approximately 10 minutes, where Lokeri were located using bare feet. The survey methods were designed to match those of Walker (1981) to allow direct temporal comparison. Empty shell numbers were also recorded in each of the two methods.

Habitat measures included water depth (cm) as the average of five measures taken in the general search area. Electrical Conductivity units (EC), pH and water temperature were recorded using a TPS WP-81 meter. Aquatic plant cover was estimated as the percentage of macrophytes covering the search area at a site. The sediment type was also recorded.

Species identification was conducted using diagrams presented in Walker (1981) and Balla and Walker (1991). The length, height and width of each live Lokeri found was measured and recorded to the nearest millimetre using 15 cm long Vernier callipers (Figures 8 and 9). Adult Lokeri were considered any measuring over 40 mm in length (sensu Walker 1981). The individual weight of a Lokeri was taken or the bag weight for the site was recorded using 2 kg portable scales. Lokeri collected for ageing were from sites where the species was most abundant, and the total catch was frozen for processing and examination in the laboratory. At sites with low numbers, Lokeri were immediately returned to the site of capture.

Figure 7. Setting up a quadrat using garden stakes and rope (left) and starting a search line at one end of a quadrat (right).

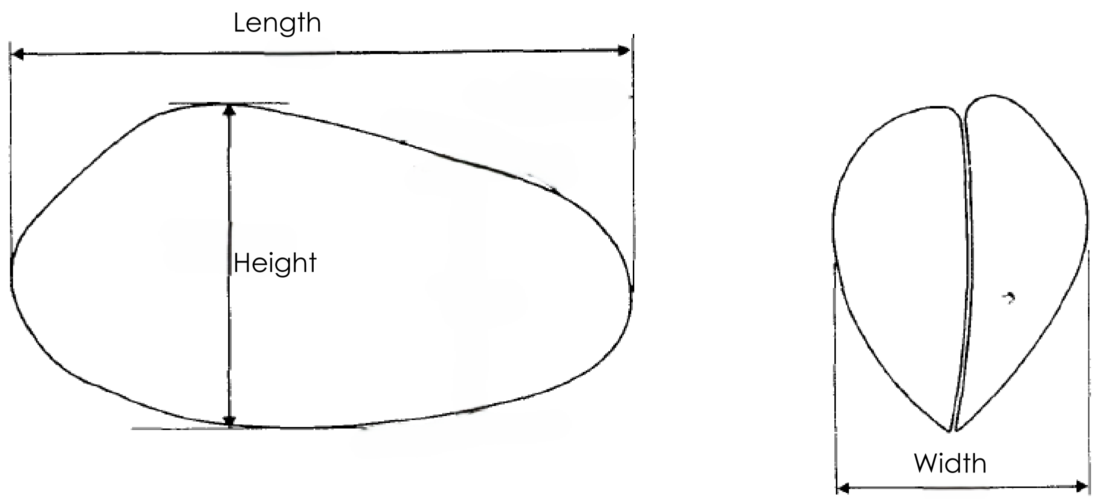

Figure 8. Measurements taken of each Lokeri found in the survey.

Figure 9. Measuring Lokeri in the field (left) and large and medium sized Lokeri (right).

3.2 *Ageing of Lokeri*

3.2.1 Shell preparation

During the December 2024 survey, 48 live Lokerar were collected for age analysis of the population in the Lower Lakes trialling three methods: external shell age estimates, thick sectioning of the umbo, and full cross-sections of the shell. Initial laboratory work commenced in July 2025, where length, height and width were measured to the nearest 0.1 of a millimetre (Figure 10) for each Lokeri. Whole weight (g) was recorded. Lokeri shells were cleaned and air dried in a fume hood.

Established ageing methods are lacking for *V. ambiguus*. Lokeri shells show external annual growth lines (growth interruption lines) which indicate periods of dormancy during winter months when water temperature falls below 12 °C (Walker 1981). In the Lower Lakes, this would mean a growth period of approximately 9–10 months per year. Growth may also be interrupted for other reasons, including disturbances like flood and drought (Walker 1981, 2016). Only one previous study has examined the feasibility of ageing *V. ambiguus* from the Lower Lakes, albeit using cross sections of the entire shell of dead Lokeri (Day 2014). Annual growth lines, however, have not been validated for the species.

Figure 10. Processing Lokeri samples collected during the December 2024 survey in preparation for ageing and growth analyses.

3.2.2 Shell erosion

In all samples, the outer layers of the shell had been eroded to various degrees. This has implications for age analysis, as the increments may not represent the true number of increments formed in the individual's life span. Therefore, all ages in this study are representative of the 'minimum possible' age of the individuals. To help determine the impact of erosion on the ageing of the shells, samples were categorised into two levels of erosion, small amounts of shell erosion which were <2 cm, and large amounts of shell erosion where more than 2 cm of the shell had eroded (Figure 11).

Figure 11. Examples of Lokeri (*V. ambiguus*) shells categorised into small (<2 cm) and large (>2 cm) amounts of erosion according to shell condition.

Figure 12. Lokeri recorded from Lake Alexandrina with high levels of shell erosion.

3.2.3 External ageing

Lokeri shells showed some indication of external annual growth interruption lines (Figure 13). To assess if the shells could be aged whilst the Lokeri is alive, all individuals were aged by three independent readers based on assumed annual lines on the exterior of the shell.

Figure 13. Lokeri (*V. ambiguus*) with distinct external growth interruption lines (indicated by white lines).

3.2.4 Umbo ageing

The umbo of bivalves often is used for ageing, due to clear representation of age increments and quick processing and high throughput. Shell samples were prepared according to shell and otolith ageing protocols (Reis-Santos et al. 2012; Izzo et al. 2017). Left valves were sectioned (~10 mm x 15 mm) at the umbo region with an Isomet low-speed saw with M1D08 diamond blades. Sections were embedded in epoxy resin (Struers Epofix) and left to harden overnight (Figure 14). Samples were sectioned again using a low-speed saw (~400 µm), and wet polished with lapping film (sequentially 30, 9 and 3 µm grade). Sections were mounted onto glass slides with crystal bond adhesive (ProSciTech Crystalbond) and cleaned using ultrapure water (Milli-Q) in an ultra-sonic cleaner.

Figure 14. Section removed from umbo of a Lokeri (left) and umbos set in resin (right).

Images were taken under reflective light with a Leica MZ8 stereo-microscope, and growth lines (assumed to be annual lines: sensu Walker 1981) were marked in ImageJ using the ObjectJ plugin (Figure 15). Three independent blind rounds of ageing occurred with different readers, achieving minimal variance with an Index Average Percent Error (IAPE) of <5% (Campana 2001; Wakefield et al. 2017). IAPE were calculated using the below equation, where R was the number of times each umbo was aged.

$$IAPE_{overall} = \frac{1}{N}\sum_{j=1}^{N}\left[\frac{1}{R}\sum_{i=1}^{R}\frac{\left|x_{ij}-\tilde{x}_j\right|}{\tilde{x}_j}\right]$$

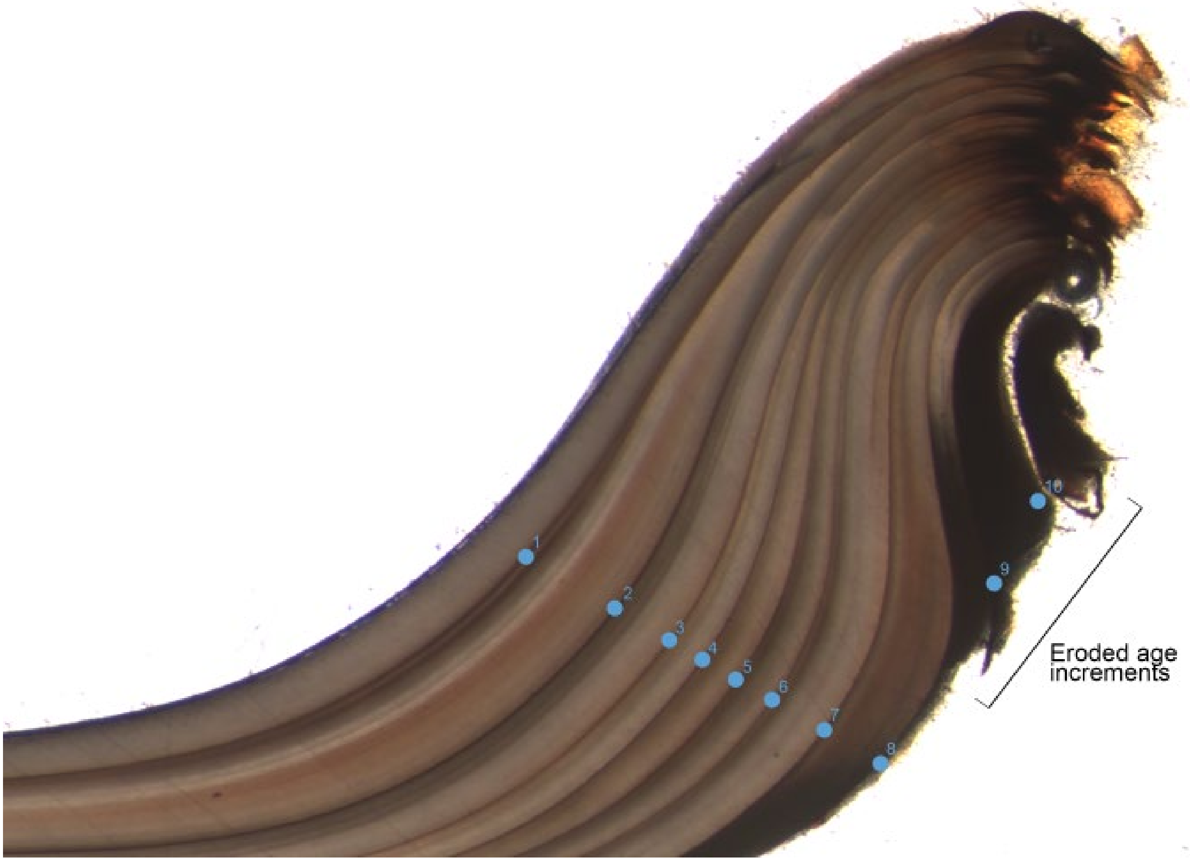

Figure 15. Umbo of Lokeri (*V. ambiguus*) with growth lines assumed to be annual increments marked with blue dots and eroded age increments highlighted.

3.2.5 Full shell length ageing

To assess if the full length of the shells were more accurate for ageing compared to umbo sections alone, a small sub-sample of entire shells (3 with small erosion and 3 with large erosion) were processed. Processing of full-length shells followed (Reis-Santos et al. 2025). Briefly, right valves were sectioned using the low-speed diamond saw (~20 mm thick), from dorsal to ventral along the maximum growth axis. Samples were then embedded in epoxy resin and sectioned (~15 mm thick) using a Gemmasta table trim wet saw, ensuring one cut aligned with the umbo. Sections were wet polished with sanding sheets (P600 grit) and lapping film (30 and 9 µm grade). Sections were cleaned with Milli-Q water and mounted onto microscope glass slides with crystal bond glue. Using a Buehler Petrothin saw, sections were cut and polished (~0.8 mm), followed by wet polishing with lapping film and cleaned in an ultra-sonic cleaner. Images of full-length shells were taken using the dissecting microscope. Due to the large size, multiple images were stitched together to achieve a full profile (Figure 16). Three independent blind rounds of ageing occurred with different readers, where the most prominent lines were assumed to be the annual mark of growth interruption.

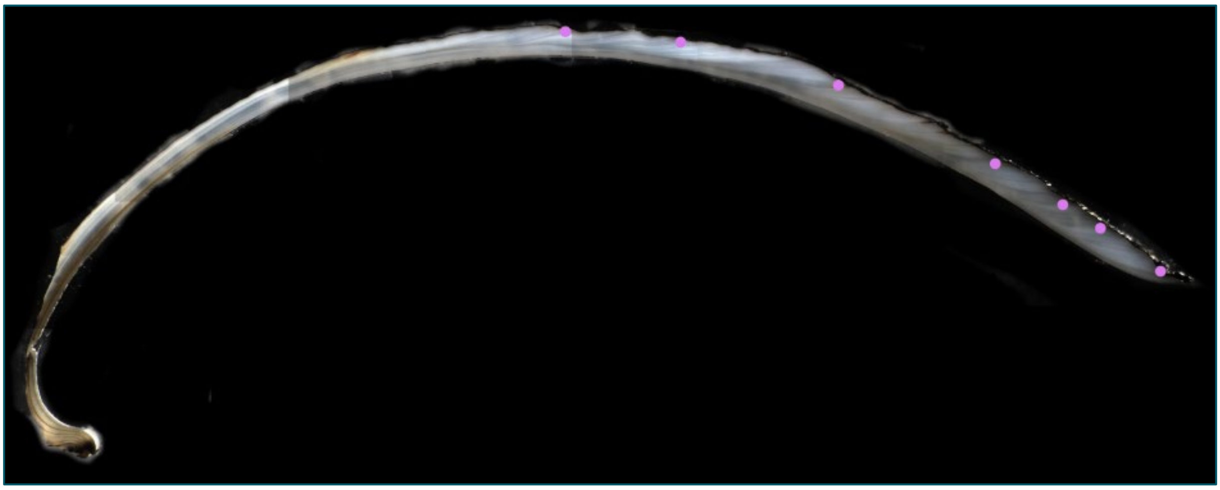

Figure 16. Full length cross-section from dorsal to ventral along the maximum growth axis of Lokeri (*V. ambiguus*) with assumed annual increments marked with pink dots.

3.2.6 Data analysis

Umbo ages were used to estimate recruitment year, represented as the year when the recently metamorphosed mussel released from its fish host, by back calculating the number of bands from the collection date of December 2024. Age structure of the Lokeri population in Lake Alexandrina was assessed by plotting frequency (%) histograms. The plots were used to examine the distribution of individuals among age classes. Individuals were plotted with age against length to assess if there were any patterns between growth and age, and to see if a possible growth curve could fit the data. R was used for all data visualisation (R Core Team 2024), with packages tidyverse (Wickham et al. 2019) and readxl (Wickham & Bryan 2023). IAEP was used to calculate variation between the three methods for ageing.

4 Results

4.1 Field survey

A total of 76 live Lokerar were recorded at 10 of the 30 sites in Lake Alexandrina during the December 2024 survey (Figure 17; Table 2). Floodplain mussels were recorded at nine sites while two river mussels (*Alathyria jacksoni*) were recorded at site 13, approximately 50 m from the lake edge west of Tolderol Game Reserve (Figure 18). Lokeri was not detected at the four sites in Lake Albert. In the combined quadrat and general search, the greatest abundance was 21 Lokerar recorded at site 27 on the eastern edge of Lake Alexandrina. Other notable sites included site 9 Point Sturt, site 32 Masondrina Station and site 12 Bremer River mouth where 17, 17 and 11 Lokerar were recorded, respectively (Figure 17).

Conductivity at the sites in Lake Alexandrina ranged 402–965 EC and 587–678 EC at sites where Lokeri was detected (Table 2). Water temperatures at sites of Lokeri detection ranged 21.3–25.9 °C. Lokeri was detected in water depths ranging 74–111 cm within 50 m of the shoreline. Generally, Lokeri were detected at sites where aquatic plants were sparse. Sediments at the sites of detection were always sand or a combination of sand and mud.

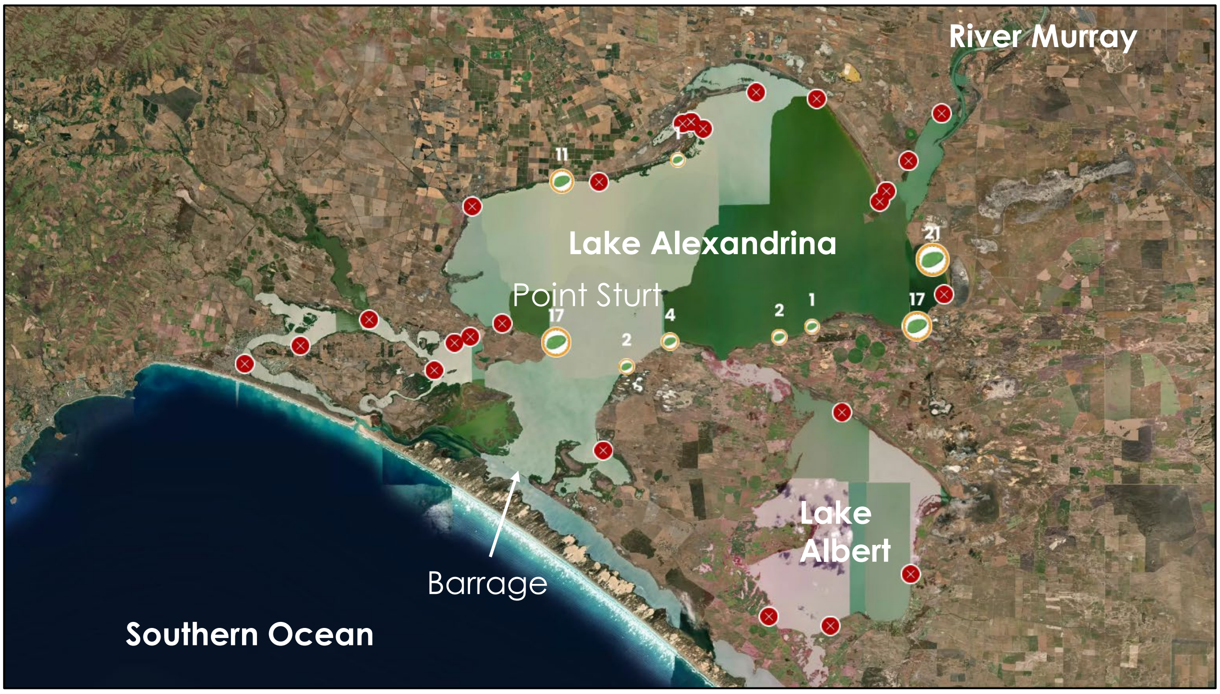

Figure 17. Survey sites indicating total numbers of live Lokeri (*V. ambiguus*) found in quadrats and general search (orange circles) and other sites (red dots) were is was not recorded (Basemap imagery © Mapbox © Maxar Technologies).


Figure 18. One of two river mussels recorded in December 2024.

Table 2. Lokeri abundances and environmental measures at sites (NR = not recorded).

SITE NUMBER	FLOODPLAIN MUSSEL	RIVER MUSSEL	EC (µS/CM)	PH	TEMP. (°C)	DEPTH (CM)	AQUATIC PLANTS (%)	SEDIMENT TYPE
1	0	0	852	8.4	22.6	100	22	mud
2	0	0	890	7.4	23.1	128	40	mud/sand
3	0	0	695	7.4	20.7	110	35	mud/silt
4	0	0	822	7.9	21.6	105	0	mud/silt
5	0	0	882	8.1	21.0	98	0	sand/mud
6	0	0	865	8.0	20.1	105	30	mud
7	0	0	NR	NR	NR	NR	30	sand
8	0	0	636	8.6	22.0	96	4	sand
9	17	0	636	8.2	22.6	111	10	sand
10	0	0	719	8.6	22.3	113	12	sand
11	0	0	670	8.4	22.3	94	10	sand
12	11	0	678	7.8	22.9	96	15	sand/mud
13	0	2	679	8.4	19.8	86	0	sand
14	1	0	601	8.4	21.3	90	10	sand firm
15	0	0	666	8.7	20.4	88	0	sand
16	0	0	965	8.5	22.3	90	10	sand/mud
17	0	0	672	8.0	19.5	84	0	mud/sand
18	0	0	400	7.9	22.0	87	0	sand/rock
19	0	0	NR	NR	NR	NR	0	sand
20	0	0	402	8.1	22.3	112	7	sand/rock
21	2	0	641	8.6	24.1	108	0	sand
22	4	0	631	8.7	25.9	100	15	sand
23	0	0	1161	8.2	20.4	100	17	sand/mud
24	0	0	1090	8.4	20.7	95	20	sand/rock
25	0	0	1090	8.6	22.9	78	0	sand
26	0	0	604	8.5	20.4	90	0	sand
27	21	0	593	8.6	21.6	110	20	sand firm
28	1	0	631	8.4	21.3	96	25	sand/mud
29	2	0	640	8.7	23.8	96	70	sand/mud
30	0	0	710	8.8	25.0	100	20	sand firm
31	0	0	1039	8.7	22.9	86	10	sand firm
32	17	0	587	8.6	24.4	74	20	sand firm
33	0	0	699	8.0	20.7	125	30	mud
34	0	0	699	8.0	20.7	80	25	sand/mud

All Lokeri captured in the December 2024 survey were adults ranging 59–104 mm long. Walker (1981) recorded a mean length of 66.5 ±6.4 (n = 100) at Point Sturt in February 1978 where juvenile Lokeri (<30 mm long) were also captured. In the December 2024 survey, the mean length of Lokeri was 76.2 ±3.8 mm (n = 17) at Point Sturt (Table 3). The density in quadrats in December 2024 ranged from 0.003 Lokeri/m^2 at several sites to 0.037 Lokeri/m^2 at the Bremer River mouth (Table 3). Notably, all Lokeri captured at the Bremer mouth were recorded in one of the three quadrats, and a broader search of the area failed to locate any further individuals. In February 1978, Walker (1981) recorded a density of 2.73 Lokeri/m^2 at Point Sturt compared to 0.013 Lokeri/m^2 at the site in December 2024. As such, our estimate of abundance represents <0.5% of the historic abundance.

Table 3. Comparison of Lokeri (*V. ambiguus*) density in quadrats at sites recording greater than zero in the December 2024 survey and February 1978 by Walker (1981)* for Point Sturt, and the mean length of the entire catch in quadrats and general search combined where n = 3 or more.

SITE NUMBER	SITE NAME	DENSITY 2024 (LOKERI/M^2)	MEAN LENGTH ±SD IN 2024 (MM)	DENSITY 1978* (LOKERI/M^2)
9	Point Sturt campground	0.013	76.2 ±3.8	2.73
12	Bremer River mouth	0.037	79.1 ±4.4	-
14	Tolderol Game Reserve	0.003	-	-
21	Terringie	0.003	-	-
22	Bullrushes Raukkan	0.007	76.5 ±4.2	-
27	Cousin Tony's	0.003	87.8 ±10.3	-
32	Masondrina Station	0.013	82.8 ±3.2	-

Across all sites, the number of empty Lokeri shells recorded in the combined quadrats and general search counts ranged widely (Figure 19). The highest counts for shells occurred at Point Sturt (143 shells) and Terringie (78 shells) which are within several kilometres of each other at the constricted southern side of Lake Alexandrina. Other areas with high shell counts included the eastern end of Hindmarsh Island (68 shells), the junction of River Finniss and Goolwa Channel (44 shells), at the eastern edge of Lake Alexandrina (29 shells), and at the supplementary site on Nalpa Station (19 shells) south-eastern Lake Alexandrina. Lokeri shells were found at 16 sites compared to live Lokeri recorded at 9 sites, and there is no obvious correlation between the locations of live and dead Lokeri.

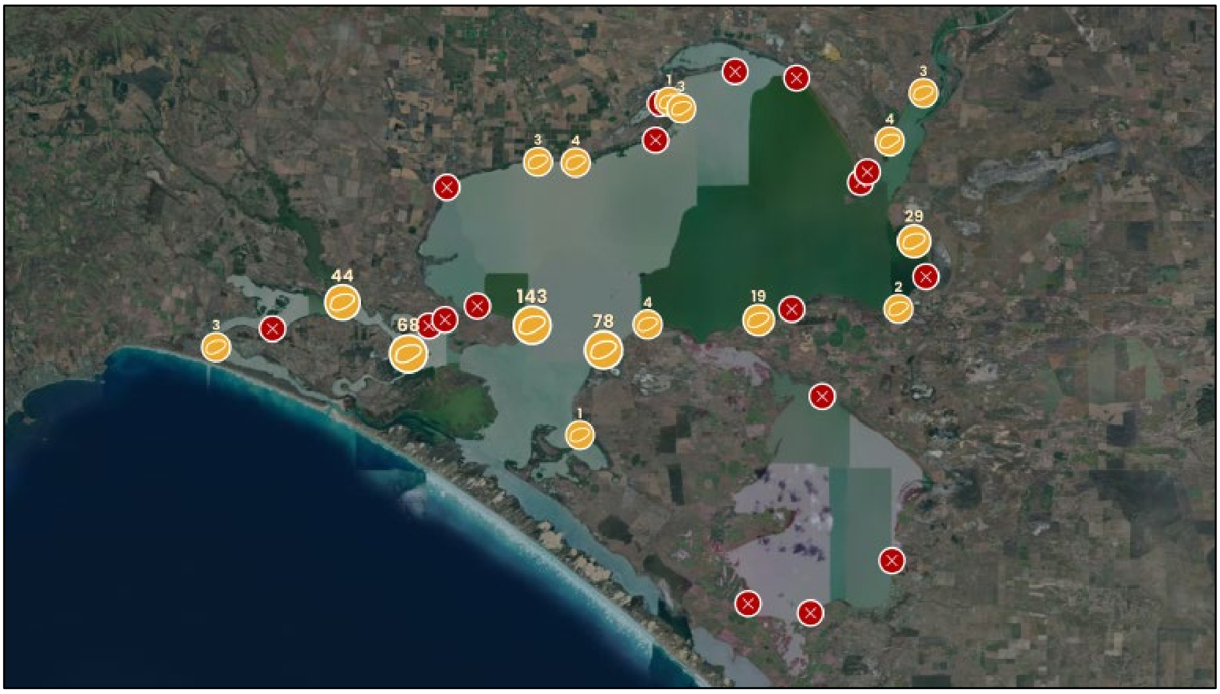

Figure 19. Survey sites and total numbers of Lokeri shells found using quadrats and general search (Basemap imagery © Mapbox © Maxar Technologies). Yellow symbols denote were shells were found, red circles denote were shells were not found.

4.2 Ageing results

4.2.1 Age structure

Lokeri samples ranged between estimated ages of 5 and 13 years from umbo sections. Recruitment spanned the years 2011 to 2019, with individuals present in each year class (Figure 20). There appeared an increase in recruitment from 2015 to 2017 and again in 2019, however, this is not definitive due to the shell erosion leading to potential errors in ageing.

Age-frequency histograms were plotted for the two sites with the highest number of Lokeri (Figure 21). The majority of individuals from site 27 Cousin Tony's had small erosion (66%), in comparison with site 9 Point Sturt where most samples had large erosion (94%). Year class representation across sites varied. For example, in 2011 and 2016 recruits were only found at Cousin Tony's and Point Sturt, while in 2019 recruits appear in four of the five sites where Lokeri were present. There were some similarities between sites including higher numbers of individuals born in 2015–2017, however, there was an absence of individuals from the 2018 and 2019 cohorts in Point Sturt.

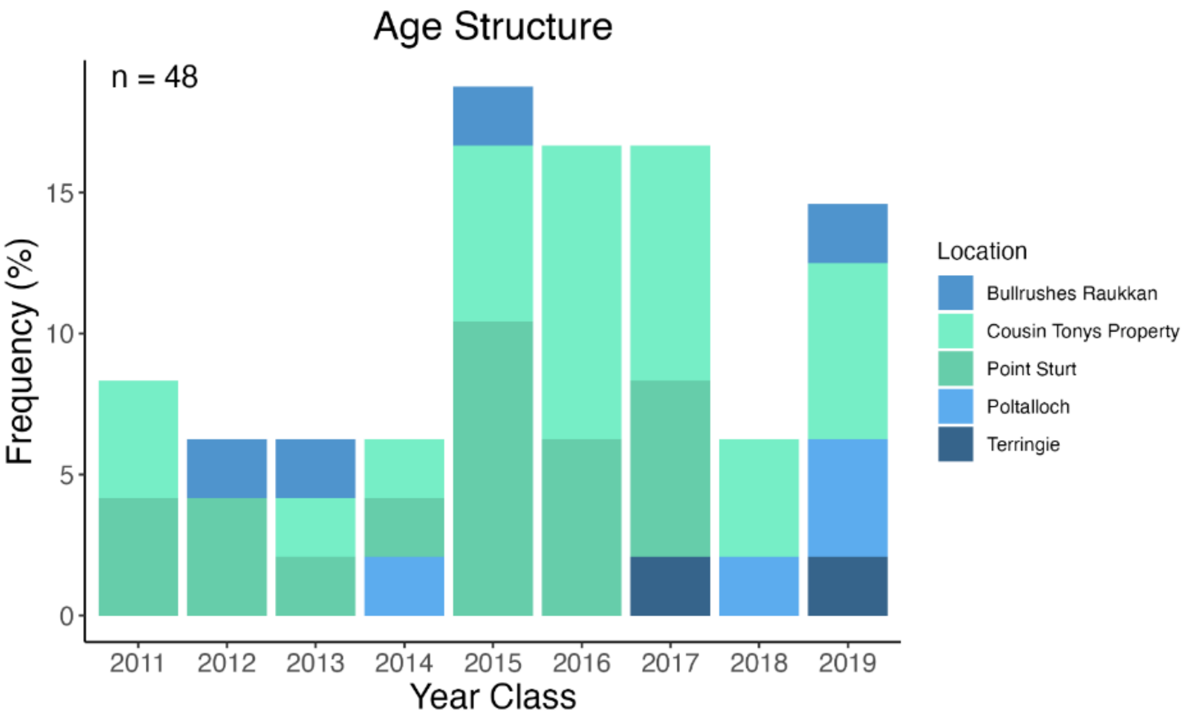

Figure 20. Frequency (%) histogram of year class (recruitment) based on ageing of Lokeri (*V. ambiguus*) using umbo sections. All samples were collected in December 2024, and locations are distinguished by colour.

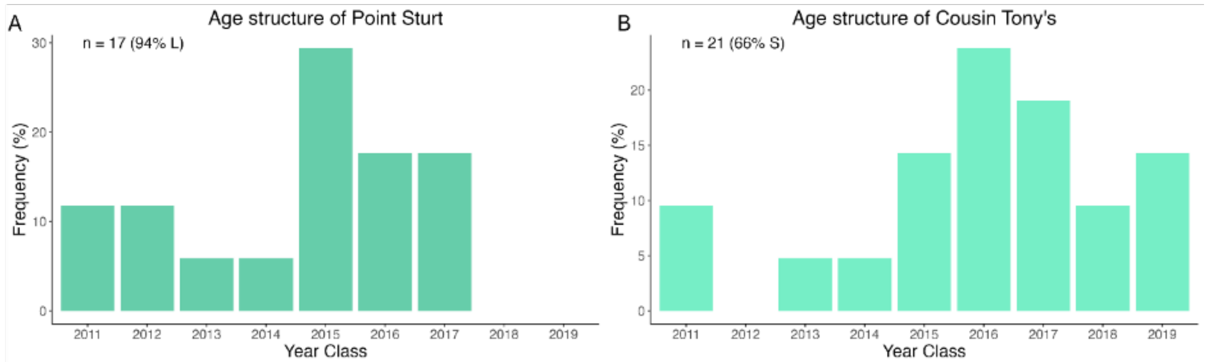

Figure 21. Frequency histogram of year class (recruitment) based on ageing of Lokeri (*V. ambiguus*) using umbo sections. All samples were collected in December 2024. The age structure for site 9 Point Sturt (*n* = 17) is shown in plot A, where 94% of samples had large erosion. Plot B shows the age structure of Lokeri at site 27 Cousin Tony's (*n* = 21), where 66% of the samples had small erosion.

4.2.2 Age and growth

Length-at-age plots revealed no distinct patterns between age and growth (Figure 22). Separating individuals into small and large erosion also had no effect on the pattern between age and growth. As such, a growth curve was unable to be fitted to the data, so size cannot be used to predict age in this study.

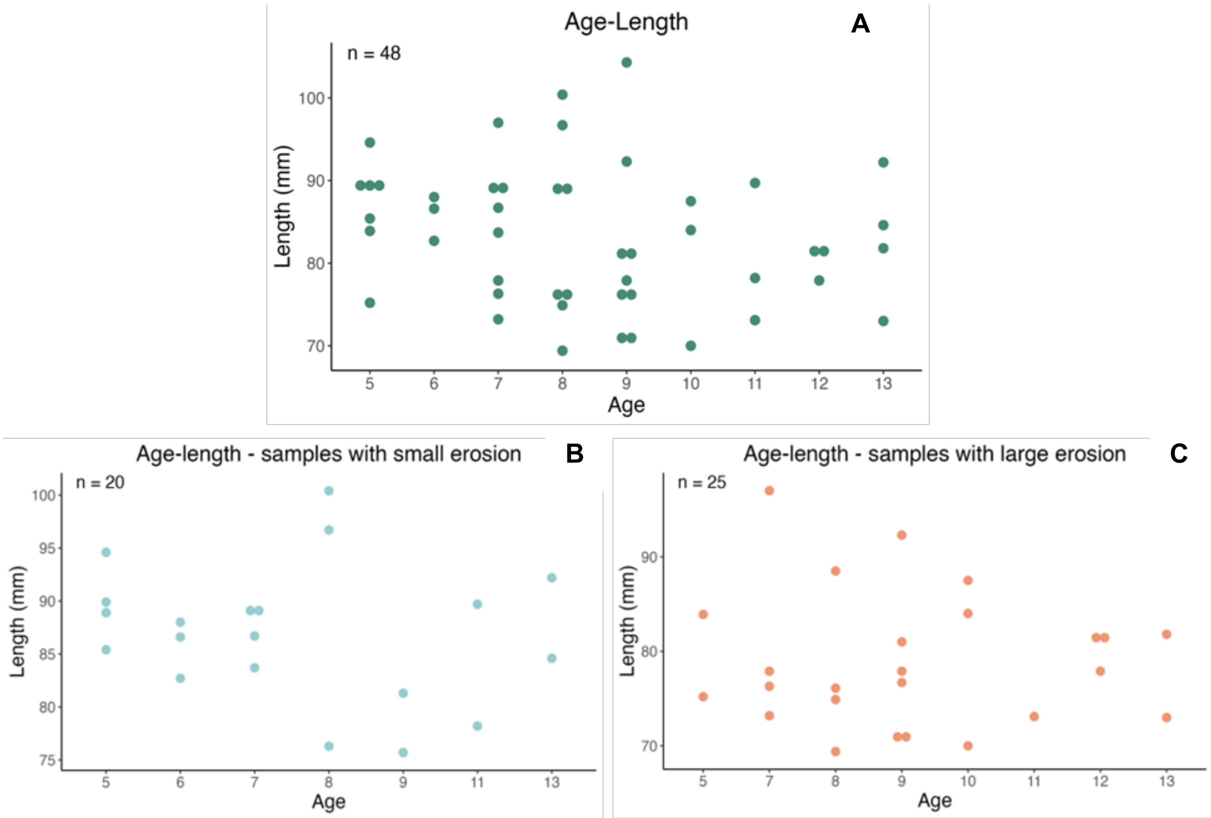

Figure 22. Lokeri (*V. ambiguus*) lengths plotted against age read from umbo. Plot A shows all individuals, plot B shows samples with small erosions, and plot C shows samples with large erosion.

4.2.3 Comparison of ageing methods

Comparing the external growth interruption lines and the umbo section approaches for ageing of 48 specimens, once age was agreed upon from three independent reads, no individuals received the same age between the two methods. Samples with large erosion had the highest discrepancy between umbo and external shell ages. Overall, the IAPE between the external and umbo aging was 17%, which indicates relatively high variation between methods. The full-section length ageing of six Lokerar samples also varied from the umbo section ageing (Table 4). Across the smaller subset of six shells samples used to compare age estimates from full cross sections of shells to umbo sections, the difference in the full shell age in comparison to the umbo age ranged from 6 years younger, to 5 years older.

Table 4. Lokeri samples aged with both umbo and full shell length with small and large erosion levels.

Sample	Erosion Level	Umbo Age (Years)	Full Shell Length Age (Years)	Difference (Years)
VA_02	small	5	10	+5
VA_14	small	6	8	+2
VA_24	small	6	7	+1
VA_31	large	9	11	+2
VA_34	large	12	6	-6
VA_45	large	13	12	-1

5 Discussion

5.1 Lokeri survey

In late 2024, during the survey of 34 sites in the Lower Lakes (Figure 23), Lokeri (*V. ambiguus*) was located at nine sites in Lake Alexandrina and the river mussel (*A. Jacksoni*) at a single site west of Tolderol Game Reserve. The density of Lokeri at Point Sturt was significantly lower than found in a 1978 survey of the site (0.01 Lokeri/m^2 cf. 2.73 Lokeri/m^2: Walker 1981). This result appears to be the case lake-wide for the species, where it was found in very low abundance at the other eight sites of presence. The species was undetected at all four sites in Lake Albert, and no empty shells were recorded. Compared to estimates over 45 years ago (Walker 1981), Lokeri abundance in the Lower Lakes currently appears to be less than 0.5% of historic abundance, perhaps representing the very early stage of recovery following its extirpation during the Millennium Drought.

Figure 23. Searching for Lokeri in a quadrat in the Goolwa Channel.

In the current study, the mean length of Lokeri at Point Sturt was higher (76.2 mm) than that recorded in 1978 (66.5 mm) by Walker (1981), indicating more younger individuals were present historically. The much smaller sample size of Lokerar collected at Point Sturt in the current study (n = 17 versus n = 100 in 1978) means this conclusion is uncertain. Furthermore, we found in this study that there was no clear relationship between Lokeri length and age. In 2024, all Lokeri collected were adult sizes, with the smallest measuring 59 mm long. Young Lokeri grow rapidly to attain a length of >50 mm in 3 or 4 years (Walker 1981). An absence of Lokeri <50 mm in the December 2024 survey may indicate recruitment was low or absent in the few years preceding the survey. The factors associated with an absence of recruitment are unknown, although Walker (1981) suggested populations of *V. ambiguus* in Lake Alexandrina fail to spawn in seasons when strong winds and waves strand Lokeri, temporarily, along the shore. Alternatively, juvenile Lokeri may have been missed with the survey methods, either due to their small size or if they occupy habitats that differ from the adult Lokeri (cf. Cyr 2020). The first few years of life for freshwater mussels are poorly understood (Walker 2016), and understanding the early life stage of Lokeri in Lake Alexandrina is an important consideration for future investigations.

Aboriginal Peoples and Freshwater Mussels

Freshwater mussels have sustained Aboriginal peoples across Australia for tens of thousands of years, serving simultaneously as food, tools, ornaments, and markers of place. Substantial middens of freshwater mussel shells along the Darling–Baaka/Barwon and Murray rivers represent ancestral places for camping, eating together, and ceremony, distinguished by accumulations of shells from cooking built up over time (Murray–Darling Basin Fish n.d.). Mussel shells were traditionally used for tools, jewellery, ceremony, and artwork, and continue to be used and valued in these ways today (Murray–Darling Basin Fish n.d.).

Freshwater middens are accumulations of shell produced by Aboriginal people collecting, cooking, and eating freshwater shellfish, and some of the oldest cultural places in Victoria are freshwater shell middens (First Peoples – State Relations 2024). The primary species represented in these deposits are *Velesunio ambiguus* (floodplain mussel) and *Alathyria jacksoni* (river mussel) (First Peoples – State Relations 2024). Many middens in the Central Murray River Valley are laterally expansive, some measuring up to 400 metres in length, reflecting intensive and repeated use of riverine environments over the late Quaternary (Garvey 2016).
Shell middens provide Aboriginal people today with an important link to their culture and their past, and those containing Ancestral Remains are particularly significant (First Peoples – State Relations 2024). Their protection and ongoing study are a matter of both cultural heritage law and living cultural responsibility.

5.2 Lokeri ageing

As identified in the current study, there are some hurdles to overcome before Lokeri can be accurately aged from shells. Freshwater mussels show growth age increments (growth interruption lines) that are formed during periods of dormancy which are most apparent from 1–2 months of winter growth cessation (Walker 1981). The current study demonstrated that growth increments were present, but it is possible some are the result of other disturbances such as changes in hydrology and water physico-chemistry (e.g. high salinities during low river flows), or seasonally related water temperature. To ensure false increments are not being counted as annual increments, a validation study is required. Validation techniques include chemically marking samples to assess growth over a known period of time (Neves & Moyer 1988; Klunzinger et al. 2014).

Shell erosion at the umbo made it challenging to use the predicated ages in this study to associate patterns of recruitment to hydrology and other environmental parameters in the Lower Lakes. Shell erosion may be an unavoidable limitation, but this may be overcome by collecting Lokeri with low erosion (though this may bias sampling). Even though the current study cannot demonstrate direct links between recruitment and growth to environmental parameters in the Lower Lakes, the putative age structure of Lokeri in Lake Alexandrina may provide some insight. For example, age-frequency analysis demonstrated increased recruitment from 2015 to 2017, which is a good indication of yearly recruitment success over that period. Although the exact years may not be accurate, the spread is a positive sign of variation in ages throughout the population, potentially promoting population resilience to environmental perturbations.

Ideally, if Lokeri can be aged from the external shell or via size, surveys could be conducted in the field without the removal of individuals. The current age study, however, has shown that neither of those field methods was feasible for *V. ambiguus* without further investigation. A growth curve could not be fitted to the data from the current study, likely due to the absence of smaller individuals. The minimum estimated age of Lokeri collected was five years, suggesting that Lokeri likely hit a growth plateau by at least that age, and possibly earlier. To incorporate smaller (juvenile) Lokeri in the data it may be possible to obtain samples from Lokeri aquaculture facilities, which would also negate the need to remove more individuals from the low abundance population.

Of the three ageing methods explored, the umbo cross-section was the most suitable for ageing Lokeri. The assumed age increments in the umbo cross-section were clear, allowing for higher confidence in ageing compared to measuring the full-length cross section and counting external growth increments. A benefit of using the umbo is that processing is much quicker and has a higher throughput than processing full length sections of shells.

5.3 Future directions

5.3.1 Population status of Lokeri

Monitoring of the Lokeri population demographics in the Lower Lakes would enable evaluation of the long-term trajectory of Lokeri in the region. Monitoring could be undertaken at a select group of sites identified in the current study, including site 9 Point Sturt and site 27 Cousin Tony's. The surveys should use the quadrat method for quantitative assessment over time and general search to assess other population parameters (e.g. size class). The methods used in the current study are suitable for the current low abundances and the quadrats provide a spatial and temporal quantitative comparison. Some consideration could be made, however, to increase the spatial distance between quadrats (e.g. random positioning of each quadrat) to increase the spatial representativeness of the sampled area, or increase the number of quadrats at a site. Also, it may be important to survey additional sites and habitats to locate smaller Lokeri (<50 mm and <4 years old) given the importance of understanding survival of early life stages for assessing recruitment success.

The use of high frequency sonar, potentially from boats, may be a suitable method for assessing Lokeri abundance in the Lower Lakes (cf. McCasker et al. 2024). This may not be possible at present due to the extreme low abundance of Lokeri but should be considered if abundances increase.

5.3.2 Recruitment of Lokeri

An important aspect of Lokeri that will help with population management and recovery in the Lower Lakes is improving understanding of the population's local recruitment, growth and reproduction patterns, and longevity. In the River Murray, Lokeri take 3–4 years to reach sexual maturity (Walker 1981). Once mature, the release of glochidia may be seasonal and opportunistic (Walker 2016). In the River Murray, *V. ambiguus* embryos are incubated over winter and glochidia are spawned in spring-summer (Walker 1981). Yet the species breeds over a longer period which enables it to adjust the timing of reproduction to variable conditions (Walker 2016).

Lokeri, specifically *V. ambiguus*, is a relatively short-lived species of freshwater mussel (<15 years), therefore, the population requires regular recruitment to persist in the variable environment of the lower River Murray (cf. Haag & Rypel 2011). Many international studies demonstrate that low river flows can lead to low levels of recruitment in freshwater mussels. For example, Ries et al. (2016) found that low flows generally resulted in poor recruitment of mussels in a side channel of the Upper Mississippi River in the USA. Wright et al. (2024) provide evidence that increased temperatures and river drying under climate change will have detrimental impacts on the distribution and abundance of freshwater mussel in Australia. Additionally, considering the rises in salinities during reduced river flows in the River Murray, Walker (1981) conducted salinity experiments on *V. ambiguus* and found that, although they can live in salinities up to 3 g/L for extended periods, lower salinities are beneficial for the species for a range of reasons including body condition of adult Lokeri and increased survival of glochidia. The influences of these factors on reproduction and recruitment of Lokeri highlights the need to understand the role of river flows, salinities and lake levels to its population dynamics in the Lower Lakes.

5.3.3 Lokeri–fish relationships

The life cycle of mussels includes an obligatory parasitic phase on a host fish (Walker 1981; Jones 2013). In this respect, the health and movement of potential host fishes can have a direct influence on the abundance and recruitment of mussel populations (e.g. barriers to fish migration: Sousa et al. 2020). The loss of mussel–fish co-evolutionary relationships is a key threat to freshwater mussels (Aldridge et al. 2023). In this regard, recruitment and recovery of Lokeri in the Lower Lakes may be as much dependent on the fish community as it is on water quality, food availability and habitat (Walker 1981). For example, Haag and Warren (1998) found that in two drainage basins in Alabama, USA, variability in the fish community and the type of strategy used by mussels for infecting host fishes influenced the freshwater mussel community more than habitat. Understanding Lokeri-fish host relationships in the lower River Murray and Lower Lakes, under contemporary conditions and considering climate change, forms an important consideration for future research.

Despite the broad ecological, management and cultural importances of Lokeri, there are no studies known for the lower River Murray and Lower Lakes that examined mussel–fish host relationships (Figure 24). In the late 1970s, Walker (1981) conducted experiments to determine which fish species in the lower River Murray and Lower Lakes were hosts of mussel glochidia. The results showed that glochidia infest at least 15 species of fish including bony bream (*Nematalosa erebi*), golden perch (*Macquaria ambigua*) and congolli (*Pseudaphritis urvillii*), among others. Conversely, glochidia failed to infest common carp (*Cyprinus carpio*) and goldfish (*Carassius auratus*), possibly due to a chemical agent in the mucous coating of the cyprinids that inhibits attachment (Walker 1981), and this finding is supported elsewhere (Walker 1981; Klunzinger et al. 2012; Jones 2013; Moore & Clearwater 2021). The obligate life cycle requirement of Lokeri for fish hosts is perhaps one of the most important areas requiring study in the Lower Lakes, especially given the manageable influences of river flows and lake water levels on fish populations. In this regard, it would be important to understand links between river management and the Lokeri-fish relationships.

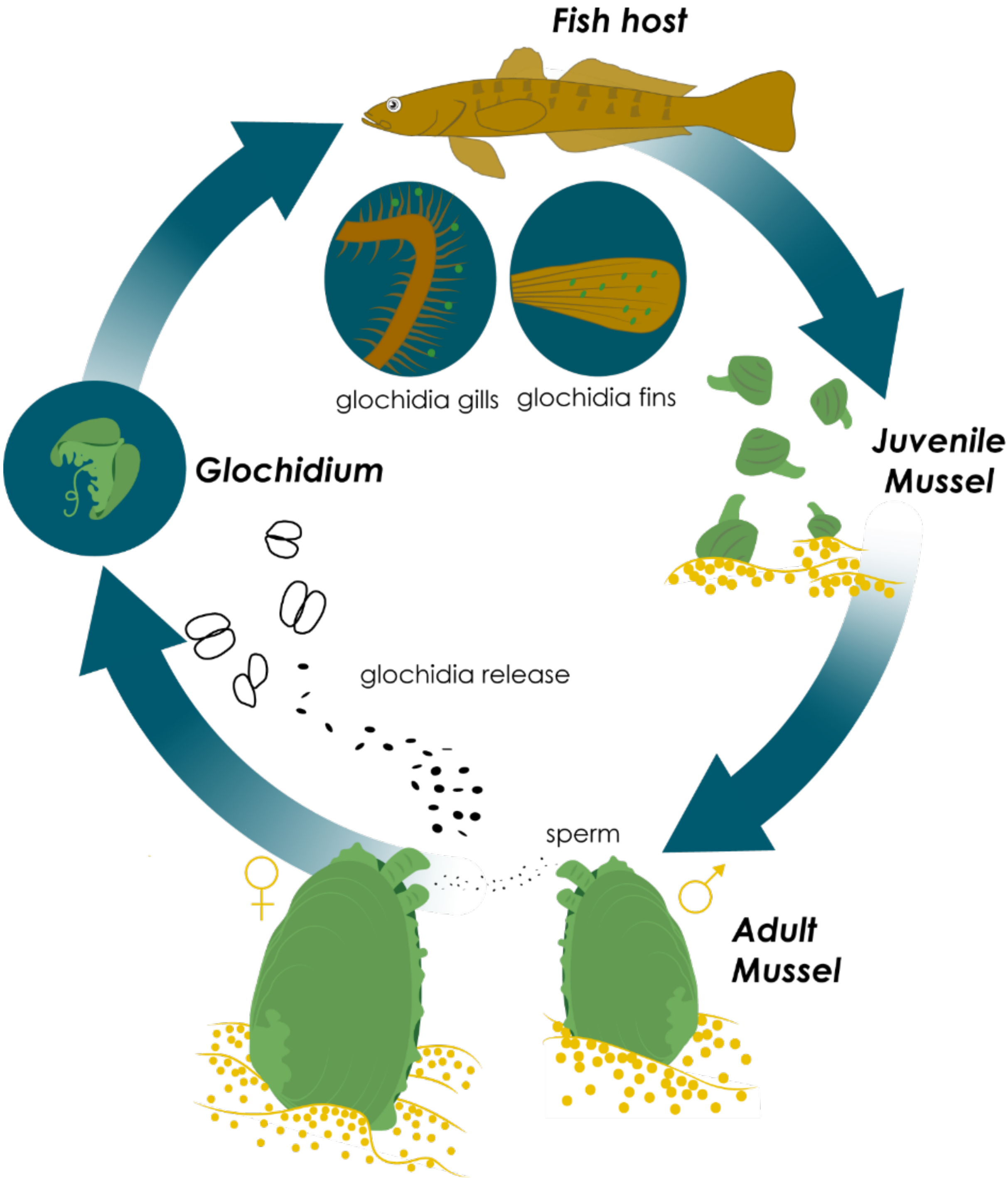

Figure 24. Life cycle of Lokeri (picture adapted from Modesto et al. 2018).

5.3.4 River flows and Lokeri population

Consequences of the latter stages of the Millennium Drought undoubtedly led to the depletion of Lokeri in the Lower Lakes. Similarly, drought-induced changes in flow regimes may lead to long-term losses in mussel-provided ecosystem services (Vaughn et al. 2015). Similarly, low and cease-to-flow conditions in the northern Murray-Darling Basin from 2017 to 2019 led to significant and widespread loss of mussel populations (Hobbs et al. 2025). Unlike most other freshwater mussels, *V. ambiguus* can form a very tight seal which enables it to survive periods (<12 months) of hypoxia and habitat drying (Walker 1981; Sheldon & Walker 1989). This suggests Lokeri can tolerate short periods of low food resources, high water temperatures and drying, but the physiological tolerances of the species is untested in the lower River Murray and Lower Lakes.

The response of Lokeri to the water management and infrastructure operation in the River Murray and Lower Lakes is unknown. Ćmiel et al. (2020) found, for example, that the five species of freshwater mussels in a Polish lake varied in their responses to changes in flow velocity. In the River Murray, Walker (2016) found gonadal cycles in populations of *V. ambiguus* were influenced by variations in river discharge. The management of water levels in Lake Alexandrina and Lake Albert is a tool that may be used to enhance populations of Lokeri and other species. The intra- and inter-annual variations in lake water levels may influence Lokeri populations. For example, Gołąb et al. (2010) showed falling water level influenced the survival, distribution and abundance of freshwater mussels in a Polish reservoir. Locally, Walker (2016) found the irregular gonadal cycles of *V. ambiguus* at Point Sturt were influenced by variable water levels of Lake Alexandrina between 1982 and 1986. Understanding the responses of Lokeri to water management in the Lower Lakes, by examining growth, reproduction and recruitment, forms an important avenue for future research to aid in the conservation and management of Lokeri in the region.

5.4 Ngarrindjeri culture by Kyla McHughes

Lokerar are an important part of Ngarrindjeri Ruwi (Country). They have been gathered and used by our people for thousands of years, with evidence held in middens across our Country. Lokerar clean our waters, have provided food and materials for tools, ornaments, fibre work, and cultural practice. Its presence in the lakes and waters reflects a long-standing relationship between Ngarrindjeri people and Yarluwar-Ruwi (Sea-Country).

Our knowledge of Lokeri comes from ongoing relationship with Country. This includes understanding where Lokeri live, how they move, when they are dormant, when they are in abundance, and how they respond to changes in water, flow, and season. This knowledge is held within our community and continues to guide how research and work should be carried out on our Ruwi.

The decline of Lokeri during the Millennium Drought reduced both its presence in the river and lakes, and our ability to continue cultural practices connected to it. This was felt across our Ruwi. This project supports the connection and continuation of these cultural practices and strengthens our connection to Country. This project created opportunities for our people to come together on Country through yarning circles and fieldwork. Community members entered the water, searched for Lokerar and shared knowledge across generations. This work supported both the collection of information and the continuation of cultural practice. Many not having been in the water for years and feeling connected to the water again after being disconnected for so long. Many reporting how their mi:wi (spirit) felt happy again.

This project reflects the importance of Ngarrindjeri involvement in research on Country. Cultural knowledge guided how this work was undertaken, and community participation ensured it remained grounded in our priorities.

Looking forward, the recovery of Lokerar is part of our responsibility to care for Ruwi. Ongoing work must continue to support Ngarrindjeri leadership in how research is designed, carried out, and applied.

5.5 First Nations perspective by Malcolm Connolly

The near-absence of Lokeri from the Lower Lakes represents not only an ecological impoverishment but a profound cultural one. For Ngarrindjeri people, Lokeri is inseparable from the fabric of Yarluwar-Ruwe (Sea Country) and the relational responsibilities they hold to their waters, their Country, and each other. The findings of this survey must therefore be understood in both registers simultaneously: as evidence of an aquatic population in the early stages of recovery, and as a measure of the extent to which a culturally significant species remains absent from Country. This loss was not merely the disappearance of a food source but a rupture in the relational fabric of Country: a species that carried knowledge, that sustained people, and that connected generations was no longer present on Country in any functional sense. The community response that initiated this project, the expressed desire to know whether Lokeri had returned, reflects precisely this kind of sustained cultural attentiveness to Country (cf. Rose 1996).

The engagement of Ngarrindjeri community members as employed participants in the field survey, rather than as passive subjects of research or consultation, reflects a collaborative model consistent with Indigenous-led approaches to Country monitoring (Ens et al. 2016; Danielsen et al. 2014). This model has parallels with structured Indigenous Ranger and Caring for Country programs operating across Australia, in which First Nations peoples are positioned as land and water managers exercising their own knowledge and custodial responsibilities, rather than as participants in externally designed monitoring regimes (Ens et al. 2016; Weir et al. 2011). In the Murray-Darling Basin context specifically, programs such as FlowMER, which integrates First Nations knowledge and engagement into environmental water monitoring, demonstrate that culturally grounded participation strengthens both the scientific quality and the community relevance of long-term monitoring outcomes.

The Lokeri project's employment of Ngarrindjeri community members through Ngarrindjeri Aboriginal Corporation, and its use of yarning circles as genuine sites of knowledge exchange rather than tick-box consultation, reflects this orientation. The presence of Ngarrindjeri participants alongside scientists from Adelaide University, CSIRO, and the CLLMM Research Centre in the December 2024 field survey is itself a methodological statement: that monitoring Lokeri on Country is most meaningfully conducted with, by, and in ongoing relationship with First Nations people (Figure 25).

Any future monitoring program for Lokeri in the Lower Lakes should formally incorporate Ngarrindjeri cultural indicators alongside ecological metrics. This could include assessments of the species' availability for cultural harvest at meaningful scale, the intergenerational transmission of collection knowledge and practice, and community-defined measures of Country health as expressed through the presence and abundance of Lokeri. The recovery of Lokeri to culturally meaningful levels, sufficient to sustain harvest, ceremony, and the teaching of knowledge to younger generations, represents a benchmark of restoration that ecological density measures alone cannot adequately express.

Figure 25. Participants in the December 2024 Lokeri survey from Adelaide University, Ngarrindjeri Aboriginal Corporation, CSIRO and the River, Lakes and Coorong Action Group included Scotte Wedderburn, Cyril Karpany, Laura Markham, Nathan Hartman, Kirsten Hartman, Julie Jones and Grant Gibson (left to right).

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