Department of **Agriculture, Fisheries and Forestry**

Moores Creek Fishway Sampling Report

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Cover Figures: Moores Creek partial-width rock ramp fishway (Top). Bottom from left to right, juvenile sea mullet, assortment of fish species captured in the fishway trap, and barramundi.

Contents

Glossary of Terms

Diadromous - Diadromous fishes are truly migratory species whose distinctive characteristics include that they (i) migrate between freshwaters and the sea; (ii) the movement is usually obligatory; and (iii) migration takes place at fixed seasons or life stages. There are three distinctions within the diadromous category, catadromous, amphidromous and anadromous.

- Catadromous - Diadromous fishes which spend most of their lives in fresh water, and migrate to sea to breed.
- Amphidromous - Diadromous fishes in which migration between freshwater and the sea is not for the purpose of breeding, but occurs at some other stage of the life cycle.
- Anadromous - Diadromous fishes which spend most of their lives at sea, and migrate to freshwater to breed.

Potamodromous - fish species whose migrations occur wholly within freshwater for breeding and other purposes.

Executive Summary

Barriers to fish passage are detrimental to the sustainability of important commercial, recreational and indigenous fisheries where recruitment is reliant on migration between marine and fresh waters during a fish's lifecycle. Barriers preventing fish migration can lead to significant changes in fish communities above barriers, including a reduction in species diversity. The demise or total extinction of diadromous fish species above barriers, especially top order predators, can upset the balance of aquatic ecosystems, altering fish community assemblages and impacting aquatic species other than fish. Remediating barriers to fish passage through the construction of fishways is therefore a vitally important rehabilitation strategy essential for maintaining not only healthy fish communities, but the entire aquatic ecosystem.

In July 2012, a partial-width rock ramp fishway was constructed to remediate a pipe culvert causeway that was acting as a barrier to fish passage on the lower reaches of Moores Creek. The causeway, which is located on Charles Street in the centre of Rockhampton, consisted of a 1.1 m high barrier to fish passage. Significantly, the barrier was located on the freshwater/estuarine interface of Moores Creek, and therefore prevented the migration of diadromous and potamodromous fish species over most medium and low flows conditions. The construction of the fishway has now provided migrating fish species the opportunity to reach important upstream nursery and feeding areas over wide range of flow conditions. To evaluate the overall effectiveness of the fishway at passing fish, a limited amount of fishway sampling was undertaken between the 18th – 22nd of February 2013.

Fishway sampling results confirmed the fishway was successful at passing both juvenile and adult fish, including bottom and surface dwelling species. Significantly, the fishway was successful at facilitating passage of larval (long-finned eel), post larval (sea mullet) and juvenile *(barramundi)* life history stages. In total, 2040 individual fish representing 18 species at a total catch rate of 26.49 fish per hour were recorded from the Moores Creek rock ramp fishway. Sixteen of the 18 fish species recoded are endemic to the Fitzroy Basin, however, two exotic pest fish species; mosquitofish and guppy, were recorded in low abundance. Fish species between 19 and 500 mm successfully migrated through the fishway, with juvenile and small prey species making up the majority of the catch. Diadromous fish species comprised 28% of the total species catch and consisted of sea mullet, flat tail mullet, barramundi, empire gudgeon and long-finned eel.

The high diversity of species (18), including both surface and bottom dwelling fish and varied size classes that successfully migrated through the fishway indicates that under medium and low flow conditions the weir no longer is an impediment to fish passage.

The following points are recommendations for implementing improved natural resource management of our fisheries and associated aquatic ecosystems utilising collaborative partnerships.

- Continue to remediate priority barriers through-out the Fitzroy Basin Association (FBA) region.
- Undertake fishway sampling to evaluate the effectiveness of fishways at passing both juvenile and adult fish species.
- Emphasis should be placed on remediating barriers close to the estuarine interface. The success of the Moores Creek fishway in providing fish passage to critical upstream nursery and feeding habitats supports this initiative.

Introduction

Australia has just over 300 species of freshwater fishes (Allen *et al*. 2002), of which 18 have been recorded migrating through the Moores Creek partial-width rock ramp fishway. Just under a quarter (28%) of the fish species recorded successfully migrating through the fishway are diadromous, migrating between estuarine and freshwaters at some stage during their life cycle (Figure 1). The remaining species complete their entire life cycle in freshwater, with a large proportion of these undertaking significant migrations within freshwaters. Fish migration between marine and freshwater habitats and within freshwater habitats is therefore a vitally important aspect of the life cycle of freshwater fishes of the region.

Barriers preventing fish migration can lead to significant changes in fish communities above barriers, including the loss of species diversity. The demise or total extinction of diadromous fish species above barriers, especially apex predators, can have detrimental impacts on the functioning of aquatic eco-systems, local communities, commercial and recreational fisheries. Remediating barriers to fish passage through the construction of fishways provides diadromous fish species the opportunity to successfully complete their life cycle and therefore fulfil their role in maintaining important eco-system processes. Fishways also provide essential connectivity for many potamodromous species which may migrate for a variety of reasons, including searching for breeding partners, to reach feeding areas and nursery habitats and for reproduction purposes. Significantly, many potamodromous fish species are inadvertently washed downstream over tidal interface barriers during flow events. Potamodromous fish species are unable to endure higher salinities experienced in estuarine waters for extended periods of time. Therefore, like some diadromous fish species, migration back into freshwaters is critical to their survival.

In recognition of the migratory requirements of many of the regions fish species and the detrimental impacts barriers have on the health of the regions aquatic eco-systems, Fitzroy Basin Basin Association (FBA) funded Fisheries Queensland (FQ) in 2011 to undertake a survey of the Moores Creek causeway. The purpose of the survey was to establish the height of the barrier, identify potential fishway location and the overall feasibility of fishway success. These preliminary investigations found that barrier remediation was achievable, and that fishway construction could begin as soon as weather conditions permitted.

Suitable weather conditions in July 2012 permitted the construction of the nature like rock ramp fishway. Based on a range of key biological, economical and practical factors it was decided to construct a partial-width rock ramp fishway. As part of the overall fish passage project, fishway sampling was undertaken to detect any differences in fish species or size classes of fish successfully migrating upstream. Fishway sampling was also undertaken to evaluate the overall effectiveness of the fishway at passing fish.

Figures 1 & 2. Diadromous fish species captured migrating through the Moores Creek partial-width rock ramp fishway. From left to right: Larval long-finned eel (glass eel) & juvenile sea mullet.

Site Information

Moores Creek

Moores Creek is a short coastal stream (17 kms) originating in the hills of Mount Archer National Park in Rockhampton, central Queensland (Figure 3). Its headwaters begin 530 m above sea level, cascading off Mount Archer through deep pools and down waterfalls in a south westerly direction before reaching the lowlands where it meanders 8 km's through Rockhampton's built up residential area and emptying into the Fitzroy River. The last kilometre of its journey is tidally influenced. Significantly, Moores Creek has the potential to offer refuge for small juvenile fish species unable to negotiate the vertical slot fishway on the Fitzroy River mainstream, which is approximately 1 km upstream.

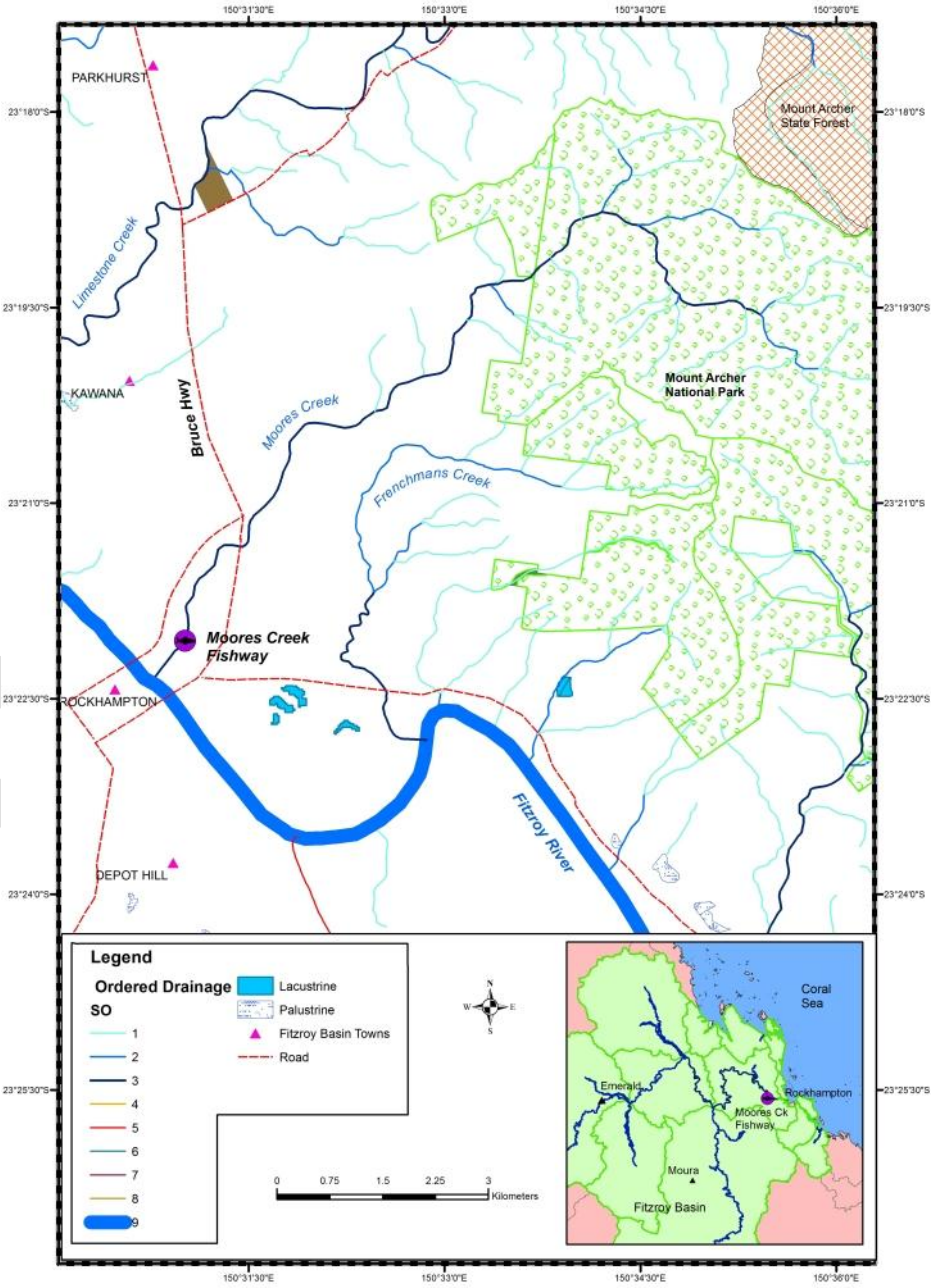

Figure 3. Site location of Moores Creek Fishway.

Located in the lower reaches of the Fitzroy Basin, Moores Creek is an ephemeral stream, generally flowing during the wet season before contracting back to a series of isolated waterholes in the dry season. During some 'wet years' base flow emanating out of Mount Archer may provide low stream flow conditions until the onset of Spring. The Strahler waterway classification ranks Moores Creek as a stream order 3. Upstream river reaches extend for approximately 8 kilometers and are dominated by pools interspersed by riffle zones. In-stream habitat is in excellent condition. Small boulders and river gravel dominate the substrate in upstream stream reaches. Substantial amounts of in-stream habitat in the form of logs and boulders provide excellent cover for fish species. Riparian habitat condition is in excellent condition owing to the protection afforded by Mount Archer National Park (Figure 4).

Figure 4. Upper Moores Creek stream condition.

The middle reaches of Moores Creek extend for approximately 7 km's and are heavily impacted by urban areas. Overall, riparian habitat condition is generally poor, with only some small sections of Moores Creek containing riparian habitat in moderate condition. Stream substrate is dominated by small pebbles and gravel, with moderate amounts of in-stream habitat and aquatic macropyhte coverage. This section contains some deep pools offering important refuge areas for fish and other aquatic animals during the dry season. Overall, middle reach fish habitat is suitable for a wide range of both adult and juvenile diadromous and potamodromous species. A moderate barrier to fish passage in the form of an 800 mm high concrete weir is located under Musgrave Street, and separates the middle and lower reaches. The Barrier is located approximately 1.4 kms upstream from the pipe culvert causeway (fishway location), and has formed a permanent pool directly upstream, creating good fish habitat.

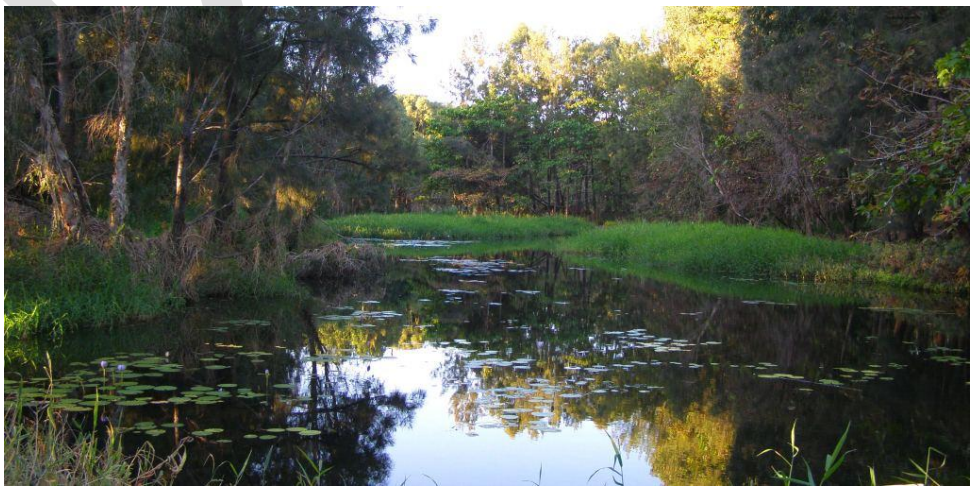

Figure 5. Moores Creek middle reach habitat.

Lower reaches of Moores Creek are heavily impacted by surrounding land use practices dominated by urban residential dwellings. Water quality in these stream reaches deteriorates significantly when compared to upper reaches. Surprisingly for an urban waterway, riparian habitat is in moderate condition in some stream reaches but very poor in other areas. A 1.1 m high pipe culvert causeway is located on the freshwater/estuarine interface of Moores Creek. The causeway has caused the accumulation of sediments to build up in the weir pool directly upstream. The sediment deposits have significantly reduced the water level in the weir pool, creating a shallow degraded urban landscape void of in-stream fish habitat (Figure 6).

Figure 6. Shallow, degraded pool upstream of the causeway on lower Moores Creek.

Lower stream reach habitat upstream from the weir pool improves dramatically, with some large pools offering good in-stream habitat in the form of woody debris and aquatic macropyhtes. These stream reaches offer good habitat for juvenile and adult diadromous and potamodromous fish species and suitable refuge habitat during the dry season (Figure 7).

Figure 7. Lower reach permanent dry season refuge habitat.

Moores Creek Barriers to Fish Passage

There are currently four barriers to fish passage located on Moores Creek (Figure 8). The first and most restrictive barrier was a pipe culvert causeway (Figure 9) located on Charles Street (this barrier has been negated due to the construction of a partial width rock ramp fishway). The adopted middle thread distance (amtd) is approximately 1 km. According to the Australian Bureau of Meteorology (n.d), the amtd is the distance in kilometres, measured along the middle of a watercourse that a specific point in the watercourse is from the watercourse's mouth or junction.

Figure 9. Moores Creek pipe culvert causeway (Charles Street).

The Moores Creek causeway is located on the freshwater/estuarine interface, and is the location for the Moores Creek partial width rock ramp fishway (Figure 10). Moores Creek causeway is a 60 m long by 10 m wide concrete pipe culvert structure. The causeway rises 1.1 high above bed level on the downstream side. The causeway is influenced by high tides around the full and new moon periods, which are capable of reducing the barriers height to approximately 600 mm. Located on Charles Street in the middle of Rockhampton, it was built to provide vehicle and pedestrian access across Moores Creek. This structure was a low transparency barrier, preventing connectivity during medium and low flow events. For information regarding the Moores Creek Fishway, please read the 'Moores Creek Fishway Construction Report'.

Figure 10. Newly constructed (July 2011) nature like partial-width rock ramp fishway

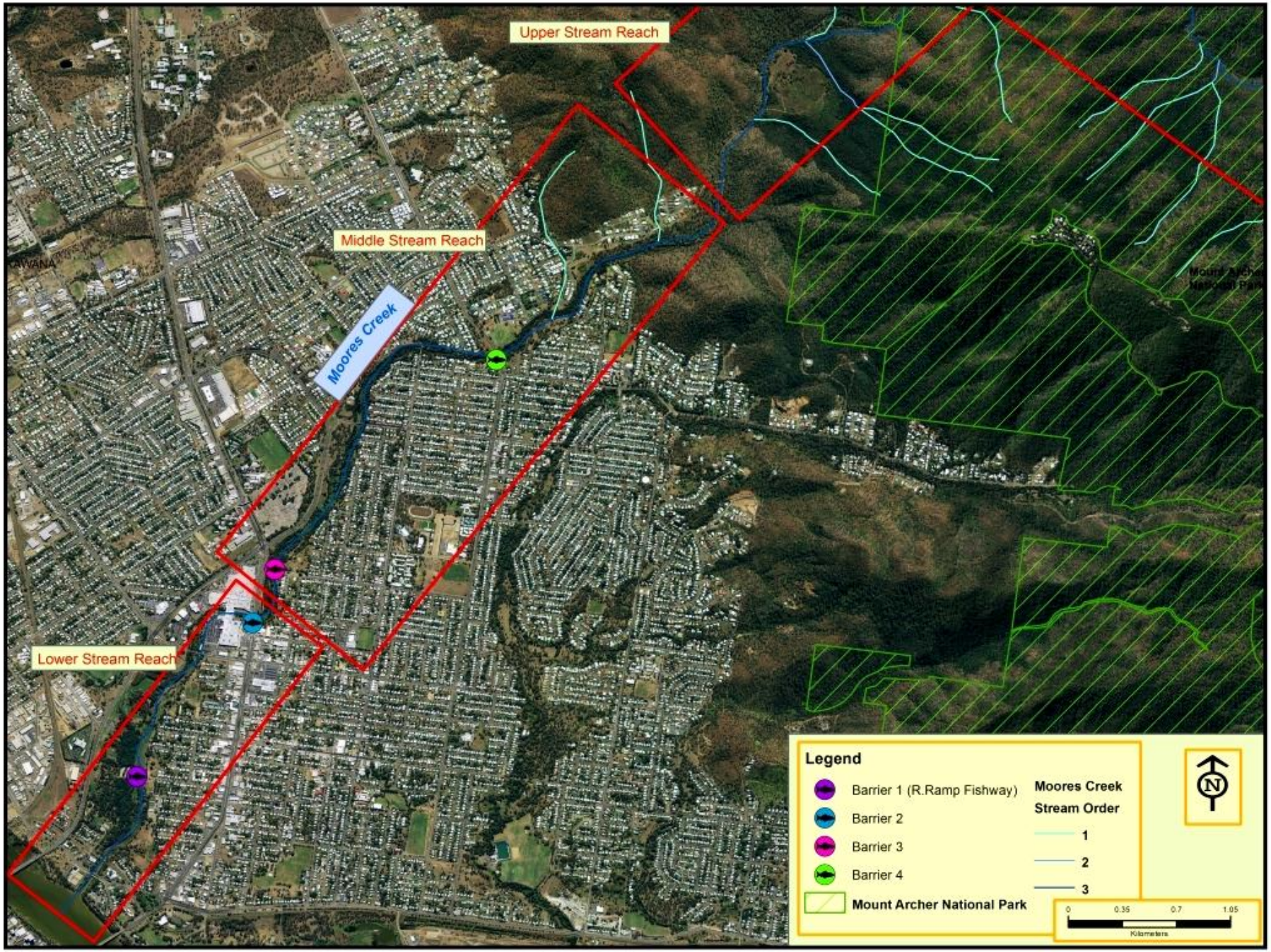

Figure 8. Location of barriers to fish passage on Moores Creek. Note barrier 1 has been remediated with a partial-width rock ramp fishway

Barrier 2 is located underneath the Musgrave street bridge, amtd 2.5 km's. Two small structures, together forming an approximate 700 mm barrier. The first small barrier has formed due to substrate being eroded away on the downstream side of a concrete apron constructed as part of the overall bridge structure. This small barrier is approximately 200 mm high (Figure 11). This drop on the downstream side of the apron is a barrier to fish passage only during low flow conditions.

Figure 11. Small barrier to fish passage on the downstream side of the concrete apron.

The second and larger barrier consists of a small concrete weir on the upstream side of the bridge (Figure 12). This barrier is approximately 500 mm high. The weir is a barrier to fish passage during most medium flow and all low flow conditions. Some fish passage for some species and size classes would be permitted on high and moderate flows. However, due to the small catchment size of Moores Creek and its geographic position in a low rainfall region, moderate and high flow conditions only occur over a limited amount of days each year. If fish species are not ready to migrate when these conditions occur, then passage would not be facilitated. However, low flow conditions persist for months on end, and if a fishway was constructed, it would allow connectivity between lower and middle reaches for thousands of diadromous and potamodromous fish.

Figure 12. Small barrier to fish passage on the upstream side of the bridge.

Barrier 3 is located 3.0 km's amtd. The structure consists of a concrete pipe culvert causeway built to provide pedestrian access across Moores Creek (Figure 13). The structure forms a velocity barrier through the small pipes during some low flow conditions and a water surface drop barrier on some low to medium flows when the water cascades over the structure. This barrier is only a small barrier, and fish would be able to negotiate this structure during most really low flow conditions and throughout most medium and high flows conditions.

Figure 13. Barrier 3, a small concrete pipe culvert causeway.

Barrier 4 is located in the middle reaches of Moores Creek on the downstream side of the Norman Road bridge, approximately 5.5 km's amtd. The structure consists of a concrete pipe culvert causeway and associated concrete apron (Figure 14). The extremely old and unused causeway consists of 3 pipes, which are currently clocked by debris (Figure 15). The barrier is approximately 900 mm in total height, consisting of a 200 mm high drop on the downstream side of the concrete apron and a 700 mm high concrete causeway. The causeway is no longer used. It's recommended that the causeway be removed, thus permitting fish passage to the upstream reaches of Moores Creek over most flow conditions.

Figure 14. Barrier 4, a pipe culvert causeway in the upper middle reaches of Moores Creek.

Figure 15. Barrier 4, showing the degraded pipes.

Methods

Fishway Sampling

Fishway sampling was conducted to validate to effectiveness of the fishway at passing different fish species and size classes. Fishway sampling consisted of placing a 'fish trap' at the top of the fishway (Figure 16) to record fish species and size classes of fish successfully migrating through the fishway. The trap used for this method was constructed out of 12 mm round bar with shade cloth (4 mm mesh size) covering the frame. One cone shaped entrance was placed into the front of the trap. A wing wall constructed from shade cloth was installed to help guide fish into the trap (Figure 16).

Figure 16. Fishway trap placed above fishway but below pipes. Note the wing wall in the foreground (right hand side) placed in position to help guide fish into the trap.

The trap was placed above the fishway, but downstream of the pipes due to large quantities of flood debris blocking the pipes and preventing the trap placement upstream of the pipes (Figure 17).

Figure 17. Large quantities of debris blocking pipes on the upstream side of the causeway.

Fishway sampling commenced on the 18th of February and continued through until the 22nd of February. Sampling was initiated on the recession of the catchments first significant rainfall event for the wet season. This rainfall event instigated one of the biggest flows down Moores Creek in the past 70 years. The power and high velocities associated with the high flow event caused significant damage to the causeway. The flood flow also altered the nature and low flow channel of Moores Creek, scouring out old pools and filling in others. Prior to this flow event, the fishway was not operating due to insufficient water levels. Increased river flows experienced during the wet season trigger many fish species to undertake both short and long distance migrations upstream. It was anticipated that fishway sampling at the recession of a flow event would capture a good representation of fish species expected to utilise the fishway.

Fishway sampling consisted of placing a trap above the top ridge of the fishway. The trap was checked and fish species were measured and counted at approximately 7am, 12pm and 5pm each day. This sampling method was utilised across 5 sampling days and consisted of 77 hours of actual trap sampling effort. All fish captured during fishway sampling were identified to species level, counted and measured to the nearest millimetre (fork length for forked-tail species, total length for all other species). Fish were then released upstream of the fishway. Only 50 individuals of a single species captured in any single ‘trapping’ were measured. The remaining individuals were counted.

Results

Total Catch Summary

A total catch summary of fishway sampling results from Moores Creek is presented in Table 1. A total of 2,040 individuals comprising 18 species at an overall catch rate of 26.49 fish/hour were recorded during fishway sampling. Five of the 18 species recorded were diadromous, including; barramundi (Figure 19), empire gudgeon, sea mullet, flat tail mullet and long-finned eel. Empire gudgeon was the most abundant species, followed by bony bream and fly-specked hardyhead 893, 575 and 323 individuals respectively (Table 1).

Table 1. Total catch summary of fish species recorded during fishway & fish community sampling.

Migration Class	Common Name	Scientific Name	Abundance	Catch Rate (fish/hour)
Diadromous	Sea Mullet	*Mugil cephalus*	23	0.31
	Flat tail Mullet	*Liza argentea*	2	0.03
	Barramundi	*Lates calcarifer*	1	0.01
	Empire Gudgeon	*Hypseleotris compressa*	893	11.60
	Long-finned eel	*Anguilla reinhardtii*	4	0.05
Potamodromous	Eastern rainbowfish	*Melanotaenia splendida*	18	0.23
	Fly-specked Hardyhead	*Craterocephalus stercusmuscarum*	323	4.19
	Bony Bream	*Nematalosa erebi*	575	7.47
	Barred Grunter	*Amniataba percoides*	18	0.23
	Spangled Perch	*Leipotherapon unicolor*	1	0.01
	Mouth Almighty	*Glossamia aprion*	1	0.01
	Flathead Gudgeon	*Philypnodon grandiceps*	1	0.01
	Purple-spotted Gudgeon	*Mogurnda adspersa*	2	0.03
	Agassiz's Glassfish	*Ambassis agassizii*	162	2.10
	Hyrtl's Tandan	*Neosilurus hyrtlii*	1	0.01
	Rendahl's catfish	*Porochilus rendahli*	1	0.01
	Mosquitofish*	*Gambusia holbrooki*	12	0.16
	Guppy*	*Poecilia reticulata*	1	0.01
Total Abundance/Catch Rate (fish/hour)			**2040**	**26.49**
Total Species			**17**	

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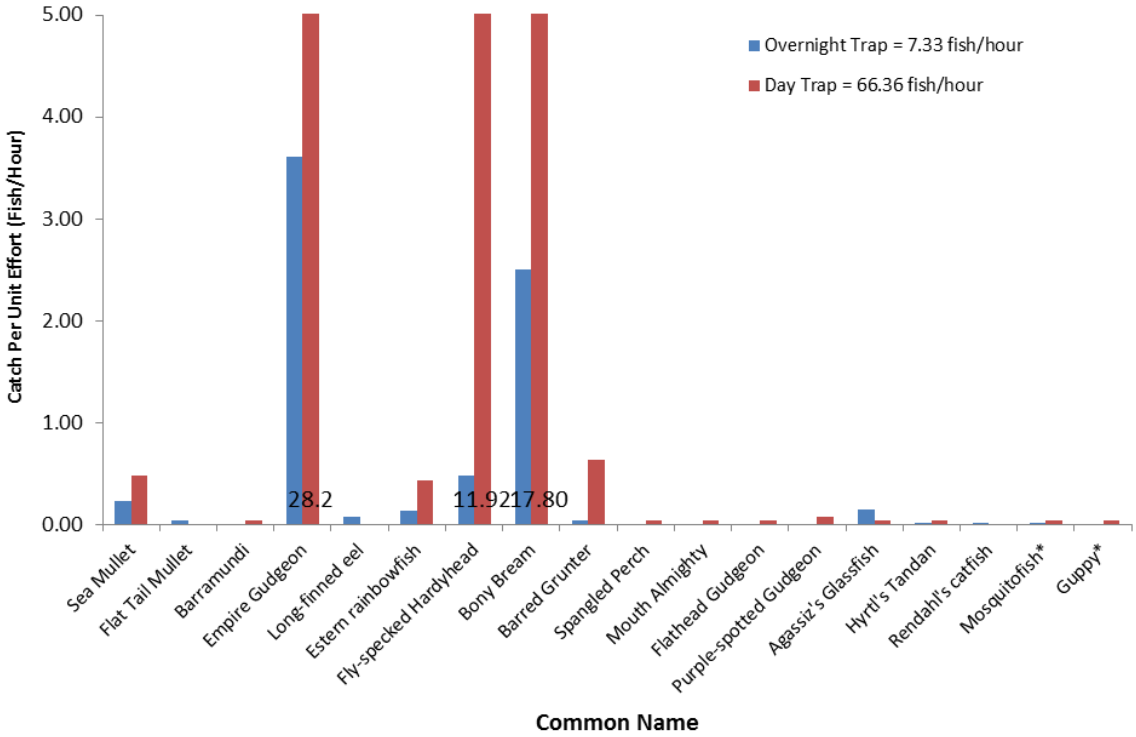

Figure 18. Catch per unit effort of fish recorded during overnight and day fishway trap sampling.

Two noxious pest fish species, mosquitofish and guppy, were recorded in low numbers, with 12 and 1 individuals respectively.

Fishway tap sampling during the day recorded a higher catch per unit effort (66.36 fish/hour) than overnight fishway trap sampling (7.36 fish/hour).Only three species; long-finned eel, rendahl's catfish and agassiz's glassfish were recorded at a greater abundance during overnight trap sampling when compared to day trap sampling (Figure 18).

Figure 19. Juvenile barramundi recorded successfully migrating through the fishway

Discussion

The findings of the current study demonstrate that the partial-width rock ramp fishway on Moores Creek is successful at passing juvenile and adult migratory fish species. The fishway was successful at facilitating migration for a diverse array of diadromous and potamodromous species. High species diversity (18) including both surface and bottom dwelling fish and varied size classes between 19 – 500 mm that successfully ascended the fishway indicates that a wide variety of fish species are now able to negotiate the once significant barrier on the tidal interface of Moores Creek.

Fish between 19 mm (empire gudgeon) and 500 mm (long-finned eel) successfully ascended the fishway, with small prey species and juvenile diadromous species making up the majority of the catch. Most importantly the fishway was successful at passing very small juvenile diadromous fish species undertaking obligatory and facultative migrations to important upstream nursery and feeding habitats, including barramundi, sea mullet, flat tail mullet, empire gudgeon and long-finned eel. Several environmental factors associated with Moores Creek may have contributed diadromous species migrating through the fishway; some of these include but are not limited too;

- Close proximity to estuarine and near shore marine environments,
- Elevated water temperature,
- Sampling undertaken during the recession of a small to medium flow.

The majority of diadromous species recorded successfully ascending the fishway migrate between estuarine and freshwater habitats to feed, grow and evade predators. Four of the diadromous species; barramundi, sea mullet, flat tail mullet, empire gudgeon fall under the amphidromous fish migration category, in that their migration between the sea and freshwaters is completed for reasons other than reproduction. Two other widely recognised migration categories occur under diadromy; catadromous – fish that migrate downstream to the sea to spawn (long-finned eel) and anadromous fish that migrate upstream into freshwaters to spawn. No anadromous species were captured during fishway sampling. However, four catadromous long-finned eel's were recorded successfully migrating through the fishway.

It is possible that sampling results were impacted by a significant fish kill which occurred in the weeks leading up to fishway sampling. The fish kill occurred in the lower freshwater and upper estuarine reaches of the Fitzroy River. Extremely low levels of dissolved oxygen appear to have killed aquatic life. Many estuarine and freshwater species were killed, including in the lower reaches of Moores Creek (S van Nunen 2013, pers. Comm., 19 Feb.) It is likely that the fish kill has impacted the abundance and possibly diversity of fish species migrating upstream through the fishway.

Conclusion

It is evident from the findings of the current study that the partial- width rock ramp fishway on Moores Creek is successful at passing a wide range fish species and size classes. Significantly, the fishway facilitates the passage of juvenile diadromous species undertaking obligatory and facultative migrations to upstream nursery habitats. The current findings highlight the importance of providing fish passage for the regions fish communities, with the facilitation of diadromous species vitally important to maintain healthy sustainable populations. The facilitation upstream through the fishway of potamodromous fish species that have been washed downstream during flow events will also improve the condition and resilience of upstream aquatic communities.

Although there are some upstream river reaches in good condition, the majority of lower and middle reaches are in poor condition. Remediation works to create additional aquatic habitat by increasing the depth of pools, planting riparian habitat and the addition of in-stream woody debris in these reaches is recommended. This is particularly pertinent directly upstream of the fishway, where sediment has deposited, in-filling the waterhole and decreasing the amount and quality of available habitat. It is recommended that the deposited sediment in this section is removed. This would provide additional dry season refuge habitat in the lowland reaches of Moores Creek. Three barriers to fish passage remain in upstream reaches. These barriers should be remediated to assist connectivity between lowland and upland river reaches. The barrier to fish migration under the Musgrave Street bridge should be the next highest priority in the Moores Creek catchment.

References

Allen, G. R., Midgley, S. H. & Allen, M. (2002). Freshwater Fishers of Australia. Western Australian Museum, Perth.

Pusey, B.J., Kennard, M.J. and Arthington, A. (2004). *Freshwater Fishes of North-Eastern Australia*. CSIRO publishing: Collingwood, Victoria.