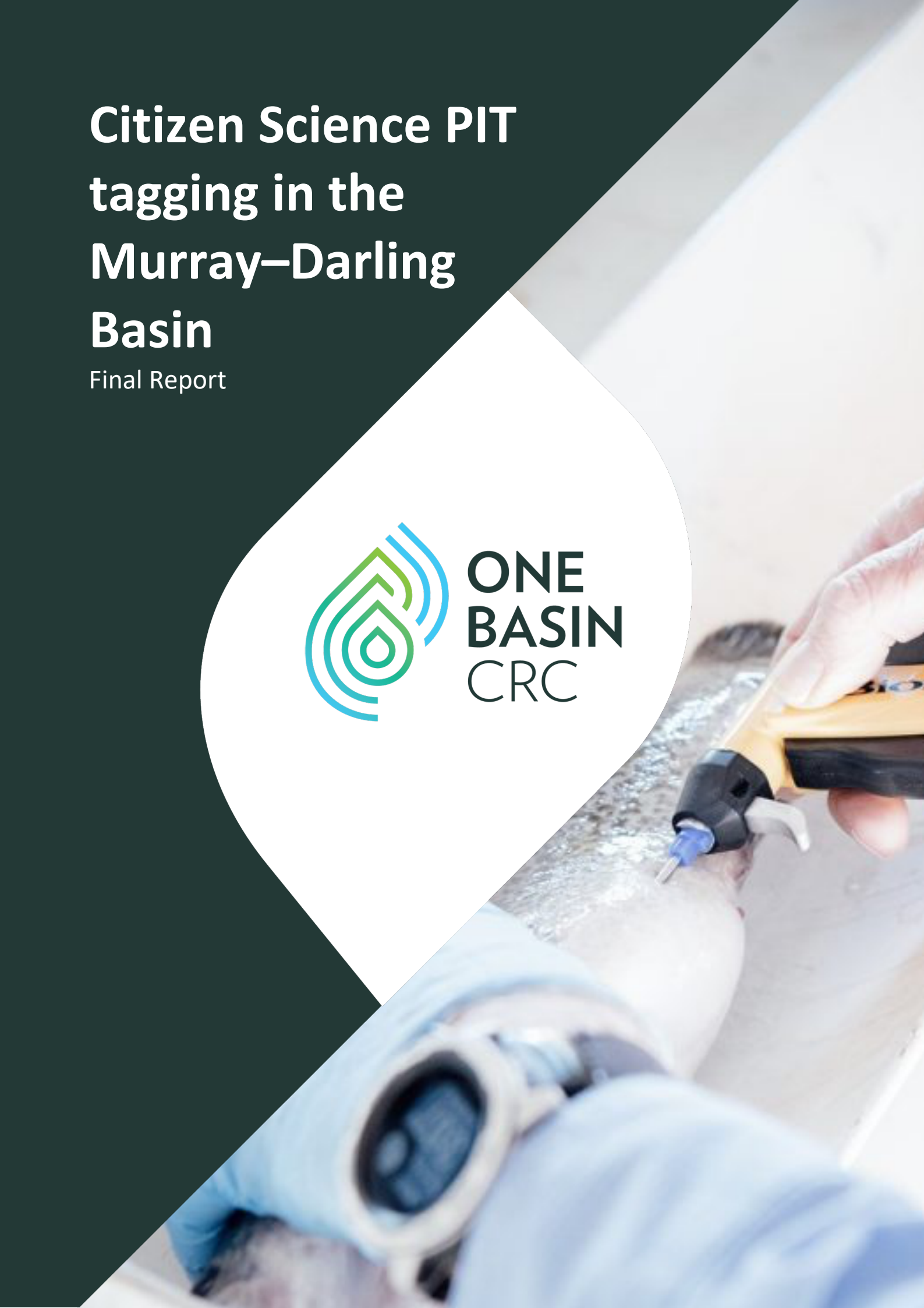
Citizen Science PIT tagging in the Murray–Darling Basin

Final Report

ONE BASIN CRC



Charles Sturt University

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Inland Fisheries Research Group

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Disclaimer

Executive Summary

This report presents the outcomes of a pilot citizen science initiative designed to assess the feasibility and value of involving community members, particularly recreational anglers and First Nations groups, in Passive Integrated Transponder (PIT) fish tagging across the Murray–Darling Basin (MDB).

The project had four specific objectives;

1. Establish a collaborative project framework by defining roles and responsibilities among key partners, including research institutions, community organisations, and technical providers.
2. Identify and engage targeted community groups to co-design and participate in training workshops that introduce fish tagging techniques and ecological monitoring.
3. Develop and deliver structured pilot community workshops to test training methods for ethical and accurate PIT tagging and data collection and assess volunteer participation.
4. Identify key benefits and challenges of involving citizen scientists in PIT tagging and evaluate the pilot program's outcomes and scalability.

Three structured training workshops were conducted in Deniliquin, Mildura, and Swan Hill. These sessions demonstrated strong community interest and engagement in river management activities and scientific research with collaboration across partner organisations CSU, OzFish and Karltek. Workshop participants successfully practiced PIT tagging techniques, with tagging accuracy exceeding 85% on first attempts and improving over time.

Community interest in fisheries research within the Murray–Darling Basin (MDB) was strong, with workshops showing that structured training, local engagement, and visible outcomes can enable meaningful citizen science participation. A key outcome was recognising that community members are important local knowledge holders, capable of identifying region-specific fisheries and river issues suitable for citizen-led research. Effective engagement should begin by listening to community priorities and working collaboratively with scientists to co-design solutions. While PIT tagging may interest some communities, it must be balanced against other locally identified priorities such as water quality monitoring, fish habitat restoration, and invasive species management. Establishing partnerships, both within project teams (e.g., OzFish, CSU, Karltek) and with communities, was a strength of this initiative and could be built upon to generate locally relevant research ideas.

Citizen science may strengthen PIT tagging activities in the MDB by expanding data coverage (through more tagged fish) and integrating local knowledge. Long-term success depends on addressing sustained participation, training and overcoming regulatory permitting challenges, while broader rollout across the MDB will require co-ordination, consistent funding, operational PIT infrastructure and consistent government support. CSU is developing a scientific paper using a mathematical model to evaluate tagging scenarios, incorporating angler interest, tagging accuracy, workshop outcomes, and environmental insights from existing government and research-led projects to guide future efforts.

Table of Contents

List of Tables

List of Figures

Introduction

The Role of Citizen Science in Scientific Research Projects

Citizen science, broadly defined as 'the active participation of the public in scientific research projects,' is becoming an increasingly valuable tool in environmental research (Bonney et al. 2016, Pateman et al. 2021). By engaging non-professional volunteers such as recreational fishers, local community members, and Indigenous groups, scientists can enhance data collection efforts in both scope and frequency (Conrad and Hilchey 2011, Thompson et al. 2020).

In fisheries-related research, citizen science enables real-time, site-specific data collection that may otherwise be logistically or financially challenging for research teams alone (Gundelund et al. 2020, DiBattista et al. 2021, Wallace and Bargeron 2022, Kiruba-Sankar and Barman 2024). Participants in citizen science projects can contribute to monitoring efforts using digital tools such as smartphone apps, online submission forms, and social media platforms, facilitating regular and up-to-date reporting of fish sightings, captures, tagging data, and environmental observations (Venturelli et al. 2017, Long et al. 2019, Wallace and Bargeron 2022). These contributions are especially effective in covering large spatial and temporal scales, offering a continuous stream of data that could support long-term or large-scale ecosystem monitoring.

By engaging the public to take part in scientific activities, citizen science may strengthen the connection between communities and their local environments, while also producing datasets that inform conservation, policy, and resource management decisions. As locals, community members also bring unique insights and observations about their environment, which can be captured and incorporated into these projects.

Citizen Science in the MDB

The Murray-Darling Basin (MDB, the Basin), Australia's largest and most complex river system, sustains more than 40 First Nations groups, regional communities, and countless recreational anglers. People have a special connection to the MDB and it's river systems, and these connections are often through the fish that inhabit the waters (Sinclair 2004, Humphries 2007, Frawley et al. 2012, Sinclair 2013, Koehn 2015). This connection is especially strong among First Nations groups, recreational anglers, and regional towns, where rivers hold ecological, historical, and cultural significance.

Traditionally, scientific research and management decisions in the MDB have been led by government agencies and professional scientists (Koehn 2004, Nicol et al. 2004, Lintermans et al. 2014, Forbes et al. 2015). However, the MDB continues to face significant environmental challenges, including altered river flows, habitat fragmentation, declining native fish populations, the impacts of invasive species such as carp (*Cyprinus carpio*) and ongoing concerns over water quality and management (Wallis et al. 2009, Lintermans et al. 2014, Hart 2016, Colloff and Pittock 2019, Lintermans et al. 2020). These issues have sparked growing interest from local communities who wish to play a more active role in river stewardship. This shift has led to the emergence of citizen science as a promising approach for engaging local communities in monitoring and stewardship efforts. By involving the public in data collection and ecological research, citizen science may enhance scientific understanding and community connection to the MDB native fish and waterways.

Citizen Science in PIT Tagging

The construction of barriers such as weirs and dams to support irrigated agriculture has made the MDB one of the most regulated river systems in the world (Nilsson et al. 2005, Lynch et al. 2019). These structures, while essential for water storage and distribution, significantly disrupt the natural movement of native fish species, contributing to their population decline. In New South Wales alone, there are 1,769 barriers in the inland catchments, with only a small portion of these structures equipped with fishways that aid fish passage (Figure 1). Early efforts to mitigate the negative impacts of barriers included the construction of 44 fishways between 1913 and 1985; however, most were ineffective (Thorncraft and Harris 2000). An additional 26 fishways have been built since 1985, aiming to better support native fish migration. Ongoing effective monitoring remains crucial of these barriers and fishways to understand fish movements and populations in the MDB (Barrett and Mallen-Cooper 2006, Silva et al. 2018).

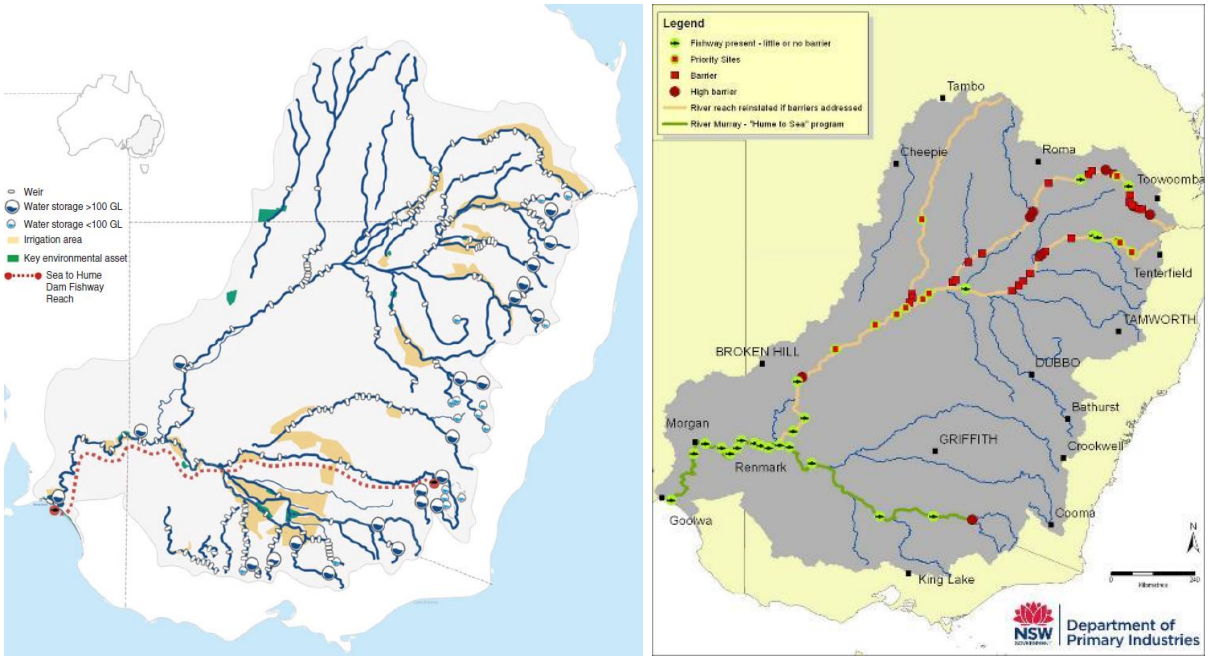


Figure 1. Left: Irrigation water allocation areas in the MDB and Right: barriers to fish movement and fishways installed (green fish icon). Source: MDBA modified and presented in Lynch et al., (2019) and Barrett and Mallen-Cooper (2006).

To evaluate fishway efficiency, track fish movement and estimate fish populations, the Australian government has implemented a network of Passive Integrated Transponder (PIT) tag detection systems at approximately 70 sites across the MDB (Barrett and Mallen-Cooper 2006). This infrastructure, covering over 1,300 km of the Murray River and its tributaries, enables researchers to monitor species such as Murray cod (*Maccullochella peelii*), golden perch (*Macquaria ambigua*), and silver perch (*Bidyanus bidyanus*). Data collected is stored in a centralised database managed by KarlTek and overseen by the Murray-Darling Basin Authority.

While PIT tagging offers a cost-effective, long-term method of tracking individual fish and collecting automated data, the effectiveness of this system depends on maintaining a sufficient number of tagged individuals, as natural mortality and tag shedding reduce detection rates over time. As such, there is now an opportunity to assess whether trained community groups (citizen scientists) can assist in replenishing the tagged fish population, thereby supporting ongoing research and contributing to improved river- and fishway management and decision making processes.

Project Objectives

This project aims to evaluate the feasibility of engaging citizen scientists, in particular recreational anglers, local community members and First Nations groups, in PIT tagging as a method to enhance scientific knowledge and community involvement in fish recovery efforts across the Murray-Darling Basin. We will do this by addressing the following specific objectives;

5. Establish a collaborative project framework by defining roles and responsibilities among key partners, including research institutions, community organisations, and technical providers.
6. Identify and engage targeted community groups to co-design and participate in training workshops that introduce fish tagging techniques and ecological monitoring.
7. Develop and deliver structured pilot community workshops to test training methods for ethical and accurate PIT tagging and data collection and assess volunteer participation.
8. Identify key benefits and challenges of involving citizen scientists in PIT tagging and evaluate the pilot program's outcomes and scalability.

Objective 1: Establish a collaborative project framework by defining roles and responsibilities among key partners, including research institutions, community organisations, and technical providers.

During the inception phase of the project, a project team was established comprising of Charles Sturt University's (CSU) Aquatic Team, technical provider KarlTek Pty Ltd, and the national not-for-profit organisation OzFish Unlimited (Figure 2).

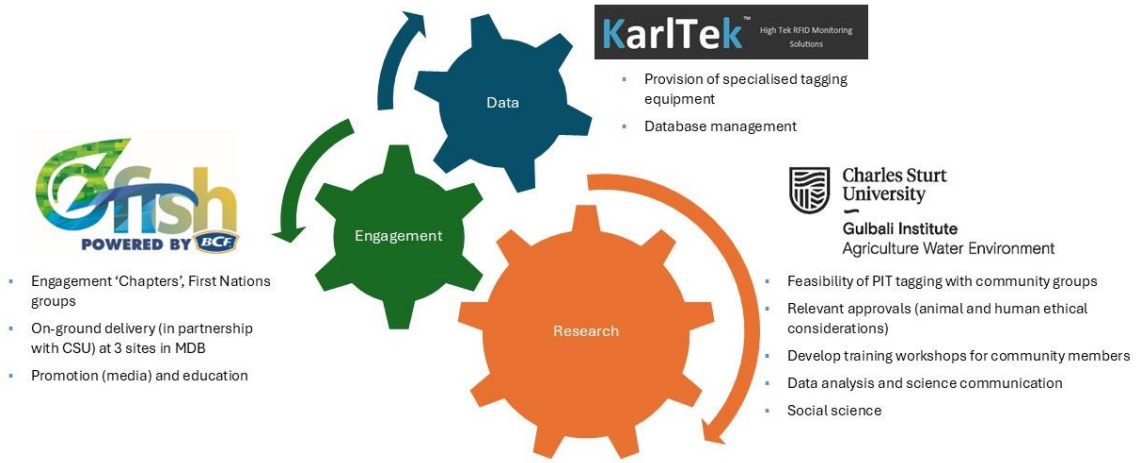


Figure 2. Summary of the roles and responsibilities of the project partners, including Charles Sturt University, OzFish and Karltek. Funding was provided by the OneBasin CRC to facilitate the research.

CSU led the academic and research components, drawing on prior experience delivering fish tagging training in the Lower Mekong Basin (Figure 3). This course was adapted to suit the MDB context, and with training materials developed to meet animal and human ethics standards. The training covered fish identification, anatomy, handling, tagging procedures, and riverine ecology. CSU staff attending the workshops were trained in these procedures and led the development of protocols and data analysis of the workshop outcomes.

Figure 3. PIT tagging training video, tagging flow chart and manual developed by Charles Sturt University for the Lower Mekong region (Weatherman et al., 2021).

KarlTek Pty Ltd, the technical partner, specialises in RFID technologies and PIT tagging systems. KarlTek provided specialised tagging equipment such as PIT tags and applicators, handheld readers and a stationary array for training purposes. Their contribution also included technical training and guidance for the community groups involved in PIT tagging and fishway monitoring.

OzFish brought experience in community engagement and river restoration activities. For this project, OzFish co-ordinated outreach activities, engaged recreational anglers and First Nations groups, and supported the co-design of locally relevant workshops. OzFish were also trained in the tagging procedures and provided tagging training at the workshops.

Objective 2: Identify and engage targeted community groups to co-design and participate in training workshops that introduce fish tagging techniques and ecological monitoring.

Which method of tagging?

Prior to the delivery of the workshops, a review of the four main fish tagging techniques, dart/spaghetti tags, PIT tags, acoustic tags, and radio-tracking tags, was conducted to assess their applications, advantages, and limitations to identify the most suitable method for the project (Table 1).

Based on the review of tagging methods summarised in Table 1, PIT tags were chosen as the preferred method for citizen science fish tagging due to:

- Their range of sizes (8 – 23mm) which allows for a range of different species to be tagged;
- Each fish is embedded with a unique 10- to 15-digit alphanumeric identification code, allowing for individual fish identification;
- Affordability;
- Ease of insertion with the appropriate training and specialised equipment;
- Long-term reliability, as they require no batteries and can last indefinitely;
- Minimal impact on fish, due to their small size and the use of light anaesthetic and a needle gun for implantation;
- Existing infrastructure, with antenna arrays already installed across parts of the Murray-Darling Basin, enabling automated data collection.

Table 1. Summary of fisheries tagging technologies including their cost, data, advantages and limitations.

Tag type	Description and implanting method	Cost	Data provided	Best for	Detection method	Advantages	Limitations
Dart/Spaghetti Tags	External plastic tags inserted into the fish's muscle near the dorsal fin using a tagging gun or needle. They typically display an alphanumeric code and contact information.	Low	Basic identification upon recapture.	Mark-recapture studies, especially involving public participation. Basic population studies, growth tracking, and angler-based recapture programs.	Requires physical recapture and manual reading of the tag.	Inexpensive and easy to apply. Useful for large-scale mark-recapture studies. Tags can be read without specialised equipment.	Rely on physical recapture or public reporting, leading to low recovery rates. Tags can be lost or cause minor injury. No real-time or remote tracking capability.
Passive Integrated Transponder (PIT) Tags	Small (usually 8–23 mm) internal microchips implanted under the skin or in the body cavity. Fish may need to be anaesthetised.	Moderate	Unique ID at detection points.	Long-term monitoring of individual fish movements through key locations (e.g., fish passages / ladders).	They emit a unique identification code when scanned. Detected by handheld scanners or stationary antenna arrays.	Each tag has a unique code for individual identification. Tags are permanent and require no battery. Can be read automatically by fixed antennas (e.g., at fishways or dams).	Require proximity to scanning equipment or fixed readers. Surgical implantation requires training and ethical clearance. No movement data between detection points.
Acoustic Tags	Battery-powered transmitters emitting sound pulses, implanted internally via surgery. Fish must be anaesthetised.	High	Detailed movement paths and habitat use.	Studying movement ecology in large water bodies. Detailed movement studies, behaviour research, and habitat use mapping.	Emit sound pulses (pings) that are detected by underwater hydrophones (receivers). Underwater hydrophones detect the acoustic signals.	Enable real-time or logged tracking of fish movements. Can be used to map movement paths and habitat use. Suitable for both freshwater and marine environments.	More expensive per tag and requires receiver infrastructure. Limited battery life (months to years, depending on tag size and ping rate). Larger tag size may restrict use to bigger fish.
Radio-Tracking Tags	Similar to acoustic tags but emit radio signals instead of sound. Surgically implanted. Fish must be anaesthetised.	Moderate to High	Real-time positioning data.	Tracking fish in freshwater systems where acoustic signals may be less effective and when active monitoring is feasible.	Detected using handheld or stationary radio receivers pick up the signals.	Effective in shallow or turbid freshwater systems where acoustic signal transmission may be hindered. Portable tracking with handheld antenna and receiver.	Signals don't transmit well in saltwater. Detection range and data resolution can be lower than acoustic tags. Require labour-intensive, real-time tracking.

PIT tagging and antenna systems

PIT tags can be inserted in different parts of a fish's body (gut cavity, cheek, shoulder, chest), with the gut cavity being the most used location. The PIT tag can be detected via a portable reader (Figure 4) or antenna array. In the wild, tagged fish are detected by antenna arrays installed in natural waterways, such as rivers and fishways, to monitor fish movements. When a tagged fish passes through an antenna system, the PIT tag is detected, and its data is captured by the system. This data is then stored and can be transmitted remotely via a control unit to an online database.

Figure 4. Examples of the training materials and equipment provided during the citizen science workshops including a beginners guide to PIT tagging (top left, Source: FishBIO (https://fishbio.com/beginners-guide-pit-tags/), approximate location of a PIT tag inserted into the gut cavity (intraperitoneal cavity) of a Murray cod and gun applicator with PIT tags (a) and a handheld reader (b).

How can citizen scientists support PIT tagging research?

Citizen scientists may support or participate in PIT tagging research activities through various roles, either by contributing to the entire process or by engaging in selected activities, including:

1. Fish capture and handling: Assisting with angling for fish, netting, trapping and electrofishing under supervision.
2. Tag insertion: Physically anaesthetising and tagging fish.
3. Data recording: Logging physical measurements and environmental data.
4. Tag scanning: Operating stationary or portable PIT tag readers.
5. Outreach: Helping educate local communities and schools about native fish and conservation.

Community engagement for training workshops

Once the project team established the tagging method and identified ways citizen scientists could contribute to PIT tagging activities, we designed workshops to explore the delivery of several key components of the process. Part 1 (fish capture) was trialled in Deniliquin through an afternoon fishing session to assess catch rates; Part 2 focused on tag insertion and accuracy; Part 3 involved data recording; Part 4 covered tag scanning; and Part 5 examined opportunities for community outreach and engagement.

Community members were engaged in the project through a combination of existing trusted community partnerships and new outreach initiatives to enhance engagement as follows;

- Charles Sturt University leveraged long-standing collaborations with the Edward Wakool Anglers Association and the Joint Indigenous Group, which had previously worked together on river management activities.
- OzFish mobilised its regional ‘Chapters’ to reach out to recreational angling communities in Swan Hill and Mildura. An Expressions of Interest (EOI) process was develop and used to specifically identify individuals most likely to attend the workshop, demonstrate genuine interest in research, and commitment to the objectives of the citizen science tagging program (Figure 5).

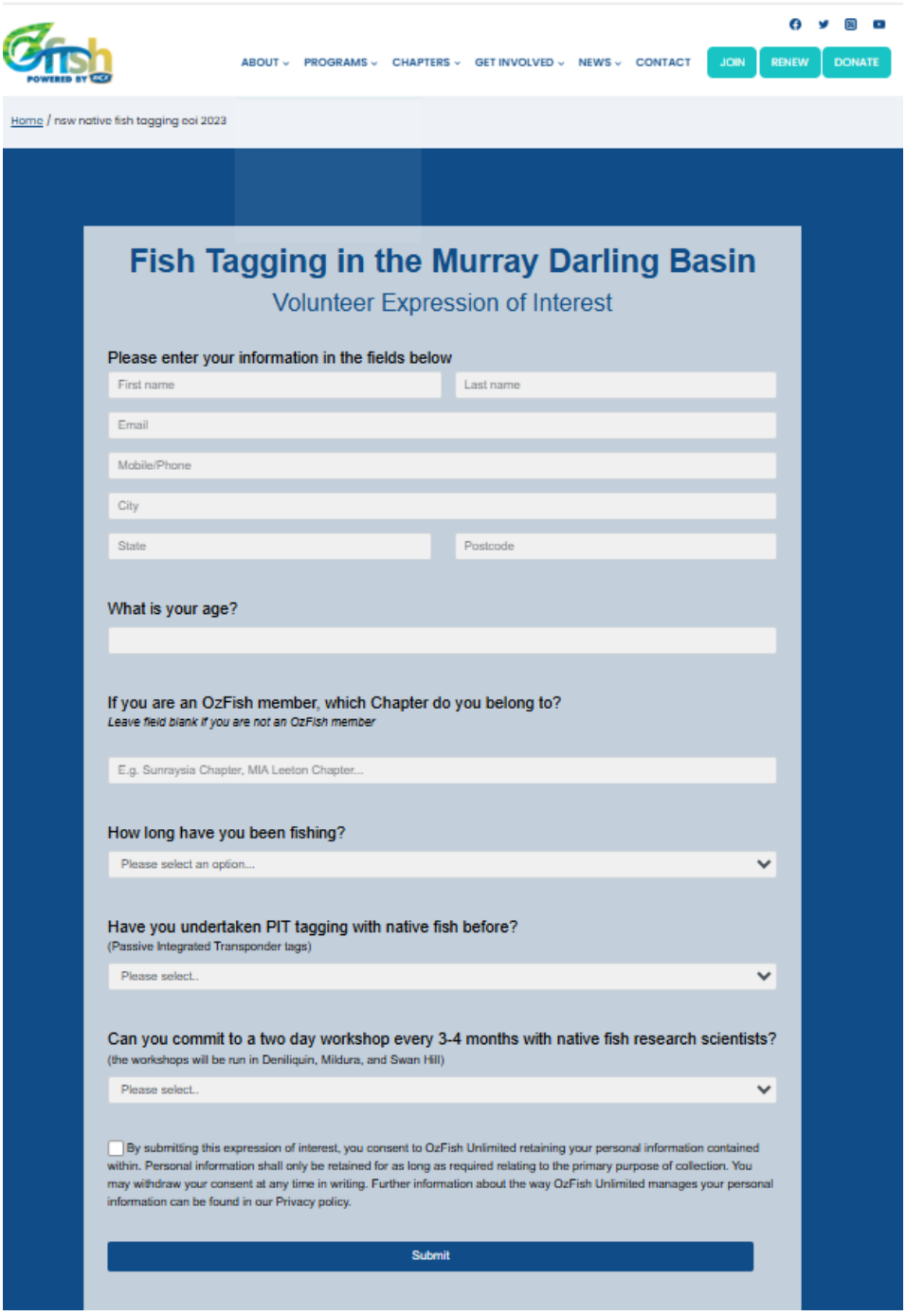


Figure 5. EOI process developed by OzFish to engage and select potential workshop participants. (Source: https://ozfish.org.au/nsw-native-fish-tagging-eoi-2023/).

Objective 3: Develop and deliver structured pilot community workshops to test training methods for ethical and accurate PIT tagging and data collection and assess volunteer participation.

Prior to delivering the workshops, several key activities were undertaken to ensure effective planning, compliance, and readiness:

Planning Meetings and Staff Training

- Regular planning meetings were held between CSU, OzFish, and KarlTek to co-ordinate workshop logistics, prepare media releases, and provide training for workshop delivery staff. Using existing training materials developed by CSU (Weatherman et al., 2021), pre-workshop training sessions were conducted by experienced CSU staff to ensure consistent, accurate, and ethically sound delivery of the citizen science PIT tagging program.

Permitting Process

- To enable workshop delivery, Charles Sturt University arranged all necessary ethical (animal and human) and fisheries approvals. This included obtaining animal and human ethics clearance through CSU's ethics committees under the Australian Animal Ethics Code of Practice, as well as securing New South Wales and Victorian fisheries permits to temporarily authorise workshop activities and participant involvement.

Fish Species Selection

- Murray cod were selected by the project team as the test species for several reasons: (1) they were readily available from fish farms, preventing any impact on wild fish populations; (2) their soft skin and large body cavity made PIT tag insertion easier for training purposes; and (3) they are an iconic species across the MDB, resonating with participants due to their recreational and cultural significance.

PIT tagging training workshops

Three workshops (Figure 6) were successfully delivered in Deniliquin (November 2023, Figures 7 and 8), Mildura (April 2024, Figure 9), and Swan Hill (April 2024, Figure 10)(Table 2).

Figure 6. Map showing the three workshop sites including Deniliquin (November 2023), Mildura (April 2024), and Swan Hill (April 2024).

Figure 7. Deniliquin Tagging Workshop (26 November 2023). Photo credits: K. Doyle and A. Vu.

Figure 8. Deniliquin Tagging Workshop (26 November 2023) showing the process of community outreach and demonstration of the aneasthetic and tagging process. Photo credits: K. Doyle and A. Vu.

Figure 9. Mildura Tagging Workshop (20 April 2024) and community forum (bottom left). Photo credits: Kate Read Photography and A. Vu.

Figure 10. Swan Hill Tagging Workshop (21 April 2024). Photo credit: A. Vu.

Table 2. Example schedule for the workshops, based on the first workshop held at Deniliquin.

8:30 – 10:30. CSU set up workshop area.
10:30 – Karltek arrives with tagging equipment
10:30 – CSU arrive with live fish
10:30 – 11. Registration / sign in sheet, check rec fishing licences
11am start
11-11:15: Deniliquin fish communities and Edward-Wakool River management presentation (CSU)
11:15-11:45: PIT systems in the MDB (Karltek demonstration)
11:45-1:30 PIT tagging fish (CSU, OzFish) • Fish handling • Anaesthetic • PIT tagging training
2:00 – Discussion with participants about what they want to see from river management and citizen science activities. Workshop wrapped up, lunch provided.
3-7pm – Launch boats and fishing on the river. Dinner with participants (optional).

Workshop PIT Tagging Training Procedure

The PIT tagging procedure was based on the original training procedures developed by CSU for the Lower Mekong (Weatherman et al. 2021), but tailored for the MDB workshops.

1. **Measuring the Fish**

Begin by measuring the fish's length. Explain to the group that this data helps estimate population structure (e.g. number of adults) and assess individual growth if the fish is recaptured later.

2. **Recording Biological Information**

Note key observations such as fish length, presence of lesions or ectoparasites, and eye condition (e.g. cloudy eyes may signal bacterial infection). This helps assess the fish's overall health and environmental stressors.

3. **Assigning Roles**

Assign participants to different tasks: scribe (data recorder), measurer, and PIT reader. Rotate roles so all participants gain experience.

4. **Tagging Demonstration and Practice**

CSU and OzFish staff will demonstrate correct PIT tagging procedures. Following the demonstration, participants will break into small groups to practice tagging using provided equipment and guidance.

5. **Reading PIT Tags**

Use handheld readers to scan, confirm and record each tag's unique code. Ensure it registers correctly before moving to the next step.

6. **Tag Placement Check (Optional)**

For training purposes, dissect a sample fish to assess the accuracy of tag placement. If placement is incorrect, participants may continue to practice tagging on additional fish under supervision.

Workshop Outputs

Approximately 20 participants attended the Deniliquin workshop, around 20 attended the tagging component in Mildura (with an additional 50 people participating in the evening community forum), and about 12 participants attended the Swan Hill event. These numbers are approximate, as not all attendees participated in tagging and some adults were present to supervise children. Not all participants that accepted the invitation attended on the day (Table 2).

Table 2. Number of participants accepting and number of participants attending.

Workshop location	Deniliquin	Swan Hill	Mildura
Accepted attendance	25	19	31
Actual attendance	~20	12	~20

Outreach and media

As part of the workshops, participants were also introduced to other scientific fisheries research methodologies currently underway at CSU. One example included education about the use of otoliths (small ear bones in fish) as tools for ageing, tracking movement, and distinguishing between wild and hatchery-raised fish (Figure 11). These discussions gave community members insight into advanced fish monitoring methods and their importance in conservation and fisheries management, while also demonstrating the outreach potential of research institutes to engage the public in current scientific initiatives.

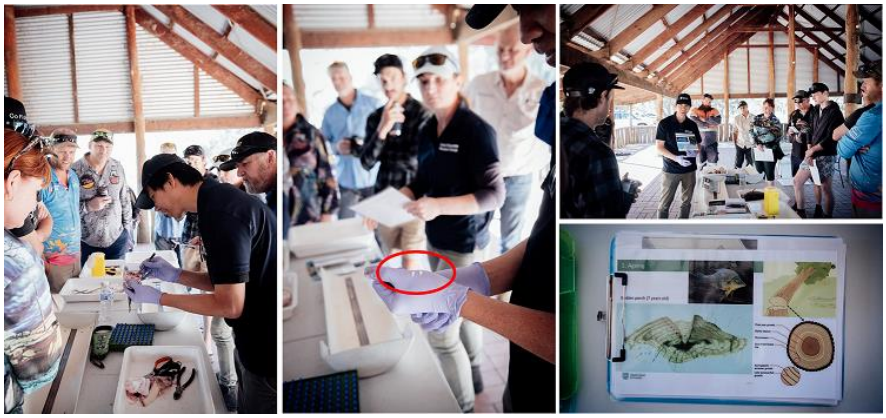


Figure 11. Introduction of otoliths to fish anglers. Removal of otoliths from a Murray cod (left image); a pair of otoliths (red circle, middle image); applications of otoliths in research (right image). Source: Kate Read Photography.

Participants expressed enthusiasm and a strong sense of contribution to fisheries research in the MDB and data collection activities. The workshops provided opportunities for community members to express what they wanted to see in future river management and citizen science activities. Each workshop highlighted local knowledge and community-specific challenges through open discussions with participants.

- At the Deniliquin workshop, key concerns included the function of the weir in facilitating fish passage (Steven's Weir), management and rescue of Murray crayfish (*Euastacus armatus*) during low dissolved oxygen events, recovery of catfish (*Tandanus tandanus*) populations, and water quality issues and monitoring.
- At the Mildura workshop, discussions focused on the role of the town weir (Mildura Weir), questions around who is conducting acoustic tagging in the area, concerns about the management of invasive species and in particular the potential release of the carp virus, and frustrations about community-generated dart tag data not being recognised or received by government agencies.
- In Swan Hill, participants discussed local river restoration efforts and the importance of inclusive events such as fishing competitions, especially those that engage children and families.

Numerous media releases were issued by CSU and OzFish throughout the duration of the project (Figure 12). Those related to the workshops aimed to encourage participation and generate interest from local community members in the native fish tagging initiative. Other releases, such as through the Australian Water School, provided opportunities to share the project and its outcomes with water professionals, broadening the visibility of the initiative across both community and industry sectors.

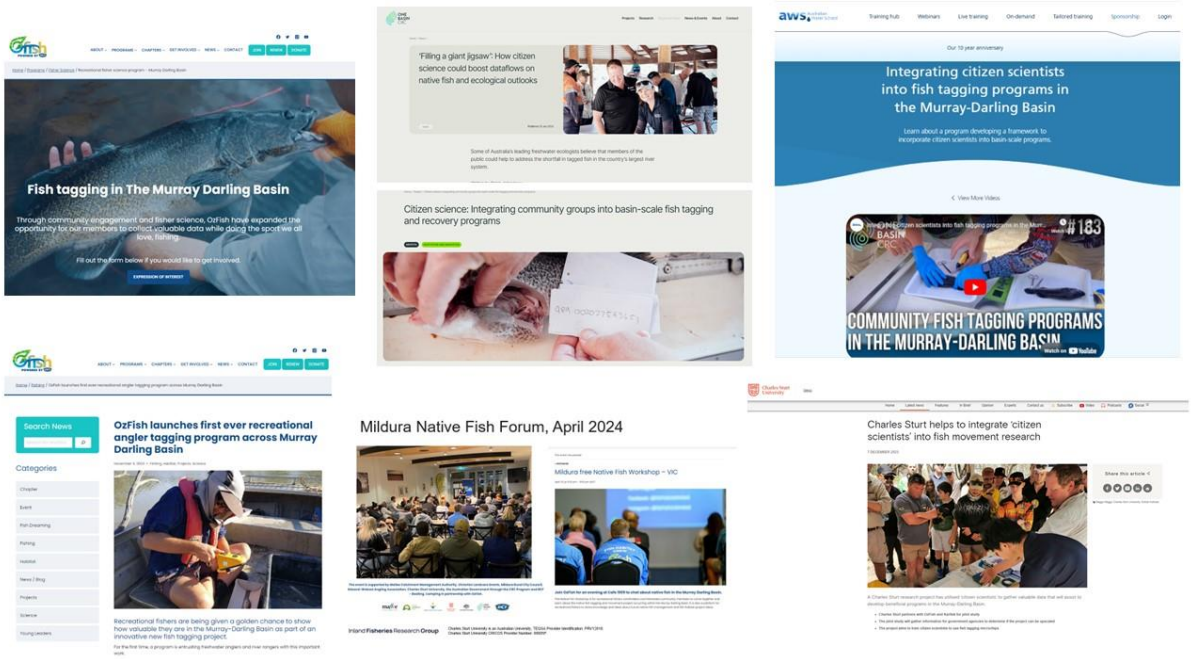


Figure 12. Examples of media releases throughout the project.

Media releases

https://awschool.com.au/training/community-fish-tagging/

https://onebasin.com.au/filling-a-giant-jigsaw-how-citizen-science-could-boost-dataflows-on-native-fish-and-ecological-outlooks/

https://onebasin.com.au/project/citizen-science-integrating-community-groups-into-basin-scale-fish-tagging-and-recovery-programs/

https://ozfish.org.au/2023/11/ozfish-launches-first-ever-recreational-angler-tagging-program-across-murray-darling-basin

https://ozfish.org.au/event/mildura-free-native-fish-workshop-vic-april-2024/

https://news.csu.edu.au/latest-news/charles-sturt-helps-to-integrate-citizen-scientists-into-fish-movement-research

https://ozfish.org.au/projects/recreational-fisher-science-program-murray-darling-basin-2023/

https://fishingworld.com.au/news/ozfish-launches-freshwater-tagging-program-across-murray-darling-basin/

https://www.sheppnews.com.au/community/anglers-hooked-on-fish-tagging/

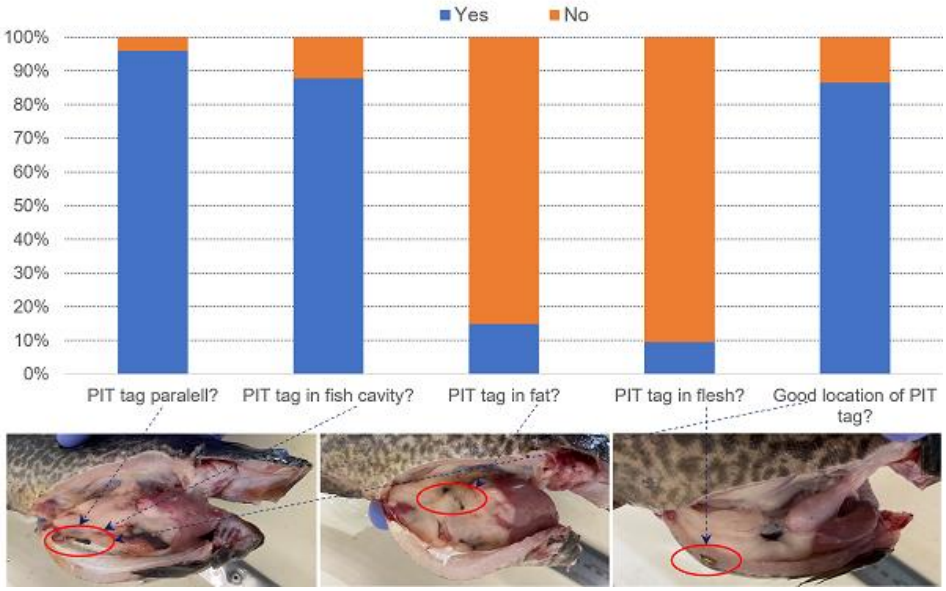
Two talk-back radio interviews were also delivered.

Tagging accuracy

Participants underwent hands-on training, including the use of anaesthetic and recovery tubs (Deniliquin only), tag placement, and equipment handling. These procedures were then reviewed by trained staff from CSU and OzFish. For a fish to be successfully tagged and to ensure it retains the tag (i.e. to avoid future tag-shedding), the PIT tag must be 1) aligned parallel with the fish's dorsal and anal fin, and 2) fully inserted into the body cavity, and not in the flesh or into organs. To assess this, dead fish were tagged and then the participants dissected their fish to find the tag and record tagging location.

Tagging angle accuracy exceeded 95%, while first-attempt accuracy for correct tagging location within the fish was over 85%. Overall, more than 85% of tags were correctly placed on the first attempt (Figure 13a). A small proportion of tags (<5%) were incorrectly positioned in internal organs, which could pose risks to fish health indicating a need for further skill development (Figure 13b); however, subsequent attempts showed improved accuracy (Figure 13c). Notably, workshops in Mildura and Swan Hill demonstrated higher tagging precision (Figure 14), likely due to refinements in training materials and methods based on feedback from the Deniliquin workshop.

a)



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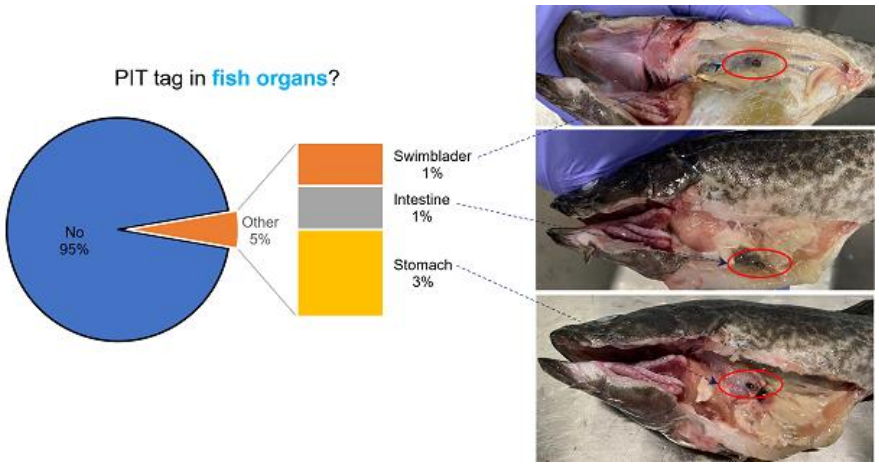

c)

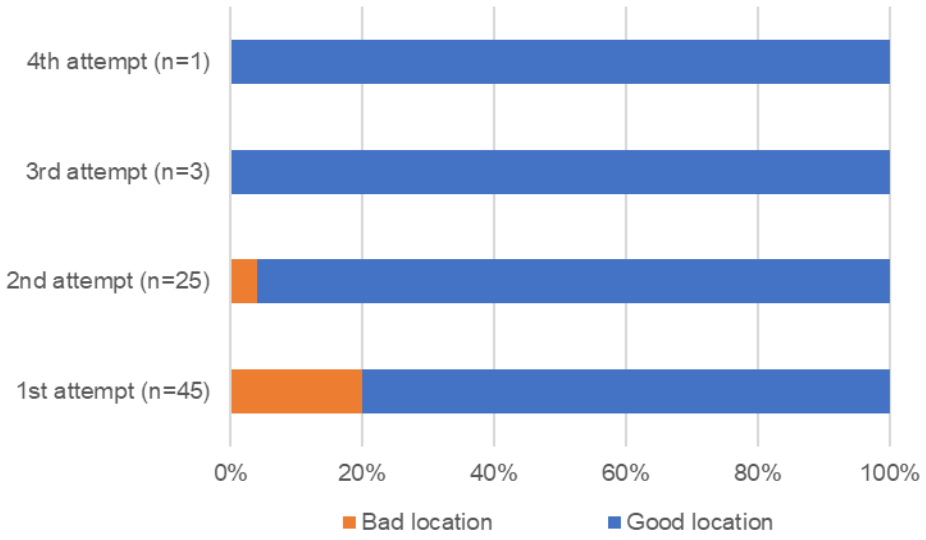

Figure 13. a) Location of the PIT tag in relation to tagging angle and part of fish's body, b) proportion of tags located in fish organs and c) number of participant attempts to achieve the correct placement (angle and location) of PIT tags.

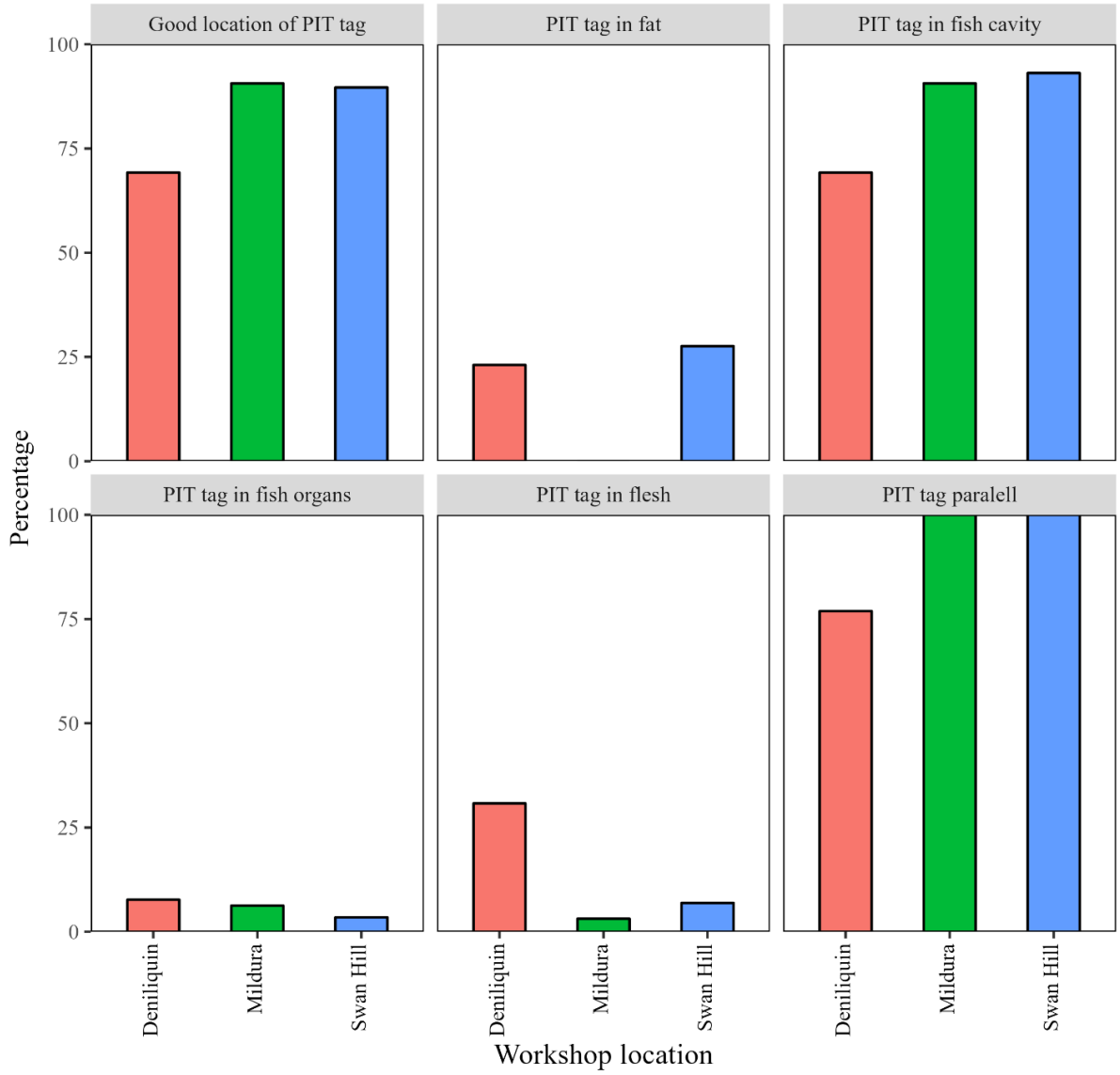

Figure 14: PIT tagging assessment across the three workshop locations. “Good location” means PIT tags were in the fish body cavity/fat, while “bad location” refers to PIT tags in the organs/flesh.

Objective 4: Identify key benefits and challenges of involving citizen scientists in PIT tagging and evaluate the pilot program's outcomes and scalability.

Benefits of Citizen Science Involvement in PIT tagging activities

- Overall, community interest in the citizen science tagging project was high, with active discussion and engagement about PIT tagging and broader MDB native fish topics. Farmed fish used during the workshops enabled large participant numbers, while local contacts and partnerships, a well-structured training format, and appropriate staffing were key to successful workshop delivery and training activities.
- Increased data collection: With the high interest from the community, more hands in the field could improve spatial and temporal data coverage of tagging projects.
- Local knowledge integration and enhanced stewardship: Community members provided valuable ecological insights of their local waterways, fishing activities and environmental concerns. Participation builds a sense of ownership and responsibility for local waterways.
- Cost efficiency: Having trained volunteers may reduce the reliance on professional field staff, particularly with travel costs to remote regional communities and locations.
- To upscale this type of project, it is necessary to identify a suitable organisation (potentially OzFish) to act as the regional coordinator or champion of citizen science planning. This organisation would be responsible for managing enquiries from fishers, uploading data into a central database, advising on equipment needs, and processing tag returns. To maintain trust within the community, this coordinating body should be a neutral and trusted advisor, separate from government or academia. The basin-wide lead organisation must be appropriately resourced to fulfil its leadership role, with support required at two levels: (a) day-to-day operations, including managing a hotline and website, responding to enquiries, maintaining equipment logs and databases, and liaising with research providers; and (b) ongoing field operations, such as working with fisher groups to implement tagging programs and co-designing these programs with clearly defined research questions. For broader scaling and outreach, international citizen science programs act as models, demonstrating how well-resourced, basin-scale initiatives can generate publishable data that informs river management decisions. These programs often feature large, coordinated tagging events, investment in community infrastructure (e.g. tagging trucks), integration of data with central

databases, AI-driven tag return systems, and the maintenance of basin-wide tagged fish populations accessible to researchers. Achieving this level of coordination and impact will require a dedicated lead agency, significant and sustained resourcing, and large-scale planning.

Challenges of Citizen Science Involvement in PIT tagging activities

- Cultural and community considerations: Meaningful inclusion of First Nations and local communities requires respectful, co-designed approaches that honour local and traditional knowledge as well as governance systems. As an example, at each workshop, participants showed strong interest in broader river management projects and issues specific to their local environment. While PIT tagging generated engagement, it was not always the community's highest priority compared to concerns such as poor water quality, invasive species management, fish habitat restoration, and improving recreational fishing opportunities.
- Participation rates were difficult to accurately predict across the workshop locations, as there was a significant difference between the number of accepted registrations via the EOI process and actual attendance. This creates challenges for planning and logistics, particularly given the need to prepare specialised equipment and pre-determine the number of fish required for tagging activities to be statistically and scientifically valid for research purposes.
- Training, supervision and data quality assurance: Volunteers require structured training and ongoing support to ensure data quality and animal welfare. Implementing clear protocols and data validation steps is essential and must be maintained continually. Training modules and certification pathways for citizen participants may be required.
- Animal ethics and permits: All activities must comply with animal ethics Codes of Practice and guidelines and State fisheries permit requirements for animal handling and fish capture. These approvals can be complex and time-consuming to obtain and manage, especially across multiple jurisdictions. Community groups may also have limited experience with these regulatory processes and ethical animal handling techniques.
- Safety: Proper safety procedures and insurance coverage are essential for all participants. Outdoor activities, including fishing, sun exposure, the use of needles or

sharp instruments, and working near water, were identified in risk assessments and require careful planning and management.

- Data management and sharing of PIT antenna data: Much of the currently available PIT data is owned by the Murray-Darling Basin Authority (MDBA). Ongoing negotiations would require establishing data sharing arrangements, including clarity on who will analyse the data and how data access, management, and reporting will be coordinated. These factors may also impact volunteer retention, as sustaining interest and participation can be challenging, especially if visible outcomes (e.g., tracking the movement of tagged fish) are difficult to address or absent.
- Government support: Representatives from the Victorian government (Victorian Fisheries Authority) showed strong support for citizen scientist involvement in recreational fisheries management activities and focusing on tagging activities in localised areas such as sites where recreational species are being relocated or stocked. This highlights potential opportunities for PIT tagging, though primarily at smaller, site-specific scales. In contrast, representatives from the New South Wales government (NSW DPIRD) reflected a more cautious approach to citizen science engagement and expressed limited support for the rolling out of the program Basin-wide. However, they advised CSU to mathematically model the scenarios testing and justifying the numbers of fish and participants required. Workshop feedback also revealed opportunities to improve communication and transparency between community members and government fisheries agencies. Some participants expressed concerns about the responsiveness of dart tagging programs, noting that contact numbers go unanswered, and noted that fisheries permit applications they submitted were often unsuccessful, with limited feedback provided. Additionally, there was a desire for clearer information about who is conducting government or research institution-led tagging activities, the purpose of the work, and where to access the results. Participants also identified a need for improved guidance on who to contact regarding PIT infrastructure and the operational status of local sites.
- Funding cycles for fisheries tagging programs must be maintained and sufficient to support ongoing activities. Securing long-term funding is critical for effective program coordination and the provision of technical support, particularly in relation to catching sufficient numbers of fish.

- Logistical Coordination: A large-scale program requires co-ordination across geographically dispersed regions. Ensuring consistent delivery of equipment, training, and support demands significant organisational resources.
- Technical constraints: Installing and maintaining PIT infrastructure (e.g., antennas and loggers) across the Basin can be costly and technically demanding, particularly in remote or flood-prone areas.

Conclusion and Future Directions

Community interest in fisheries research activities in the MDB was high, with workshops demonstrating that structured training, local engagement, and visible outcomes can facilitate meaningful citizen science participation. A key insight from these workshops is that community members are valuable local knowledge holders who can identify region-specific fisheries and river issues that could be addressed through citizen science. Effective engagement should begin by listening to local concerns and collaborating with scientists to co-develop solutions. While PIT tagging to understand fish movements, populations, and fishway performance may interest some communities, it must be balanced against other locally identified priorities such as water quality monitoring, fish habitat restoration, and invasive species management. Establishing partnerships, both within project teams (e.g., OzFish, CSU, Karltek) and with communities, was a strength of this initiative and could be built upon to generate locally relevant research ideas.

Citizen science may strengthen PIT tagging activities in the MDB by expanding data coverage (through more tagged fish) and integrating local knowledge. Long-term success depends on addressing sustained participation, training and overcoming regulatory permitting challenges, while broader rollout across the MDB will require co-ordination, consistent funding, operational PIT infrastructure and consistent government support. To inform this, a scientific paper is underway led by CSU, using a mathematical model to assess different tagging scenarios based on existing government and research-led tagging projects, incorporating variables such as angler interest, tagging accuracy and workshop outcomes, and the environmental insights and research activities these efforts aim to support.

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