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Tedlands and Boundary Wetlands Fish Passage Monitoring

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Cover image. Showing Tedlands rock ramp fishway located on Landing Road (top), showing juvenile empire gudgeons and barramundi captured successfully migrating through the Tedlands rock ramp fishway during the current monitoring activities (bottom left) and Boundary Creek cone fishway located on Marklands wetland (bottom right).

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Background

The Tedlands and Boundary wetlands are an extensive wetland complex situated in the Rocky Dam Catchment, south of Mackay. The wetlands support a wide variety of wildlife and provide critical nursery habitat for many fish species. This includes species with significant value to commercial, recreational and indigenous fisheries (e.g. barramundi, eels and mullet). Over the past five years, significant investment has been made to improve fisheries productivity within the wetlands, with a large part of this investment in the form of fish passage remediation. Fish passage remediation at both wetlands is critical as the extensive earthen bund walls which form the wetland complexes, also create a barrier to fish migration, blocking their access into the wetlands from upper estuarine habitats. Several fishways have now been constructed to improve connectivity between the freshwater wetlands and neighbouring estuarine systems.

Recently, the Sarina Landcare Management Association (SLCMA) in collaboration with Catchment Solutions, were successful in applying for a Communities Environment Program Grant, to undertake fish passage monitoring at the most recently constructed rock-ramp fishway at Landing Road. Importantly, this fishway features a number of key design components pioneered across a number of fish passage rehabilitation projects here in central Queensland. Monitoring this fishway is critical in providing detailed data on the species and size classes utilising the fishway to access the wetlands, and to validate the cost-effective design to promote adoption of this strategy at similar sites throughout Queensland, improving our biodiversity and fisheries stocks.

An opportunity was seen to value add to the Landing Road monitoring by taking advantage of the close proximity of this site to the other fishways at Tedlands and Boundary wetlands. Reef Catchments Limited (RCL) Natural Resource Management group who have contributed significantly to the construction of these fishways, were eager to be involved and contributed extra funding to allow additional monitoring to be undertaken. This contribution meant that an additional three fishways could be monitored concurrently with the Landing Road fishway, increasing the overall data and research which could be undertaken during the monitoring.

It was intended that four fishways were monitored as part of the program. These included:

- Landing Road rock-ramp fishway (Tedlands wetland),
- Eastern bund wall rock-ramp fishway (Tedlands wetland),
- Concrete cone-ramp fishway (Boundary wetlands), and
- Rock-ramp fishway (Boundary wetlands).

Adverse weather conditions prevented access to the eastern bund wall rock-ramp at Tedlands and the Boundary wetlands rock-ramp. The remaining two fishways were monitored on two occasions in February and March 2020.

This report outlines the fish passage structures at each site, details the monitoring results and outlines a number of key conclusions regarding overall fish passage at each of the fishways.

Sites

Tedlands Wetland- Landing Road Fishway

The Landing road causeway was a significant barrier to fish passage, bisecting upper tidal habitats of Rocky Dam creek and the extensive Tedlands wetlands complex. A rock-ramp was constructed at the site in 2008, however prolonged exposure to the marine environment significantly degraded the lower half of the structure. In 2019, funding was secured to repair the fishway. Larger rock and fibre-reinforced concrete was used to increase the functionality and longevity of the fishway (Figure 1). Innovative design features such as deeper resting pools (600mm) were also factored into the repair works. Ridge spacing is 2.0m, with 75mm drops between ridges. The width of the resting pools is 2.0m.

Figure 1. Landings Road causeway barrier (top left), original fishway prior to 2019 maintenance works (top right), fishway during repair works in 2019 where larger wall and ridge rocks replaced existing rock (bottom left) and image during first flow following repairs in 2019 (bottom right).

Tedlands Wetland- Eastern Bund Wall Fishway

The Tedlands wetland eastern bund wall has also been fitted with a rock-ramp fishway. The fishway is a pool/ridge configuration. Pools are 4.0m wide, separated by 75mm drops over the ridges. Ridge spacing is 2.0m. The fishway was constructed in 2015 and provides additional connectivity between the wetlands and the Rocky Dam estuary (Figure 2).

Figure 2. Tedlands Wetland eastern bund wall rock-ramp fishway.

Boundary Wetlands- Concrete Cone-Ramp Fishway

The cone-ramp fishway at the Boundary wetlands was constructed in November 2015 and was retrofitted to an existing causeway on the bund wall (Figure 3). This fishway is a pool/ridge configuration, which uses precast concrete as the ridge components. Ridge spacing in 1.5m, with 75mm drops between ridges. Pool width is 1.4m. The precision of concrete walls and ridges allows for a more compact design. This fishway provides connectivity between the wetlands and the Boundary Creek estuary.

Figure 3. Cone-ramp fishway following dry-season construction in late 2015 (left) and during fishway monitoring, with the fish trap visible at the top of the fishway (right).

Boundary Wetlands- Rock-Ramp Fishway

In 2019, a second causeway was constructed at the Boundary wetlands on the eastern bund wall. This was done to alleviate the pressure on the bund walls during high flows in the wet-season, and reduce the risk of the bund walls being overtopped and damaged. The rock-ramp is a pool/ridge configuration with 2m ridge spacing and 75mm ridge drops. Pool widths are 2m and depth of the pools is 600mm which provides additional connectivity between the wetlands and the Rocky Dam estuary (Figure 4).

Figure 4. Boundary wetlands rock-ramp fishway and causeway following construction in the 2019 dry season. The freshwater wetlands are visible to the left of the image, upper tidal reaches visible on the right.

Methods

Fishway monitoring was conducted on two occasions; 10th - 11th February 2020, and 18th - 20th March 2020. The sampling program was originally anticipated to comprise of a single monitoring event over five consecutive days. High rainfall on the night of the 11th February forced sampling to be postponed until conditions improved. The access tracks to the Boundary rock-ramp and Tedlands eastern bund rock-ramp were impassable during both monitoring occasions due to wet weather conditions, resulting in these sites being excluded from the sampling program.

The monitoring at both the Landing Road rock-ramp and Boundary cone-ramp used the same trap configuration. These traps consisted of a single cone entrance, 120mm wide x 600mm high. The trap frames were constructed from 10mm stainless steel round bar and measured 1.4m x 1.0m 1.1m. Shade cloth (2.0mm mesh size) covered the trap frames. Where necessary, shade cloth wing walls were used to prevent fish from swimming around and under the traps. The traps and wing walls were secured using sand bags.

All fishway traps were positioned at the top of the fishway to ensure all fish captured had ascended the entire fishway. At each site, multiple trap checks were made each day and left in place each night to continue sampling.

Figure 5. Landing Road fishway at Tedlands wetlands during the monitoring, with fishway trap visible in the final cell of the fishway, catching all fish ascending the fishway.

All individual fish captured were identified to species level, counted and measured to the nearest millimetre (fork length for forked-tailed species, total length for all other species). When more than 25 individuals of a single species were captured in any single trapping event, a randomised subset of 25 fish were measured and the remainder only counted to contribute to abundance data. All native fish were then released upstream of the fishway. Pest fish species were euthanised as per Biosecurity Queensland legislation and ANZCCART procedures and disposed of in an appropriate manner.

Results

Tedlands Wetland- Landing Road Fishway

Fishway monitoring at the Landing Road fishway was conducted for a total sampling time of 3.05 days (73.08 hours). In total, 16,223 individual fish representing seven native species were captured at an overall rate of 5,327.51 fish successfully ascending the fishway per day (Table 2). Diadromous (migrate between sea and freshwater to complete their life-cycle) individuals represented 99.01% (n=16,062) of the total catch, whilst the size range of all fish captured ascending the fishway ranged between 16mm and 157mm, with the median size of all fish captured equating to 34mm.

Empire gudgeon (*H. compressa*) were the most abundant species (5,266.75 fish/day) making up 98.86% of the total catch, followed by eastern rainbowfish (*M. splendida*) (29.56 fish/day), Agassizi's glassfish (*A. agassizii*) (22.99 fish/day) and barramundi (*L. calcarifer*) (5.25 fish/day). Following this, the remaining three species were captured in relatively low abundances ≤5 individuals. The smallest fish recorded was a 16mm empire gudgeon, whilst the largest species recorded was a 157mm tarpon (*M. cyprinoides*), with the largest individuals of remaining species <90mm.

Water quality parameter variation between upstream and downstream of the fishway were generally consistent for each trap set period (Table 2). Over the monitoring period, temperature upstream of the fishway (within the wetlands) ranged from 24.7°C to 28.1°C, and between 24.7°C and 28.3°C downstream of the fishway. The pH ranged from 5.2 to 6.02 upstream and 5.54 to 6.09 downstream, whilst electrical conductivity showed little variation, ranging from 111µs/cm to 185µs/cm upstream and 112µs/cm to 183µs/cm downstream. Dissolved oxygen saturation ranged between 3.6% and 28.8% saturation upstream and 17.6% and 41.7% saturation downstream. A general trend was observed towards increasing dissolved oxygen concentrations moving from upstream to downstream of the fishway, due to the oxygenation of turbulent water moving through the fishway.

Table 1. Water quality parameter readings taken upstream (US) and downstream (DS) of the fishway at the commencement of each trap set period. Readings in bold indicate parameters outside typical ranges and may impact fish movement.

Sample Date & Time	Location (US/DS)	Temp. (°C)	pH	E.C. (µs/cm)	D.O. (% sat.)
10-02-20 17:00	US	28.1	5.2	185	**3.6**
	DS	28.3	5.54	183	17.6
18-03-20 10:00	US	25.8	5.89	111	**10.9**
	DS	25.9	5.88	112	28.8
18-03-20 15:15	US	27.5	1.73	116	22.3
	DS	*	*	*	*
19-03-20 9:00	US	24.9	5.93	111	**8.01**
	DS	25.4	6.04	115	27
19-03-20 14:05	US	27.6	5.72	120	23.9
	DS	27.7	5.8	120	41.7
19-03-20 16:50	US	27.2	5.84	118	22.4
	DS	27.3	5.85	119	41.6
20-03-20 8:15	US	24.7	6.02	116	**4.9**
	DS	24.7	6.09	117	24.3
20-03-20 11:30	US	27.8	5.79	124	28.8
	DS	27.4	5.62	124	34.8

* Indicates water quality readings unable to be taken

Table 2. Species captured during fishway monitoring at the Landing Road fishway, separated into migratory classifications and displaying the minimum, maximum and median sizes (mm) as well as the total individuals captured, total number of species and catch per unit effort expressed as fish per day.

Migration Classification	Species	Common Name	Size			Total Individuals	CPUE (fish/day)
			Min. (mm)	Median (mm)	Max. (mm)		
Diadromous	*Hypseleotris compressa*	Empire gudgeon	16	20	79	16, 038	5, 266.75
	Lates calcarifer	Barramundi	31	55.5	89	16	5.25
	Megalops cyprinoides	Tarpon	83	100	157	5	1.64
	Selenotoca multifasciata	Banded scat	32	35.5	42	3	0.99
Potamodromous	*Ambassis agassizii*	Agassizi's glassfish	25	32	39	70	22.99
	Leiopotherapon unicolor	Spangled perch	45	-	-	1	0.33
	Melanotaenia splendida	Eastern rainbowfish	23	36	65	90	29.56
	Overall Min., Median, Max., Total Individuals and CPUE		**16**	**34**	**157**	**16, 223**	**5, 327.51**
	Total Species				**7**		

**Note: where only a single individual was netted and/or measured, there is no median or maximum size indicated.*

Figure 6. Top to bottom, left to right, 1) panoramic image of Landing Road fishway in flow during monitoring, 2) close up image of empire gudgeon (*H. compressa*), Agassizi's glassfish (*A. agassizii*) eastern rainbowfish (*M. splendida*) and barramundi (*L. calcarifer*), 3) young-of-year barramundi recruit with fishway in the background, 4) and 5) typical mixed species trap haul, comprised primarily of high numbers of juvenile empire gudgeon.

Boundary Wetlands- Concrete Cone-Ramp Fishway

Fishway monitoring at the Boundary wetlands cone-ramp fishway was conducted for a total sampling time of 3.38 days (81.17 hours). In total, 4,602 individual fish representing 11 native species were captured at an overall rate of 1,360.76 fish successfully ascending the fishway per day (Table 4). Diadromous individuals represented 46.76% (n=2,152) of the total catch, whilst the size range of all fish captured ascending the fishway ranged between 15mm and 380mm, with the median size of all fish captured equating to 31mm.

Empire gudgeon (*H. compressa*) were the most abundant species (552.05 fish/day) making up 40.57% of the total catch, followed by eastern rainbowfish (*M. splendida*) (504.44 fish/day) which comprised 37.07% of the total catch and Agassizi's glassfish (*A. agassizii*) (213.19 fish/day). The smallest fish recorded was a 15mm empire gudgeon, whilst the largest species recorded was a 380mm fork tailed catfish (*A. graeffei*), with the largest individuals of remaining species <110mm. See Figure 7 for field images of species captured.

Water quality parameter variation between upstream and downstream of the fishway were generally consistent for each trap set period (Table 3). Over the monitoring period, temperature upstream of the fishway (within the wetlands) ranged from 25.1°C to 32.4°C, and between 25.1°C and 32.5°C downstream of the fishway. The pH ranged from 6.12 to 6.47 upstream and 6.04 to 6.52 downstream, whilst electrical conductivity ranged from 160µs/cm to 405µs/cm upstream and 129µs/cm to 409µs/cm downstream. Dissolved oxygen saturation ranged between 46.1% and 84.4% saturation upstream and 54.2% and 81.6% saturation downstream.

Table 3. Water quality parameter readings taken upstream (US) and downstream (DS) of the fishway at the commencement of each trap set period.

Sample Date & Time	Location (US/DS)	Temp. (°C)	pH	E.C. (µs/cm)	D.O. (% sat.)
10-02-20 15:10	US	32.4	6.12	405	46.1
	DS	32.5	6.12	409	56.1
18-03-20 9:00	US	25.1	6.42	160	55
	DS	25.1	6.43	169	54.2
18-03-20 14:20	US	28.3	6.14	170	66.8
	DS	28.3	6.04	173	71.4
18-03-20 16:45	US	28.8	6.37	171	84.4
	DS	28.7	6.37	129	81.1
19-03-20 12:45	US	27.1	6.33	236	62.2
	DS	27.2	6.41	242	68.3
19-03-20 15:30	US	28.6	6.47	225	74.5
	DS	28.6	6.52	224	81.6
20-03-20 9:50	US	25.5	6.47	225	51.7
	DS	25.5	6.44	224	59.1
20-03-20 13:10	US	27.2	6.28	238	55.7
	DS	28	6.33	236	65.5

Table 4. Species captured during fishway monitoring at the Boundary wetlands cone-ramp fishway, separated into migratory classifications and displaying the minimum, maximum and median sizes (mm) as well as the total individuals captured, total number of species and catch per unit effort expressed as fish per day.

Migration Classification	Species	Common Name	Size			Total Individuals	CPUE (fish/min)
			Min. (mm)	Median (mm)	Max. (mm)		
Diadromous	*Ambassis vachellii*	Vachelli's glassfish	25	37.5	47	10	2.96
	Anguilla reinhardtii	Long-finned eel	58			1	0.30
	Arius graeffei	Fork-tailed catfish	41	51	380	121	35.78
	Gerres filamentosus	Threadfin silver-biddy	22	27.5	32	7	2.07
	Hypseleotris compressa	Empire gudgeon	15	23	78	1, 867	552.05
	Lates calcarifer	Barramundi	25	47	108	95	28.09
	Megalops cyprinoides	Tarpon	24	63	69	25	7.39
	Selenotoca multifasciata	Banded scat	19	27	42	26	7.69
Potamodromous	*Ambassis agassizii*	Agassizi's glassfish	19	32	48	721	213.19
	Leiopotherapon unicolor	Spangled perch	33	46	69	23	6.80
	Melanotaenia splendida	Eastern rainbowfish	18	23	66	1, 706	504.44
	Overall Min., Median, Max., Total Individuals and CPUE		**15**	**31**	**380**	**4, 602**	**1, 360.76**
	Total Species				**11**		

**Note: where only a single individual was netted and/or measured, there is no median or maximum size indicated.*

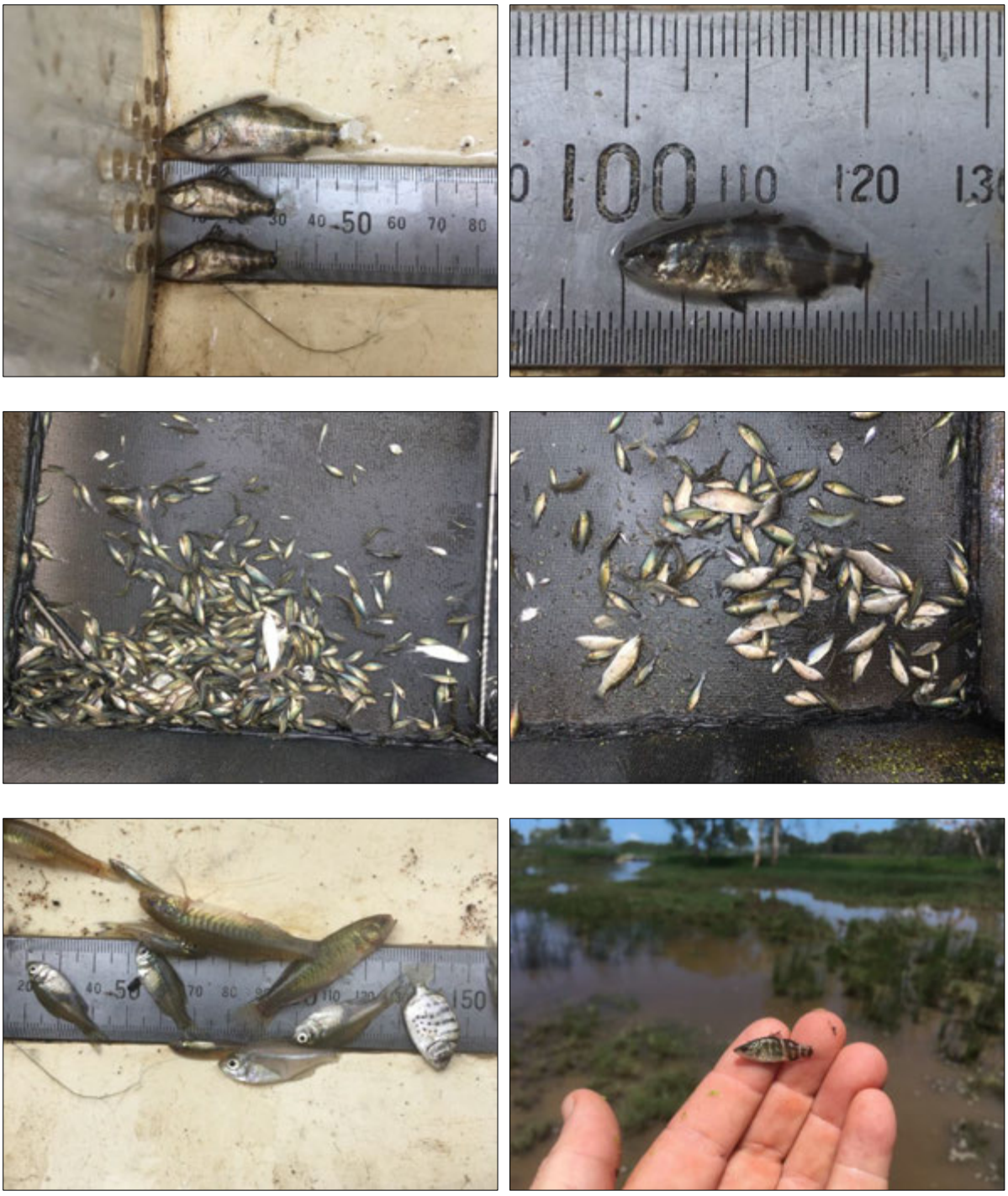

Figure 7. Top left to bottom right, 1) Juvenile barramundi (*L. calcarifer*), 2) smallest barramundi captured ascending the cone-ramp at 25mm, 3) typical mixed species trap haul, 4) single trap haul consisting of 49 juvenile barramundi recruits amongst other species, 5) close up image of empire gudgeon (*H. compressa*), Agassizi's glassfish (*A. agassizii*) and banded scat (*S. multifasciata*), and 6) juvenile barramundi showing supralittoral post-larval habitat in the background.

Discussion & Key Findings

The time of year sampling was conducted (wet-season) is generally considered to coincide with peaks in fish movement throughout the central and northern Queensland. Increased stream flow in the weeks prior to monitoring provided ideal conditions for fish passage monitoring and in stimulating fish migration.

Tedlands Wetland- Landing Road Fishway

During the first overnight monitoring period across February 10th and 11th, overall catch rates and species diversity were discernibly lower than recorded at the Boundary wetlands cone-ramp for the same period. This was attributed to the poor quality of water (low dissolved oxygen saturation) discharging from the wetlands during these early wet-season flows. This is evident in the upstream dissolved oxygen reading taken at the commencement of the first trap set period on February 10th at 5:00PM, where dissolved oxygen was recorded at 3.6% saturation. This is considered hypoxic and is below tolerance levels for fish communities within the wetlands. These results were consistent with previous years monitoring of the two wetlands.

Figure 8. Left; water quality meter showing dissolved oxygen reading of 5.25% during February monitoring, and right; juvenile barramundi (L. calcarifer) monitored ascending the fishway when dissolved oxygen levels in the wetlands returned to tolerable levels in March.

Catch rates and species diversity increased considerably during the second round between March 18th and 20th, which coincided with improved dissolved oxygen levels during the daytime sets. Notably, the dissolved oxygen levels fluctuated considerably throughout the day, dropping below tolerable limits of many species during the evening. This was reflected in poorer catches in the overnight trap sets, and through the dissolved oxygen readings taken upon arriving at the site each morning. Morning DO readings upstream of the fishway were 10.9%, 8.01% and 4.9% for each of the consecutive three days (Table 1).

The reduction of DO to hypoxic conditions overnight is of concern. There is the possibility under particular weather conditions (e.g. still, overcast days) that oxygen levels may fall below tolerance limits for extended periods ($6h^{+}$) and cause fish kills. The low DO levels in Tedlands have been attributed to the overgrowth of the invasive weed *Hymenachnae ampiplexis* (Hymenachnae). It is recommended that Hymenachne control continues to increase and maintain the amount of open water. It is also recommended that more in depth investigations into ambient water quality conditions throughout the wetlands be undertaken, especially of dissolved oxygen.

Despite the variable catches, it appeared that remediation work is having a positive effect on the fish habitat condition of the Tedlands wetlands. Control programs which aimed at reducing the coverage of Hymenachne, have resulted in larger areas of open water. This allows greater light penetration, providing favourable conditions for submergent macrophytes and phytoplankton to establish, increasing oxygen production during daylight hours.

Importantly, the capture of 16 young-of-year barramundi (*L. calcarifer*) recruits during the second monitoring period show that the fishway is having the desired effect, allowing species of high fisheries significance access to the wetland nursery habitats. Furthermore, extremely high numbers of empire gudgeons (*H. compressa*) which are a small diadromous fish, were monitored entering the wetlands, which shows the fishway is functioning as anticipated and boosting the wetlands overall biomass.

Boundary Wetlands- Concrete Cone-Ramp Fishway

Monitoring results at the Boundary wetlands cone-ramp fishway were relatively consistent in terms with previous years and to other similar interface barriers in the region. This indicates good connectivity is provided by the fishway.

Numbers of juvenile barramundi (*L. calcarifer*) recruits ascending the fishway were the highest recorded from the region and likely the highest recorded in Australia, with 89 captured in a single 24-hour period. This is a significant outcome, with barramundi being the highest economical contributor to the regions commercial and recreational fisheries. To put the high numbers of barramundi captured ascending the fishway into perspective, the average daily catch rate of barramundi recorded migrating through the Fitzroy River barrage fishway in Rockhampton is just 3.55 fish per day. The fishway provides critical access for young barramundi to wetland habitats, where they can grow rapidly utilising the abundance of food resources and refuge habitat. This increases the productivity of the wetlands, and provides a boost to the region's fisheries resources. The catch rates of barramundi at the site reduced in March, which is in line with a tapering of the recruitment migration season for this species.

Figure 9. Panoramic image showing the fishway in the left foreground, which boosts the regions fisheries resources through allowing aquatic connectivity between the Boundary Creek estuary (left of image) to the extensive Boundary wetlands (right of image). The image is taken from the concrete causeway, which creates the barrier between the two water bodies.

In the Boundary wetlands (upstream water quality measurements), water quality was within the tolerable limits of fish species expected to occur within the wetland habitat. Dissolved oxygen was significantly higher in these wetlands, with the lowest measurement recorded at 46.1% oxygen saturation. Provided sufficient open water can be maintained, it is expected that the fish habitat value of these wetlands will continue.

In the 2018 and 2019 dry seasons, the Boundary wetlands went dry. In the hope of remediating this, large refuge pools measuring 30m long x 2.5m deep and 8m wide, were constructed in 2019. These pools are expected to provide dry season refuge for fish until the wetlands refill each wet season, with more refuge habitats expected to be constructed in the future as climate change impacts intensify as predicted.

While restricted access prevented sampling of the new rock-ramp fishway, it is expected that the new fishway will provide high levels of connectivity between the wetland and the estuary, based on monitoring of other fishways in the region with the same design features and on similar barrier types.

Notes:

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