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Fish Passage and Community Assessment Report; Forbes Rd Fishway and Blackrock Creek

Mackay Regional Council

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Cover Image: Forbes Road Fishway, O'Connell River – April 2015

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Executive Summary

Migration for most native fish species is important to maintain populations and species diversity. Barriers preventing fish migration can lead to significant changes in fish communities above barriers, including loss of species diversity. The loss of diadromous fish species above barriers, especially top order predators, can upset the balance of aquatic ecosystem. This loss within these systems have the potential to alter fish community assemblages and impact on aquatic species other than fish. Unlike many exotic salmonids species, most native fish species do not have the ability to transverse over large barriers and vertical inclines. These barriers are built for a variety of purposes such as: irrigation supply, flow gauging and regulation, on-farm irrigation supply; urban or industrial supply, flow management and flood control, road crossings or simply for urban beautification and recreational facilities. Remediating large barriers to enhance 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.

As part of an assessment of fishway efficiencies Mackay Regional Council (MRC) commissioned Catchment Solutions (CS) to undertake fish sampling in two drainage systems. The concepts of the project has a dual purpose, firstly to determine the performance of an existing partial width rock-ramp fishway (constructed 2013), and secondly to assess the fish communities and assemblages prior to a proposed construction of a fishway on a similar barrier type (Old Bowen Road Crossing).

Fishway performance sampling was conducted at the Forbes Road causeway on the O'Connell River, above and below the causeway utilising cone traps. Sampling results confirmed the fishway was successful at passing both juvenile and adult fish, including bottom and surface dwelling species. Two bottom dwelling species of gudgeon and speckled goby (*Redigobius bikolanus*) were sampled above and below the barrier. Notably, a total of 238 primarily juvenile (25-54mm sized) empire gudgeon (*Hypseleotris compressa*) were captured above the barrier during fishway sampling, emphasising the utility of fishways in passing juvenile fish. In total, 358 individual fish representing 13 species at a total catch rate of 8.6 fish/h were recorded from the Forbes Road rock ramp fishway. Eleven species successfully ascended the fishway, two additional species were recorded only from the lower portion of the fishway. Records identified no significant difference ($t(60)=-0.20$, $p>0.05$) in the size range of the fish attempting to ascend fishway and fish which successfully ascended the fishway. Sampling demonstrated that the Forbes Road fishway was successful at passing small fish (<150 mm). The absence of large fish from sampling records was most likely a result of the unseasonal low flow conditions at the time of sampling, however this could not be confirmed without further sampling during higher river flow conditions.

Fish community sampling was conducted at four sites within Blackrock Creek using electrofishing techniques. Two sites were immediately upstream and downstream of the Old Bowen Road causeway barrier, while the other sample sites were approximately 800 m upstream and 1.2 km downstream of the causeway. In total 1103 individual fish at a total catch rate of 20.31 fish/min were recorded during sampling operations. Sixteen species were identified, including several catadromous species. Ten species were common to both upstream and downstream reaches, while each reach contained three species that were not identified from the other. Independent t-tests comparing the average length of two potamodromous species upstream and downstream of the causeway found no significant difference ($t(91)= -1.63$, $p>0.05$) in the mean size of eastern rainbowfish, but did identify a significant difference ($t(30)= 3.97$, $p<0.05$) for flyspecked hardyhead.

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.

Surface drop – Vertical drop from the surface of one area to the surface of another. With regards to migratory fish barriers a surface drop is associated with the vertical height difference (head loss) of the water surface on the upstream side of the structure and the water surface on the downstream side.

Velocity barrier – A structure that increases the speed at which water flows beyond the swimming ability of one or more fish species. Velocity barriers are often associated with smooth surfaces such as culvert barrels, causeways pads and aprons.

Physiological barrier – A structure that creates conditions that fish are physically able but not willing to move through. Physiological barriers are often associated with the low light conditions created in culvert barrels.

Acronyms

CS	– Catchment Solutions Pty Ltd
MRC	– Mackay Regional Council
CPUE	– Catch Per Unit Effort

Introduction

In the Mackay region, impacts of barriers such as causeways, road crossings, weirs and dams on fish passage has been identified as a major cause in the reduction of native fish populations and community assemblages (Marsden & Kerslake, 2002). Barriers affect fish community condition by preventing movement of species which require unimpeded passage through aquatic ecosystems to complete a number of key life stage requirements (Moore & Marsden, 2008). This movement may be required for:

- Preserving populations of potamodromus species, to access a variety upstream habitats for reproduction, recruitment and feeding,
- Juvenile fish species to migrate upstream to access nursery habitats,
- To avoid predators
- Provide opportunity for genetic diversity, and
- Maintaining populations of diadromous species, which required free unimpeded access between freshwater, estuarine and marine environments to breed.

Many fish species found in the O'Connell River and Blackrock Creek systems are diadromous. Fish migration between and within freshwater, estuarine and marine habitats is a vitally important aspect of the life cycle of these fish. Barriers preventing migration contribute to the loss of species diversity within fish communities, severely impacting the health of the regions aquatic ecosystems and are considered to be one of the main anthropogenic impacts on fish communities within the Mackay region (Moore & Kerslake, 2002). The installation of fishways is one remediation option that can improve connectivity between fragmented sites. Fishways are designed to reduce the surface drop and water velocities caused by the barrier, creating conditions that fish are able to negotiate.

In recent years there has been significant investment by Mackay Regional Council and Reef Catchments in infrastructure to improve the biodiversity of the region's waterways, including the construction of fishways. Many of the fishway installations consisted of rock ramp designs as this style is relatively inexpensive and easily retrofitted to a wide range of small to moderate sized barriers. Common locations for installation of rock ramp fishways have been road causeway. These causeways generally form a small to moderate sized surface drop barrier and often incorporate a velocity barrier, created as water passes through culverts or across the road surface.

On the O'Connell River and Blackrock Creek two similar causeways form barriers to fish migration. Forbes Road causeway on the O'Connell had a fishway installed in 2013, while a fishway installation is proposed for Old Bowen Road on Blackrock. Given the similarities between the two causeways it was possible to assess the effectiveness of this existing fishway and provide an indication of the suitability of this design in similar conditions. Prior to the commencement of habitat improvement works it is beneficial to conduct baseline surveys, this data helps identify any changes to community and population structure that may result from improvement works.

The intent of this project was to provide relevant information on potential impacts and changes in fish communities in the O'Connell River and Blackrock Creek, post and pre construction of causeway fishways. The objective of the Forbes Road fishway sampling was to validate the performance of an established fishway, while the Blackrock Creek survey was to form a baseline fish community record that establishes preliminary data prior to the installation of a fishway on the Old Bowen Road causeway. Additionally, comparisons in species composition and population structure upstream and downstream of the Old Bowen Road provided an indication of the current impacts caused by the road crossing. This information is valuable when predicting the potential benefits of remediating this and similar barriers to fish passage.

Site Information

O'Connell River

The O'Connell River originates in the Cathu State Forest draining northward past the township of Bloomsbury then turning east, entering the sea at Repulse Bay (Figure 1). The upper reaches of the river are in good condition with limited removal of riparian zones and some grazing. As the river enters the floodplain, grazing and some intensive cropping has seen an increase in clearing, however much of the lower reaches still have moderate riparian zones. Overall the stream condition of the O'Connell River is moderate with moderate levels of disturbance. The Andromache River forms the northern sub-catchment of the O'Connell catchment and enters the O'Connell River in the lower reaches below the study site.

In the past the O'Connell River has experienced a variety of flow conditions, typically characterised by large flows during the wet season (December to April) and low flows during the dry seasons (June to November). Since early 2012 a steady fall of peak flows and low flows has occurred. Utilising gauging station data (2007 - 2015) it was calculated that the average flow for April 2015 was less than two percent of the April average for the previous 8 years at the Forbes Road site (DNR river flow data: gauge 124005A, accessed June 2015). Additionally the gauging station did not record any rainfall reading for the month of March 2015. Consequently the flow conditions leading up to and during the sampling period should be considered as unseasonal.

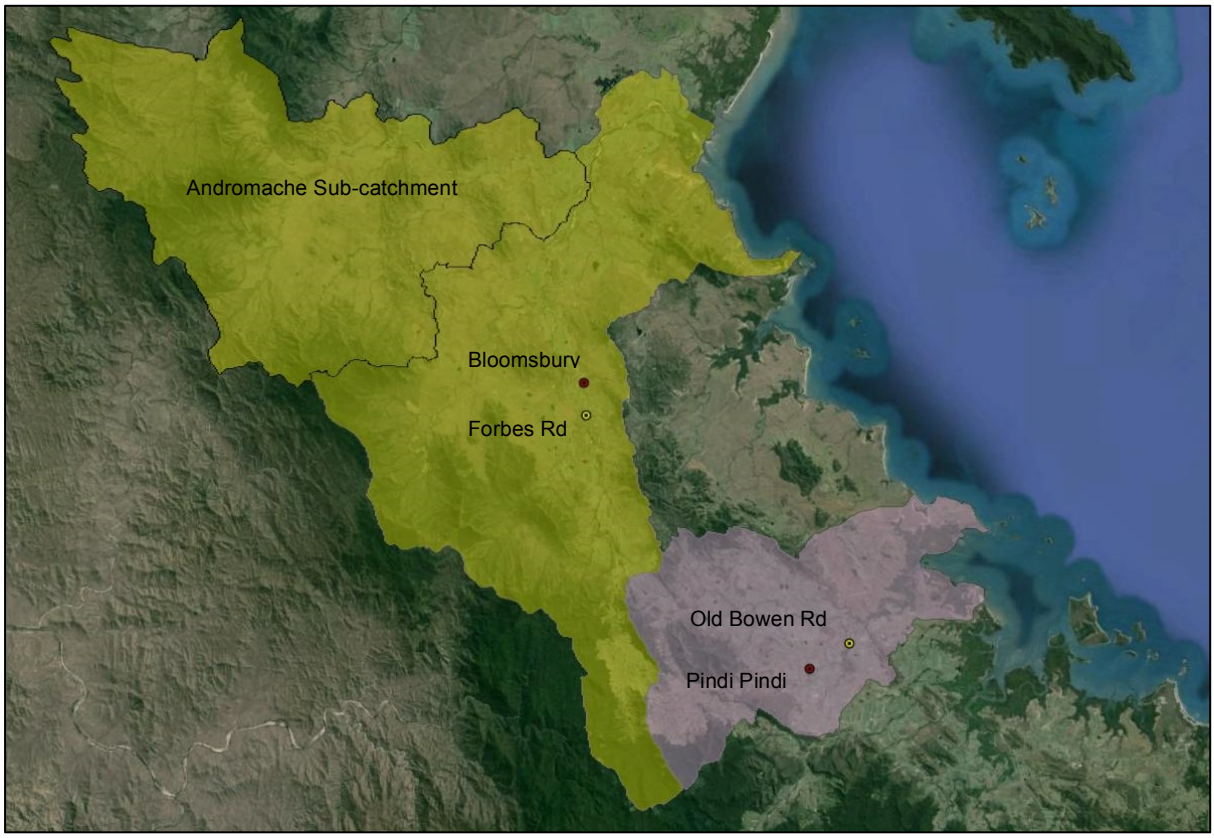

Figure 1. Yellow - O'Connell River Catchment including the township of Bloomsbury, location of Forbes Road fishway and northern Andromache sub-catchment. Pink – Blackrock Creek Catchment including township of Pindi Pindi and location of Old Bowen Road causeway. Google Earth base image.

Blackrock Creek

The headwaters of Blackrock Creek are adjacent to Eungella National Park draining eastwards past the township of Pindi Pindi then turning north east, entering the sea at St Helens Bay (Figure 1). The upper reaches are in poor condition with grazing adjacent to the creek system with limited riparian shading and zones. As the creek moves into the floodplain, extensive cropping surrounds the creek system with moderate riparian zones. The lower reaches and estuarine areas have moderate riparian and marine plant zones with extensive grazing to the north of the estuarine habitat.

Similar to the O'Connell River, Blackrock Creek typically experiences increased flow during the dry season and low flows during the dry season. Although there is no stream flow gauging stations on Blackrock Creek, observations from nearby Saint Helens Creek (DNR river flow data: gauge 124002A, accessed June 2015) indicated that flows leading up to and during the sampling period were unseasonably low.

Fish Passage Barriers

Forbes Road Fishway – O'Connell River

Prior to the construction of the fishway, a box culvert causeway was acting as a barrier to fish passage on the middle reaches of O'Connell River. The causeway, located on Forbes Road approximately two km south of Bloomsbury (Figure 1), consisted of a 0.8 m high surface drop and five, 6 m long culvert barrels that created velocity barriers and physiological barriers.

In 2013 a fishway was constructed at the Forbes Road causeway to facilitate fish passage during low and medium flow conditions. This project (*O'Connell River removal of barrier to fish passage*) involved the construction of a partial width rock-ramp (Figure 2). The fishway was designed to incorporate a series of ridges that were separated by resting pools; each ridge stepped up by 100 mm. A concrete nib wall and the top ridge of the fishway backed approximately 300 mm of water through two existing culvert barrels, reducing velocity through the culverts. Fishway construction was timed during the low flow period (dry season) to reduce fish passage disruption and maximise site/river access. The fishway was constructed over a four day period with a 21 tonne excavator, using approximately 130 tonnes of assorted large rock (>1.5m diameter) and 25 cubic metres of coarse aggregate concrete (Figure 2).

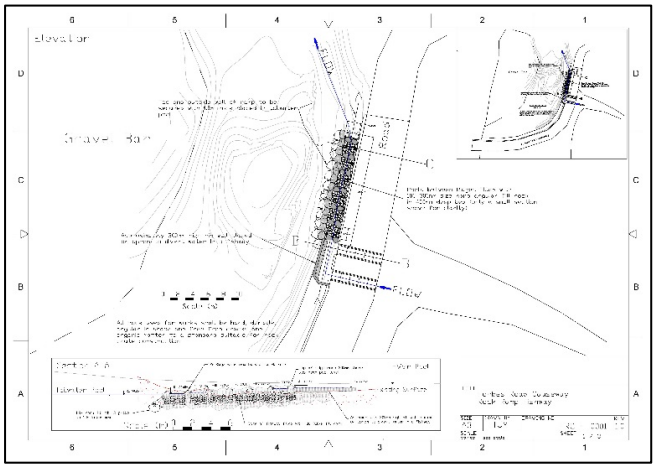

Figure 2. (Left). Forbes Road fishway design, Figure 3 (Right) Construction of Forbes Road Fishway

Old Bowen Road Crossing - Blackrock Creek

The Old Bowen Road Crossing (Figure 3) currently consists of a concrete causeway with two pipe culverts spanning the road width (5 m). The downstream concrete apron has a 0.4 m surface drop, while the overall head loss between downstream and upstream is 0.8 m. Fish passage at this site is limited by number of factors including a surface drop, increased flow velocity and low light conditions.

During high flow the causeway on Old Bowen Road would drown out allowing some fish passage past the structure. As the tail water level recedes below the top of the causeway the velocity through the culvert barrels and surface drops would reduce fish passage considerably. As medium and low flows persist for a longer period, fish passage would be impeded for the majority of the flow cycle.

Figure 3. Old Bowen Road Causeway, Blackrock Creek

Methods

Fishway Sampling

Due to sediment deposition within the fishway over previous flow periods, a large quantity of material needed to be removed prior to fishway sampling. Once the fishway was cleared, trapping commenced at the top of and within the lower section of the fishway (Figure 4). Traps were alternated between the top and bottom of the fishway to capture fish that successfully negotiated the fishway as well as those which enter the fishway but may not have been unable to make it to the top. Prior to the removal of the top trap, electrofishing was conducted in the pool immediately below the culvert, this was to provide an indication of any species which may have successfully ascended the fishway but not passed through the culvert to the trap. Before commencing electrofishing screens were placed across the top ridge of the fishway and the culvert entrance to prevent fish from leaving the pool during electrofishing operations.

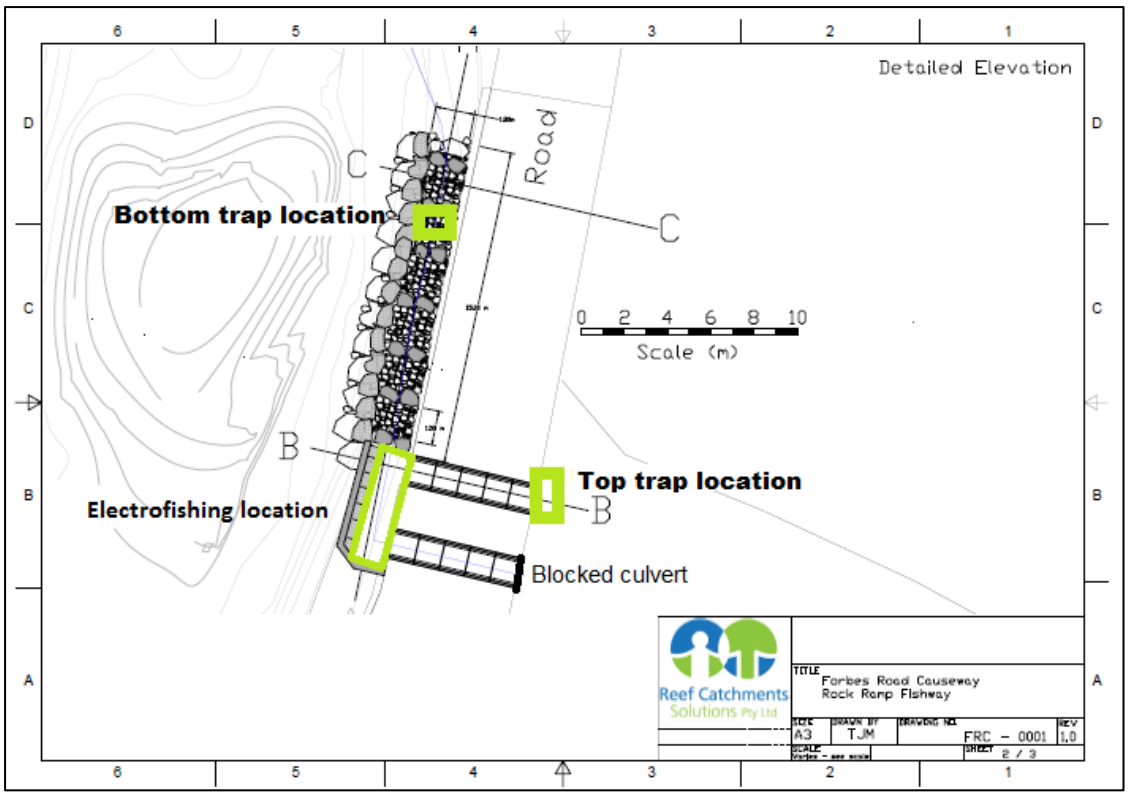

Figure 4. Sampling location of the fish traps

The trap located at the top of the fishway consisted of a double cone configuration, constructed from 8 mm round bar with shade cloth (4mm mesh size) covering the frame (Figure 5.). Shade cloth wing walls prevented fish from swimming around trap. The trap dimensions were 1040 mm x 720 mm x 800 mm. Sandbags and river stones were used to secure the trap in place.

Figure 5. Double cone trap upstream of rock ramp and box culvert

The bottom trap had a single cone configuration, constructed from 8 mm round bar with shade cloth (4 mm mesh size) covering the frame (Figure 6). Shade cloth wing walls prevented fish from swimming around trap. Dimensions of this trap were 900 mm x 720 mm x 800 mm. Sandbags and river stones were used to secure the trap.

Figure 6. Single cone trap within the base of the fishway

Fishway sampling was conducted from the 31st March through to the 3rd April 2015, alternating between the top and bottom of the structure. The fishway was sampled for a period, 40.5 hours at the top of the structure and 51.0 hours at the base. Sampling incorporated both day and evening deployments at both locations. All fish captured during fishway sampling were identified to species level, counted and measured to the nearest millimetre (folk length of forked-tail species, total length for all other species). If large numbers of a species were captured during a single trap set a random subset of 50 fish were measured with the remaining only contributing to abundance data. After processing all fish were released above the causeway.

An Independent t-test (α=0.05) was performed on length frequency data between the top and bottom trap captures. The test was used to detect any significant difference in size classes between the entrance and exit of the fishway. Insufficient data prevented comparison for individual species; however, pooled data of all species provided an indicative comparison of size distributions.

Fish Community Sampling

Fish community sampling was undertaken in Blackrock Creek, using boat mounted and backpacker electrofisher on the 1st and 2nd of April 2015. Fish community sampling was performed four sites (Figure 7), site one was approximately 800m upstream of the causeway, site two (upstream) and site three (downstream) were adjacent to the Old Bowen Road causeway barrier, while site four was 1.2 km downstream of the causeway.

Figure 7. Blackrock Creek community sampling sites in relation to the Old Bowen Road causeway. Google Earth base image

Electrofishing was conducted from the 3.7 m vessel (Electrolyte) operating a Smith-Root 2.5 GPP electrofisher unit, equipped with a single boom arm, 6 dropper anode array and hull cathode. Settings were adjusted based on electrical conductivity of the water on site to maximise the effectiveness of electrofishing operations. A master and single dip-netter were employed during all sampling activities on Electrolyte.

Sampling was conducted at various depths and encompassed all types of instream habitats within the waterbody. The electrofishing methodology used was a combination of power on, power off for the duration of the sampling effort. The sampling effort consisted of a series of 300 second 'shots' where the boat was maneuvered in and out from the shoreline as well as parallel to the shore in deeper water. The effective electric field of this unit was approximately 3 m radius (centered on the anode) to a depth of 3 m. Fish positively identified during operations but not captured were also recorded and contributed abundance and assemblage data in this report.

At sites not accessible with the boat, backpack electrofishing was used to collect fish community data. The backpack unit utilised was a Smith-Root Model-LR24 Backpack Electrofisher operating a 300-500 volt pulsed-DC current and a standard pulse setting (1ms). An operator and single dip-netter were employed during all backpacking operations. Sampling effort was the same used for boat mounted operations and was limited to a wading depth of 1.2 m.

All fish captured during electrofishing were identified to species level, counted and measured to the nearest millimetre (folk length of forked-tail species, total length for all other species). Where more than 50 individuals of a single species were captured from a site, a random subset of 50 was measured for length data. The remaining individuals were counted but not measured. Fish observed as affected by the electrical field and positively identified, but not netted, were included in abundance data. After processing all fish were released in same location as captured.

An Independent t-test (α=0.05) was performed on pooled length frequency data of species populations upstream and downstream of the Old Bowen Road causeway. The test was used to detect any significant difference in size classes between the populations between the two reaches. Comparisons were limited to species that yielded sufficient data to meet the requirements of the statistical method.

Results

Forbes Road Fishway

A total of 13 species were sampled from Forbes Road fishway. Eleven species recorded from the top trap had successfully negotiated the fishway (Table 1). An additional two species (sooty grunter and midgleys carp gudgeon) were only recorded from the bottom trap. Three species (sooty grunter, purple spotted gudgeon and hyrtl's catfish) were only represented by single captures, while midgleys carp gudgeon recorded two individuals. Total abundance of the remaining species varied considerably (Table 2). All species sampled during trapping operations were potamodromus.

Table 1. Summary of the species caught during fishway sampling of Forbes Road Fishway on the O'Connell River, March/April 2015

Common name	Species	Migratory status	Top trap	Bottom trap
Agassizis glassfish	*Ambassis agassizii*	Potamodromous	✓	×
Barred grunter	*Amniataba percoides*	Potamodromous	✓	×
Flyspecked hardyhead	*Craterocephalus stercusmuscarum*	Potamodromous	✓	✓
Mouth almighty	*Glossamia aprion*	Potamodromous	✓	✓
Sooty grunter	*Hephaestis fuliginosous*	Potamodromous	×	✓
Empire gudgeon	*Hypseleotris compressa*	Potamodromous	✓	✓
Midgley's carp gudgeon	*Hypseleotris sp1.*	Potamodromous	×	✓
Spangled perch	*Leiopotherapon unicolor*	Potamodromous	✓	✓
Eastern rainbowfish	*Melanotaeniasplendida splendida*	Potamodromous	✓	✓
Purple spotted gudgeon	*Mogurnda adspersa*	Potamodromous	✓	×
Hyrtl's catfish	*Neosilurus hyrtlii*	Potamodromous	✓	×
Speckled goby	*Redigobius bikolanus*	Potamodromous	✓	✓
Pacific blue-eye	*Pseudomugil signifera*	Potamodromous	✓	✓
		Total	**11**	**9**
			13	

Table 2. Total catch and size class summary for fish species sampled from Forbes Road fishway on the O'Connell River, March/April 2015.

Common name	Species name	Size range (mm)	Total abundance top trap	Total CPUE top trap (fish/h)	Total abundance bottom trap	Total CPUE bottom trap (fish/h)	Electrofishing top of fishway
Agassizis glassfish	*Ambassis agassizii*	45-54	21	0.52			
Barred grunter	*Amniataba percoides*	60-92	9	0.22			✓
Flyspecked hardyhead	*Craterocephalus stercusmuscarum*	25-74	12	0.30	15	0.29	✓
Mouth almighty	*Glossamia aprion*	70-74	6	0.15	1	0.02	
Sooty grunter	*Hephaestis fuliginosous*	46			1	0.02	
Empire gudgeon	*Hypseleotris compressa*	24-54	238	5.88	7	0.14	
Midgley's carp gudgeon	*Hypseleotris sp1.*	32-42			2	0.04	
Spangled perch	*Leiopotherapon unicolor*	67-151	2	0.05	2	0.04	✓
Eastern rainbowfish	*Melanotaenia splendida splendida*	35-82	10	0.25	3	0.06	✓
Purple spotted gudgeon	*Mogurnda adspersa*	43	1	0.02			
Hyrtl's catfish	*Neosilurus hyrtlii*	115	1	0.02			
Pacific blue-eye	*Pseudomugil signifera*	24-45	9	0.22	12	0.24	
Speckled goby	*Redigobius bikolanus*	26-31	3	0.07	3	0.06	
		Totals	**312**	**7.70**	**46**	**0.90**	

Pooled catch rates of all fish were higher for the top trap (7.70 fish/h) than the bottom trap (0.90 fish/hr). The predominant species sampled from both the top and bottom traps were empire gudgeon which comprised 69% of the total species catch at an overall CPUE of 6.02 fish/h. While this species were captured during each trap set, the vast majority (>90%) came from two trap sets (Figure 8). Catch rates of other species recorded during sampling operations ranged between 0.02 fish/h and 0.59 fish/h (Table 2).

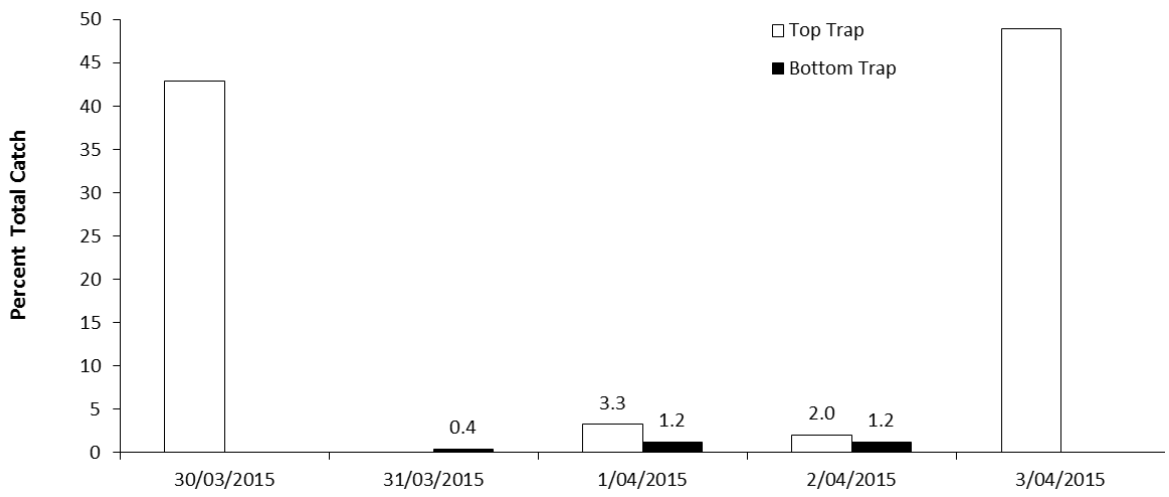

Figure 8. Percentage of total catch for empire gudgeon (*Hypseleotris compressa*) recorded during fishway sampling at Forbes Road, March/April 2015.Note: date listed is trap set date, set duration may have extended into the following day.

Length frequency data was reviewed for all species to compare the size range of fish that were attempting to move through the fishway (bottom) and those that successfully ascended the fishway (top). The size of individuals recorded during fishway sampling ranged between 24 mm – 155 mm, with the majority of fish measuring <100 mm (Figure 9). The smallest species recorded were empire gudgeon and pacific blue-eye and the largest was spangled perch (Table 1). Insufficient data was available to compare length frequencies of individual species, however pooled length data of all species was compared using an independent t-test. No significant difference ($t(60)= -0.20$, $p>0.05$) was found between the mean size of fish captured from the bottom trap (mean=42.4, standard deviation=20.8) and fish captured from the top location (m=43.0, s=16.5)

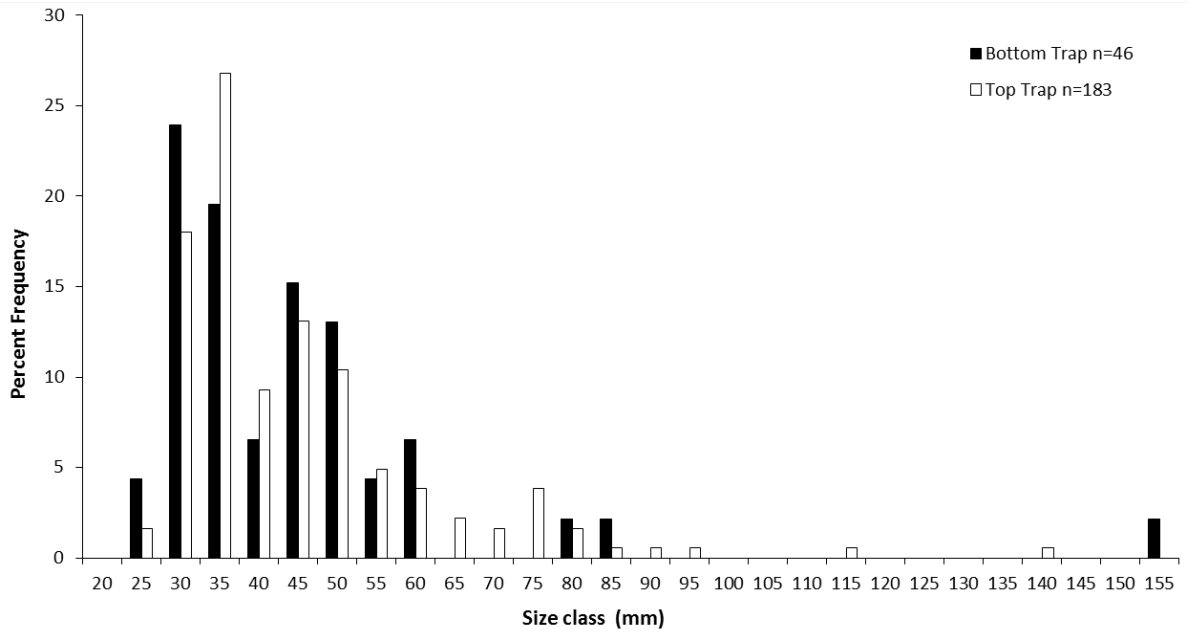

Figure 9. Percent frequency distribution of pooled size class data for all species from each trapping location at Forbes Road fishway, March/April 2015.

Blackrock Creek Fish Communities

Fish community sampling yielded a total of 16 species from the four sites sampled in Blackrock Creek (Table 3). Eleven potamodromous species and five diadromous species were among captures. Upstream (Sites 1 and 2) and downstream reaches (sites 3 and 4) recorded ten species that were common to both reaches (Table 3). Additionally, each reach recorded three species that were not identified from the other. Roman-nosed goby, snake head gudgeon and bullrout were not identified from upstream sites, while spangled perch, one-gilled eel and tarpon were not identified from downstream sites. Notably, four diadromous species were recorded from downstream sites and three diadromous species were recorded from upstream sites (Table 3).

Table 3. Summary of the species caught during fish community sampling in Blackrock Creek, April 2015

Common name	Species	Migratory status	Upstream		Downstream	
			Site 1	Site 2	Site 3	Site 4
Agassizis glassfish	*Ambassis agassizii*	Potamodromous	✓	✓	✓	×
Long-finned eel	*Anguilla reinhardtii*	Diadromous	✓	✓	✓	✓
Roman-nosed goby	*Awaous acritosus*	Potamodromous	×	×	✓	×
Flyspecked hardyhead	*Craterocephalus stercusmuscarum*	Potamodromous	✓	✓	✓	✓
Snake head gudgeon	*Giurus margaritacea*	Potamodromous	×	×	×	✓
Mouth almighty	*Glossamia aprion*	Potamodromous	✓	×	×	✓
Empire gudgeon	*Hypseleotris compressa*	Potamodromous	✓	✓	✓	✓
Gudgeon sp.	*Hypseleotris sp.*	Potamodromous	✓	×	×	✓
Spangled perch	*Leiopotherapon unicolor*	Potamodromous	×	✓	×	×
Tarpon	*Megalops cyprinoides*	Diadromous	✓	×	×	×
Eastern rainbowfish	*Melanotaenia splendida splendida*	Potamodromous	✓	✓	✓	✓
Purple-spot gudgeon	*Mogurnda adspersa*	Potamodromous	✓	✓	✓	×
Sea mullet	*Mugil cephalus*	Diadromous	✓	×	✓	✓
Bullrout	*Notesthes robusta*	Diadromous	×	×	✓	✓
One-gilled eel	*Ophisternon bengalense*	Diadromous	✓	×	×	×
Pacific blue-eye	*Pseudomugil signifera*	Potamodromous	✓	×	✓	✓
		Site Totals	**12**	**7**	**10**	**10**
		Reach Totals	**13**		**13**	
		Sampling Total	**16**			

Fish abundance varied between sites as well as between reaches (Table 4). Total CPUE for the upstream reach (29.27 fis/min) was over twice the total CPUE of the downstream reach (14.28 fish/min).The most abundant species recorded in Blackrock Creek were flyspecked hardyhead, comprising 31.5% of the total catch at a CPUE of 6.39 fish/min. Eastern Rainbowfish were next most abundant species comprising 28.5% of the total catch at a CPUE of 5.80 fish/min. Agassizis glassfish, empire gudgeon and purple-spot gudgeon were also well represented in the total catch, recording total CPUE ranging between 1.46-2.08 fish/min. The remaining species were present in lower abundance (Table 4).

Site 1.

A total of 358 individuals comprising of 12 species were recorded at this site 1 at a catch rate of 25.60 fish per minute. Of the 12 species, three species were diadromous (Table 3). The most abundant species was flyspecked hardyhead, contributing 37.7% of the catch at a rate of 9.65 fish/min.

Site 2.

Sampling immediately upstream from the crossing at site 2 yielded 282 individuals representing seven species at a catch rate of 35.77 fish per minute. The majority of species recorded were potamodromous (6 species) with a single diadromous species being identified (Table 3). Flyspecked hardyhead was the most common species, comprising 48.95% of the catch at a rate of 17.51 fish/min.

Site 3.

Within site three a total of 274 individuals comprising of 11 species were recorded at a catch rate of 21.1 fish per minute. Of the 11 species, three were diadromous (Table 3). The most abundant species at this location was eastern rainbowfish, comprising 32.8% of the catch at 6.94 fish/min, this was followed closely by flyspecked hardyhead which contributed 24.8% of the catch at a rate of 5.24 fish/min.

Site 4.

Sampling downstream from the crossing and closest to the freshwater/estuarine interface at site 4 yielded 189 individuals representing ten species at a catch rate of 9.7 fish per minute. The majority of species recorded were potamodromous (seven species) with three diadromous species being identified. The most abundant species was eastern rainbowfish comprising of 48.7% of the catch at a rate of 4.73 fish/min.

Table 4. Summary of the catch species size ranges and catch rates (CPUE – fish/min) during fish community sampling in Blackrock Creek, April 2015

			Upstream			Downstream			Species Total
Common name	**Species**	**Size Range (mm)**	**Site 1**	**Site 2**	**Reach**	**Site 3**	**Site 4**	**Reach**	
Agassizis glassfish	*Ambassis agassizii*	32-51	1.14	2.66	1.69	3.24		1.30	1.46
Long-finned eel	*Anguilla reinhardtii*	100-800*	1.29	1.27	1.28	1.00	0.51	0.71	0.94
Roman-nosed goby	*Awaous acritosus*	221				0.08		0.03	0.02
Flyspecked hardyhead	*Craterocephalus stercusmuscarum*	26-82	9.65	17.51	12.48	5.24	0.31	2.28	6.39
Snake head gudgeon	*Giurus margaritacea*	296-325					0.21	0.12	0.07
Mouth almighty	*Glossamia aprion*	38-87	0.72		0.46	0.08	0.51	0.34	0.39
Empire gudgeon	*Hypseleotris compressa*	19-96	1.43	2.28	1.74	2.54	2.16	2.31	2.08
Gudgeon sp.	*Hypseleotris sp.*	28-38	0.93		0.59		0.41	0.25	0.39
Spangled perch	*Leiopotherapon unicolor*	166		0.38	0.14				0.06
Tarpon	*Megalops cyprinoides*	200-400*	0.36		0.23				0.09
Eastern rainbowfish	*Melanotaenia splendida splendida*	12-98	5.65	6.85	6.08	6.94	4.73	5.61	5.80
Purple-spot gudgeon	*Mogurnda adspersa*	31-87	3.93	4.82	4.25	0.08		0.03	1.73
Sea mullet	*Mugil cephalus*	152-366	0.36		0.23	1.47	0.36	0.80	0.57
Bullrout	*Notesthes robusta*	100-200*				0.39	0.15	0.25	0.15
One-gilled eel	*Ophisternon bengalense*	210	0.07		0.05				0.02
Pacific blue-eye	*Pseudomugil signifera*	15-30	0.07		0.05	0.08	0.36	0.25	0.17
		Site/Reach Total	**25.60**	**35.77**	**29.27**	**21.13**	**9.72**	**14.28**	
								Sampling Total	20.32

Length frequency data was reviewed to compare the size range from populations of individual species upstream and downstream of Old Bowen Road causeway. Insufficient length data was available to perform statistical comparisons for the majority of species, including all diadromous species. Two potamodromous species, eastern rainbowfish and flyspecked hardy head did yield sufficient data to perform independent t-tests on the upstream and downstream populations.

Eastern rainbowfish captured upstream of the causeway ranged in size from 15-98 mm and fish downstream ranged in size from 12-90 mm (Figure 10). No significant difference ($t(91)= -1.63$, $p>0.05$) was found between the mean size of fish upstream ($m=38.7$, $s=22.6$) and the mean size of fish downstream ($m=44.7$, $s=16.5$).

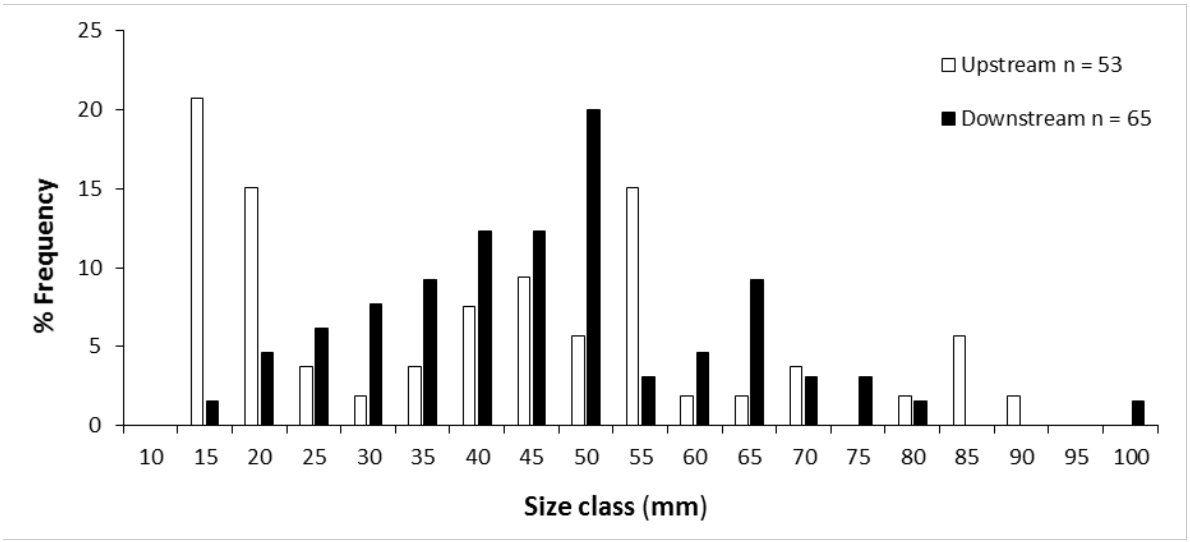

Figure 10. Percent frequency distribution of pooled size class data for eastern rainbowfish (*Melanotaenia splendida splendida*) from Upstream (Sites 1 and 2) and Downstream (Sites 3 and 4) of Old Bowen Road Causeway in Blackrock Creek, April 2015.

Flyspecked hardyhead captured upstream of the causeway ranged in size from 32-76 mm and fish downstream ranged in size from 26-82 mm (Figure 11). A significant difference ($t(30)= 3.97$, $p<0.05$) was found between the mean size of fish upstream ($m=54.6$, $s=7.8$) and the mean size of fish downstream ($m=43.7$, $s=11.9$).

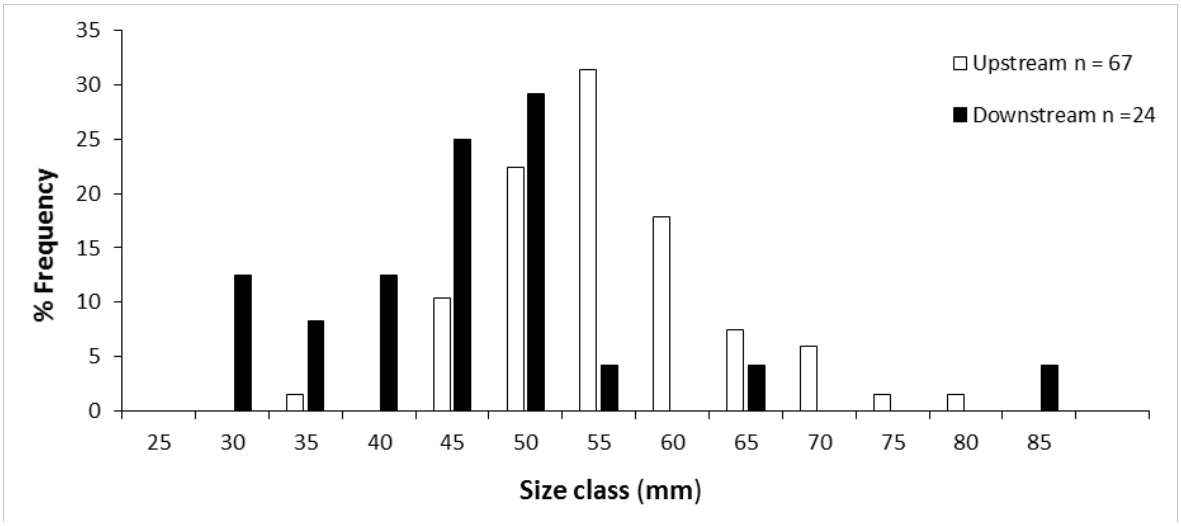

Figure 11. Percent frequency distribution of pooled size class data for flyspecked hardyhead (*Craterocephalus stercusmuscarum*) from Upstream (Sites 1 and 2) and Downstream (Sites 3 and 4) of Old Bowen Road Causeway in Blackrock Creek, April 2015.

Discussion

Forbes Road Fishway

Fishways have been demonstrated to have a positive effect on freshwater fish communities by providing connectivity between fragmented habitats (Donaldson et al. 2012, Power and Marsden 2006; Marsden et al. 2003). Previous studies have found that the O'Connell River contains good fish habitat with minimal barriers to freshwater fish communities (Moore et al. 2007). Although the assessment of the Forbes Road fishway was limited to a snapshot in time and river conditions, the data collected demonstrates that a variety of potamodromus species are moving between downstream and upstream habitats. Interestingly no diadromous species were recorded during the sampling events, however this may be a result of low flow conditions during sampling and reduced recruitment caused by a below average wetseason.

Eleven species successfully negotiated the fishway to access habitat upstream of the Forbes Road causeway. The two species (sooty grunter and midgleys carp gudgeon) absent from captures in the top trap were represented by 1 and 2 individuals respectfully. It is probable that these fish would have successfully ascended the fishway if the trap was not present.

Empire gudgeon was the most abundant species recorded during trapping operations. The majority of these fish were captured during two trap sets, indicating that this species was moving on mass. Similar mass migrations of empire gudgeon have been observed during other fishway sampling studies (Donaldson et al. 2012; Marsden et al. 2003). In these studies increases in catch rates of empire gudgeon were associated with increases in river flow. Flow rates during the current study were unseasonably low, indicating that this species migrates over a range of flows. This also highlights the need for providing adequate fish passage during all flow conditions.

The fishway at Forbes Road was effective at passing a range of fish sizes during low flow conditions. Fish between 24 and 151mm were recorded during trapping operations. Comparisons in size distributions found no significant difference between the size of fish recorded at the bottom and top of the fishway. This provides an indication that fish within the size range sampled should be able to make a successful ascent. It must however, be noted that the comparison was performed on pooled data of all species and some individual species may not fit within this generalised comparison.

Fish community sampling conducted in the O'Connell River has identified a number species including several diadromous fish that were not recorded during trapping operations (Moore et al. 2008). Many of these species grow larger than fish recorded during the current study and the capacity of the fishway to pass these fish remains uncertain. Factors which may restrict the movement of larger fish through the fishway include: pool depth, ridge slot width as well as water velocity and turbulence. Sampling of similar fishways in northern Australia recorded captures of larger fish (150-900 mm) during various flow conditions (Moore and Marsden 2010; Power and Marsden 2006; Marsden et al. 2003). This suggests the Forbes Road fishway should also pass larger fish, however, further sampling would be required to confirm this expectation.

Blackrock Creek fish Communities

Fish communities sampled during the survey of Blackrock Creek are comparable to similar systems within the region (Moore et al. 2007). The presence of several catadromous species above Old Bowen Road causeway indicate that fish passage does occur, however, for the majority of species this passage would be limited to periods of high flow and restricted in duration. Bullrout (*Notesthes robusta*) was the only diadromous species not sampled above the causeway. This species has been shown to travel long distances upstream and prefers habitats with abundant aquatic vegetation (Pusey et al. 2004), similar to the upstream sites sampled in Blackrock Creek. The absence of bullrout from captures at these locations may be an indication that upstream movement of this species is being restricted by the causeway.

Comparisons in abundance of potamodromous fish suggest that several of the species recorded are able to maintain healthy populations despite the presence of a migratory barrier. Several patamodromous species however, were recorded in low abundance. The fish community study conducted by Moore et al. (2007) recorded these species in low abundance in other systems within the region. It is possible that some species such as roman-nosed goby and one-gilled eel naturally occur in low abundance in this region, however, it remains unclear whether the abundance of other species is being impacted by barriers to fish migration as well as other factors such as habitat degradation and poor water quality. Regardless, predictive modelling and field studies have shown that species in low abundance are less robust and more susceptible to pressures such as climate change and continued habitat modification (Kennard et al. 2006; Harris and Silveira 1999). Improvements in connectivity between fragmented sites within Blackrock Creek will help build resilience of fish populations reduce the severity of other anthropogenic pressures.

The limited comparisons in the average size of populations between upstream and downstream reaches identified a significant difference for one species. The average size of flyspecked hardyhead was significantly larger upstream than downstream. It is common for eggs and fry of potamodromous species to be swept downstream during periods of high flow and migrate back upstream as flows recede (Moore et al. 2010; Marsden et al. 2003; Donaldson et al. 2012; Pusey et al. 2004). The smaller average size of this species at downstream sites may be an indication that juvenile fish are being prevented from migrating back upstream after being washed down as fry. It must be noted that other factors such as sampling effort or habitat preference may have contributed to the size difference observed for this species. Further sampling over consecutive seasons would be required to determine conclusive impacts of the causeway on the population structures of flyspecked hardyhead and other species sampled from Blackrock Creek.

Conclusion

Results of trapping operations demonstrate that the fishway at Forbes Road is successful at passing small fish (<150 mm) during low flow conditions. It is anticipated that the fishway will also be successful at passing both small and large fish in moderate flow conditions before the causeway drowns out, however further sampling in during conditions would be required to confirm this.

Many of the potadroumous species recorded in Blackrock Creek were also recorded during fishway sampling at Forbes Road on the O'Connell River. This suggests that a fishway on the Old Bowen Road would facilitate increased fish passage during similar flow conditions and that improved fish passage would also be likely during moderate flow conditions as well.

Recommendations

It needs to be recognised that the fish communities of the Mackay Whitsunday region play an important role in the ecology of the area's waterways. To maintain and enhance the condition of these fish communities, management strategies need to be developed. To assist this process a number of activities may be undertaken to provide adequate information for the development of integrated management options, these include:

- Continued work on the habitat improvement of freshwater stream in throughout the region, including the installation of fishways on barriers to fish migration such as the causeway at Old Bowen Road on Blackrock Creek.

- Ongoing maintenance of Forbes Road fishway and other fishways within the region to ensure each continues to function according to its design. A number of aspects of the design may be compromised after a period of no maintenance.

- Continued fishway and water quality monitoring during pre and post wet season conditions to identify any trends or structural changes in fish communities over time and assist with improving fishway design.

- Investigate management options for improving riparian buffers, instream habitat as well as assisting land holders to improve land use practices to enhance water quality and improve fish habitat.

- Further fish community sampling within streams that undergo habitat improvement works to assess current and future fish community changes, particularly vulnerable species such as jungle perch.

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