Fitzroy Barrage Cone Fishway

Initial Monitoring Report

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Fisheries Collective

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1.Introduction

The Fitzroy River contains one of the most biodiverse and important fish assemblages in tropical eastern Australia with at least 30 species, including a variety of freshwater and estuarine/freshwater species (Berghuis and Long 1999). Almost all of these fish species migrate as part of their life-history with approximately half moving between the estuary and freshwater (Stuart and Mallen-Cooper 1999). The Fitzroy River tidal barrage, 60 km from the river mouth, is a major fish passage barrier and has contributed to fragmentation of fish migration pathways between the estuary and freshwater and reduced ecosystem function (Sheaves et al. 2014).

To improve fish passage, various fishways have been installed on the Fitzroy barrage since the barrage was first constructed in 1970 (Figure 1). These included the original pool and weir fishway constructed with the weir in 1970, an upgraded version of the pool and weir fishway constructed in 1987, a new vertical slot fishway built over the top of the old pool and weir fishway in 1994 and a cone fishway built adjacent to the vertical slot fishway in 2015.

The first two pool and weir fishway designs were largely ineffective (Kowarsky and Ross 1981, Byron and Toop 1993) and passage for most species was only provided once the vertical-slot fishway was installed in 1994. However, this fishway could not provide passage for small fish (Stuart and Mallen-Cooper 1999, Marsden et. al. 2015) and further modifications to fish passage were recommended in 2015 (Marsden et. al. 2015). Improving connectivity and fish passage for these small fish is likely to represent an outstanding investment opportunity for the FBA. To this end a cone fishway was constructed on the Fitzroy Barrage adjacent to the vertical slot fishway in 2015.

The objective of the present report is to experimentally determine the success of the new cone fishway at passing small fish as compared to the existing vertical slot fishway. To this end, parallel sampling of the vertical slot and cone fishways was undertaken to determine the species, numbers and size ranges of all fish using the two fishways.

Figure 1. The four fishways that have been installed at the Fitzroy Barrage since 1970.

2. Methods

The assessment at the Fitzroy Barrage vertical slot and cone fishways was based on evaluating the successful passage of small fish with a total length less than 100 mm. As these are the size classes of fish that are known to be inhibited by the existing vertical slot fishway.

Two lightweight single cone traps were manufactured from steel rod and covered with standard 70% shade-cloth with an average mesh diameter of 1.5 mm. Fish greater than 100 mm in length were excluded by a mesh panel with 25 mm square openings located in the entry of the cone trap. In addition, a dip net with a 300mm opening and 1.5mm mesh was used to collect fish from the entrance of each fishway.

A sub-sample of fish species and sizes classes attempting to enter the fishways was collected by scooping the dip net several times through the pool at the entrance to the two fishways (Figure 2). This collected a representative sample of small fish attempting to move into the fishway.

Figure 2. Location of dip net samples from the entrance of the two fishways.

A sample of fish that had successfully ascended and exited the fishways was obtained by placing a trap immediately upstream of the last fishway baffle as shown in Figure 3. Traps were installed so as to prevent fish escaping from the fishway, with a tight fit against the channel walls to prevent escape.

At the conclusion of each exit sample the trap was manually lifted out of the fishway and fish released into a 100 litre tank partly filled with aerated water. All fish captured during fishway sampling were identified to species level, counted and a sub-sample of 50 fish from each

species were measured to the nearest millimetre (fork length for forked-tail species, total length for all other species). Fish were then released into the headwater pool, with the exception of noxious species who were euthanased.

Sampling was conducted over two separate weeks in March 2016, corresponding with periods of smaller high tides. These times were chosen to maximise the effort require by fish to ascend the fishway. In this way we could establish the passage under the worst migration conditions. If the fishway was successful under these conditions, then it could be expected that under better conditions the fishway would pass even more fish than recorded during this sampling.

Sampling occurred over the period of high tide each day, with the trap set in the fishway prior to the bottom end of the fishway being inundated by the high tide and then checked at high tide and then again once the tide had receded below the apron of the weir.

Figure 3. Location of the exit traps for the vertical slot fishway (foreground) and cone fishway (background).

3. Results

Over the duration of the sampling 17 species of fish were captured either in the vertical slot fishway the cone fishway or by dip netting downstream (Table 1). Empire gudgeon were the most abundant species overall, accounting for 83% of the catch and were abundant during every sample. Blue catfish were the second most abundant species, their numbers were highest in overnight traps, with only small numbers captured during the day. Long-finned eels were abundant throughout sampling, however their numbers in sampling were relatively low as they could avoid or escape from the traps. Fly specked hardyhead and bony bream were sporadically present in large numbers, with most of them sampled from just a few sampling runs. All other species captured over the sampling period were present in low numbers.

New Cone Fishway Versus Vertical Slot Fishway

The cone fishway consistently outperformed the vertical slot fishway, with the vertical slot fishway (1,540 fish) only catching 14% of the fish captured in the cone fishway (11,044 fish) (Table 1). The catch rate of the cone fishway (147.0 fish/hr) was also significantly higher than the vertical slot fishway (22.4 fish/hr). The vertical slot fishway (14) captured two more species in total than the cone fishway (12). Mouth almighty, hyrtl's tandan, sleepy cod and tilapia were all recorded from the vertical slot fishway, but not from the cone fishway, however they only occurred in very low numbers (<7 individuals). Barramundi, western carp gudgeon and spangled perch were captured from the cone fishway, but not from the vertical slot fishway. These species were also captured in very low numbers (<2 individuals).

Some species showed distinct preferences for either the vertical slot or cone fishway, with generally more species finding the cone fishway met their migration requirements. Long-finned eel, empire gudgeon, fly specked hardyhead and bony herring all were captured in much larger numbers from the cone fishway than they were from the vertical slot fishway (Table 1). Conversely longtom were captured in larger numbers in the vertical slot fishway. In general, the smaller species appeared to prefer the cone fishway while larger species used the vertical slot fishway more. However small species also used the vertical slot fishway and larger species also used the cone fishway.

Length Frequency Comparison

The data from the March 2016 sampling of the vertical slot and cone fishways were analysed to determine differences in size classes for abundant species entering and exiting the two fishways (empire gudgeons and long-finned eels) and between the vertical slot and cone fishway exits (bony bream and Agassiz's glassfish).

Empire Gudgeon

Data from the length frequency graph for empire gudgeons indicates a distinct variation between the size classes at the entrance, the exit of the cone fishway and the exit of the vertical slot fishway (Figure 5). Smaller fish were found at the entrance of the two fishways, with fish between 10 and 14mm common. The cone fishway successfully passed fish as small as 12mm, but in low numbers, while by 16mm most fish successfully passed the cone fishway. The vertical slot fishway passed fish as small as 18mm in low numbers, but fish needed to be

greater than 20mm before ascending in any great numbers. This indicates that the new cone fishway is passing smaller fish than the cone fishway, however some very small fish still cannot ascend.

Table 1. Species and number of fish sampled from both the vertical slot and cone fishways.

Common name	Species	Vertical Slot Fishway	Cone Fishway
Diadromous			
long-finned eel	*Anguilla reinhardtii*	30	121
blue catfish	*Arius graeffei*	470	550
empire gudgeon	*Hypseleotris compressa*	865	9592
barramundi	*Lates calcarifer*	0	1
striped mullet	*Mugil cephalus*	7	0
Longtom	*Strongylura krefftii*	27	5
Potadromous			
Agassiz's Glassfish	*Ambassis agassizii*	17	43
banded grunter	*Amniataba percoides*	2	2
Fly-specked Hardyhead	*Craterocephalus stercusmuscarum*	4	324
mouth almighty	*Glossamia aprion*	1	*0*
Western carp gudgeon	*Hypseleotris klunzingeri*	0	1
Spangled Perch	*Leipotherapon unicolor*	0	*2*
eastern rainbowfish	*Melanotaenia splendida*	18	14
bony herring	*Nematalosa erebi*	89	389
Hyrtl's tandan	*Neosilurus hyrtlii*	5	0
Sleepy cod	*Oxyeleotris lineolata*	2	*0*
Tilapia*	*Oreochromis mossambicus*	3	0
	Total Number of Fish	1540	11044
	Total Sampling Time (hrs)	67.75	74.66
	Catch Rate (Fish/Hour)	22.4	147.9
	Total Number of Species	14	12

*- Introduced species

Long-finned Eels

Data from the length frequency graph for long-finned eels indicated that most fish were less than 70 mm in length and that fish were ascending both the cone fishway and the vertical slot

fishway (Figure 6). There were generally more fish at the entrance to the fishways and in the cone fishway than there was in the vertical slot fishway.

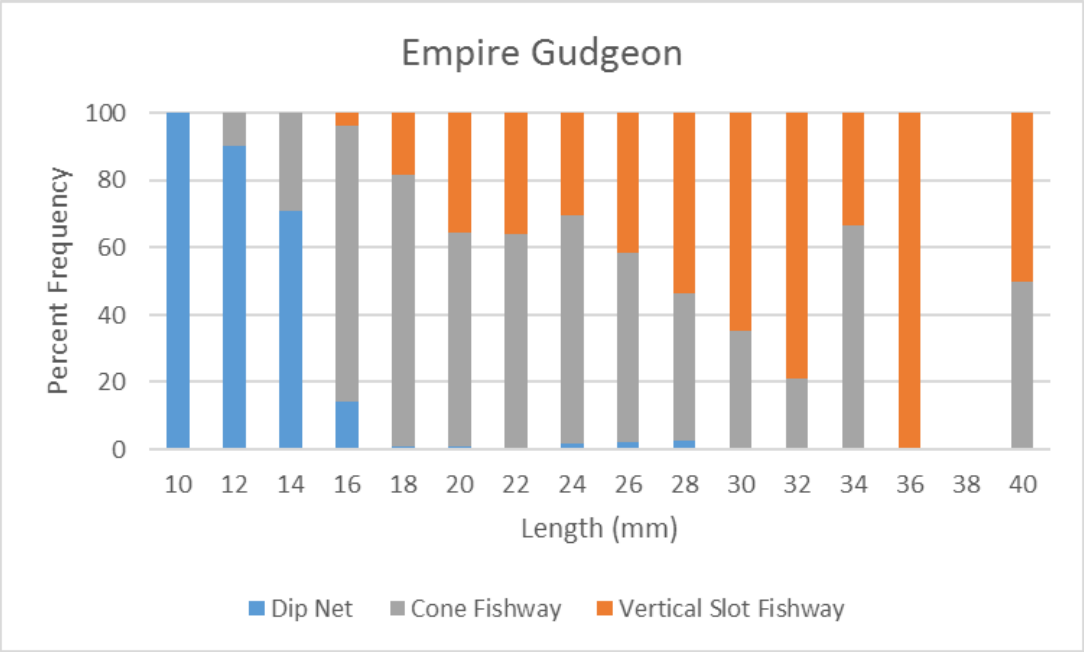

Figure 5. Length frequency of empire gudgeon captured in the March 2016 entrance and exit trap samples.

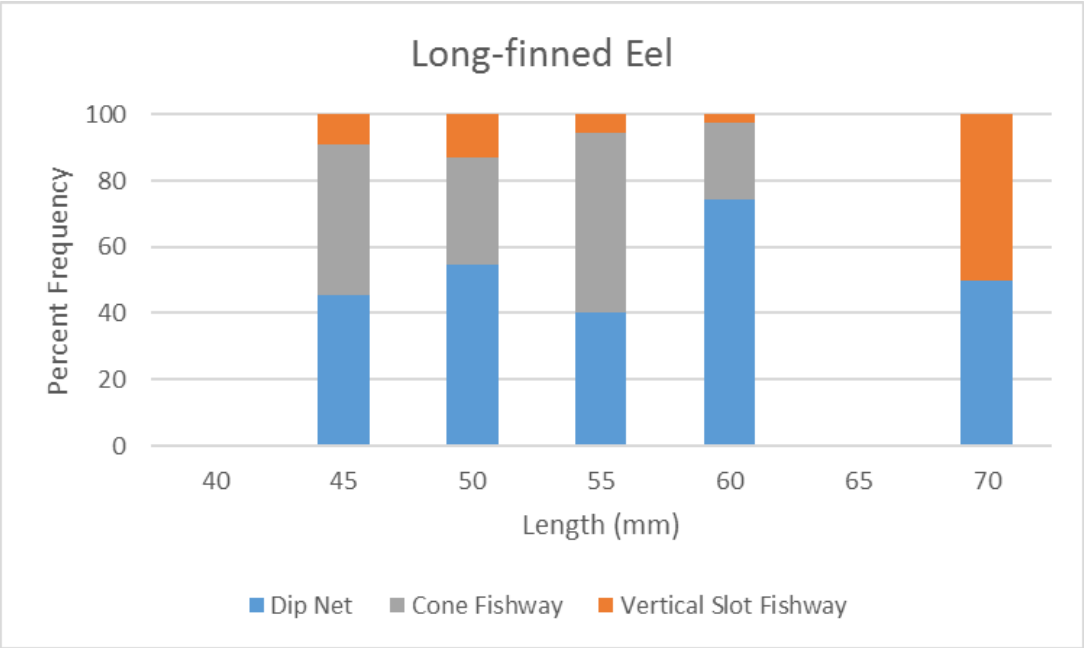

Figure 6. Length frequency of long-finned eels captured in the March 2016 entrance and exit trap samples.

Bony Bream

Data from the length frequency graph for bony bream indicated that most fish passed through the cone fishway and that the cone fishway passed much smaller fish than the vertical slot fishway. In the vertical slot fishway bony bream needed to be larger than 50mm to pass in any great numbers, while the cone fishway passed fish as small as 20mm (Figure 7).

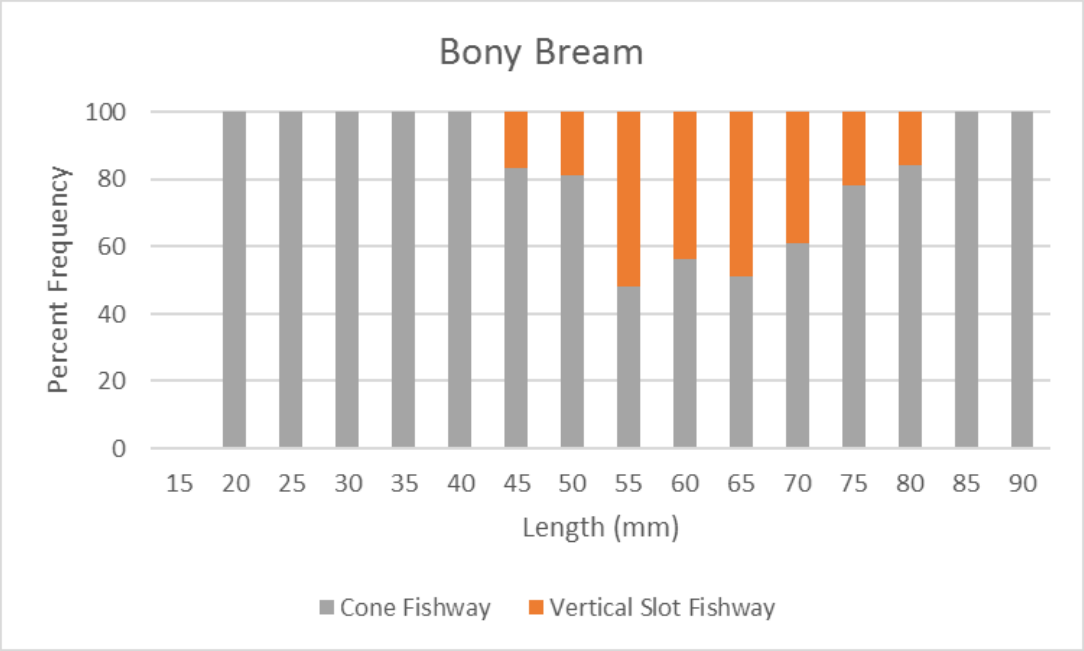

Figure 7. Length frequency of bony bream captured in the March 2016 exit trap samples.

Agassiz's Glassfish

Data from the length frequency graph for Agassiz's glassfish indicated that most fish passed through the cone fishway and that the cone fishway passed much smaller fish than the vertical slot fishway. In the vertical slot fishway fish needed to be larger than 40mm to pass in any great numbers, while the cone fishway passed fish as small as 9mm (Figure 8).

Figure 7. Length frequency of Agassiz's glassfish captured in the March 2016 exit trap samples.

4. Discussion

Restricted passage of the smallest size classes of fish was confirmed in earlier studies of the vertical-slot fishway on the Fitzroy Barrage (Marsden et. al. 2015) and at other vertical slot fishway sites in both tropical and temperate rivers (Stuart and Mallen-Cooper 1999; Stuart and Berghuis 2002; Barrett and Mallen-Cooper 2006; Stuart et al. 2007; Baumgartner et al. 2014). Passage of fish within the existing barrage vertical slot fishway was limited to fish >45 mm long, which in a tropical biodiverse river can exclude hundreds of thousands of individuals per year.

At the Fitzroy Barrage, a new cone fishway was constructed to assist the passage of these small fish past the barrage. The new cone fishway was determined by this study to be quite successful, with large numbers of small fish successfully ascending the fishway. In general, the cone fishway passed seven time more fish than the vertical slot fishway, with many of these fish being of a small size class that could not successfully pass the barrage previously.

A number of species appear to preferentially use the cone fishway instead of the vertical slot fishway, with significantly larger numbers of bony bream, empire gudgeon, fly-specked hardyhead and Agassiz's glassfish ascending the cone fishway. Generally, the individuals of these species that used the cone fishway were smaller than those that used the vertical slot fishway, indicating the limitations that the vertical slot fishway has at passing small fish. Only one species, longtom, were recorded from the vertical slot fishway in greater numbers than the cone fishway. However, it was noted that a number of longtom occurred in the cone fishway, but could not enter the trap due to the smaller mesh on the trap entrance. A number of species were captured in very low numbers from only one of the fishways. Barramundi, striped mullet, mouth almighty, western carp gudgeon, spangled perch, Hyrtl's tandan, sleepy cod and tilapia numbers were too low to establish if they had a preference for either of the fishways, with more sampling required to determine if they preferentially use one fishway type.

A number of species were captured in large numbers that allowed comparison of their length frequencies between the two fishways. The results of this analysis indicated that the cone fishway was able to successfully pass smaller fish than the vertical slot fishway. Species such as the bony bream were able to pass the cone fishway as small as 20mm, less than half the size required to be successful in the vertical slot fishway. Agassiz's glassfish and empire gudgeon also had similar results, with glassfish and empire gudgeon as small as 9mm and 12mm respectively, ascending the cone fishway. The minimum size successful through the vertical slot fishway for glassfish was 25mm and for empire gudgeon was 16mm.

Increasing passage of these smaller fish is critical to the long-term survival of these species. The lack of passage for these small fish was identified as early as 1997 (Figure 8) during sampling of the vertical slot fishway (Stuart 1999). Delaying their successful passage and forcing these fish to congregate below the barrage is likely to have disastrous consequences on their mortality. The area below the barrage is intensively fished by predators such as birds (Figure 9), barramundi and bull sharks. These predators can quickly deplete the stocks of juvenile fish trying to pass the barrage, negatively affecting the production of the whole river system. Successfully passing these fish through the cone fishway, day and weeks earlier than when they could pass through the vertical slot fishway will increase survival rates and increase the productivity of fisheries above the barrage.

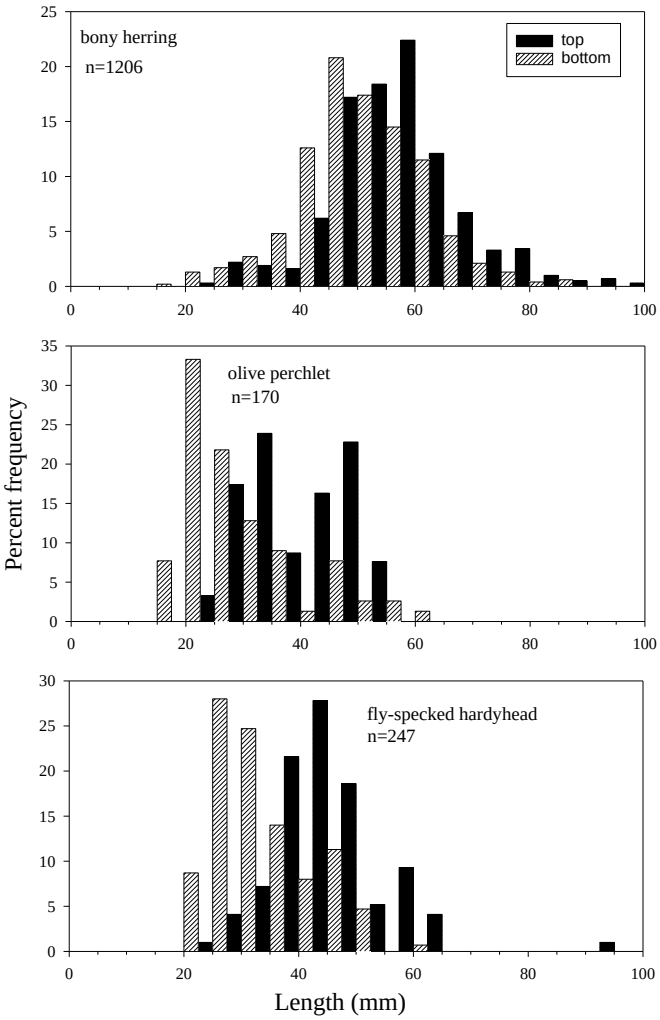

Figure 8. Length frequency of bony herring, Agassiz's glassfish (olive perchlet) and fly-specked hardyhead at the top and bottom of the barrage fishway in 1995-97 (Stuart 1999)

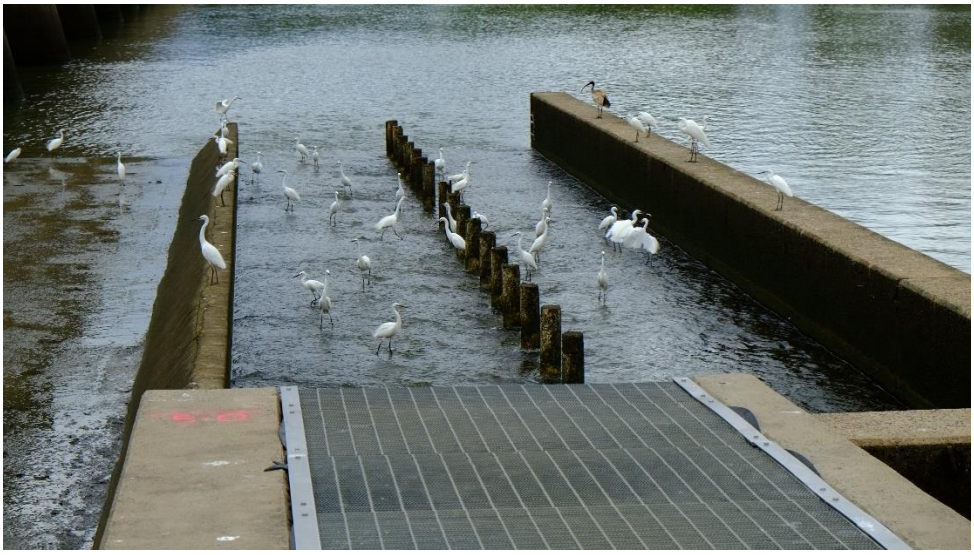

Figure 9. birds feeding on fish ejected from the vertical slot fishway prior to modification.

The new construction also stabilised the tailwater of the existing vertical slot fishway which increased the period of operation of that fishway from approximately 6 hrs per day to 24 hrs per day (Figure 10). The sampling conducted in this study did not identify if this modification has had a positive impact as the objective was to determine the success of the new cone fishway, hence sampling was conducted under different tidal conditions (i.e. small high tides for this study to maximise fishway length and test fishway performance versus previous study that had large high tides to minimise fishway length) however future sampling will determine the impact that this modification has had on the vertical slot fishway. It is anticipated that the modifications have had a significantly positive affect, as fish were observed in the fishway long after they would have been ejected from the fishway under the previous conditions.

Figure 10. Newly constructed tailwater pool for the two fishways has stabilised tailwater for the vertical slot fishway and prevents fish being ejected from the fishway.

The passage of large fish through either of the fishways was not specifically studied during this sampling as we were determining the success of the new fishway for small fish. The methods used would have excluded large fish from the traps, hence the low numbers recorded by the sampling. Barramundi, longtom, catfish and large bony bream were observed in the cone fishway on several occasions during the sampling, so it anticipated that they can successfully ascend this fishway type. Further sampling of large fish in both fishways would be useful in the future to determine the success of the new cone design for these larger fish.

5. Conclusion

The construction of the new cone fishway alongside the vertical slot fishway on the Fitzroy Barrage has increased the passage of small fish species at this site. This was identified as a specific issue in previous sampling at the vertical slot fishway and was the main impetus for the cone fishways development and installation. Previous sampling of the various incarnations of fishway on the Fitzroy Barrage have demonstrated various levels of fish passage (Table XX).

Table xx. The configuration of fishways constructed on the Fitzroy Barrage over the last 45 years

Fishway type	Construct Date	Head loss per Pool (mm)	Maximum water velocity ($m.s^{-1}$)	Turbulence (W/m^3)	Water use (Ml/day)	Estimated Fish Numbers (fish/day)
Pool and weir	1970	150	0.87	215	52	-
Hybrid pool and weir	1987	150	2.50	250	52	45
Vertical-slot	1994	97	1.40	42	18	302
Cone Fishway	2015	80	1.20	<17	8	1577

The 1970's pool and weir fishway and the 1987 modification of this fishway was described as very poor (Stuart 1999), while the vertical slot fishway was estimated to pass over 500,000 fish per year (Stuart 1999). This sampling has demonstrated that the new cone fishway is passing seven times as many fish as the vertical slot fishway and based on the figures from Stuart 1997 would mean that the new fishway may be passing over 3,500,000 fish per year.

This clearly demonstrates the worthwhile investment made in the new fishway at the Fitzroy Barrage.

Future sampling to enhance the current dataset and to specifically capture the juvenile mullet migration will occur in October/November. Once this sampling is complete a full report of the success of the new cone fishway will be completed.

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