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Macs & Alligator Creek Wetlands Fish Community Assessment 2023

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Cover image: From top, left to right; Showing the suite of rehabilitation works that occurred at Macs wetland in 2022 (main image), a 300 mm long tarpon recorded during electrofishing surveys in June 2023 (bottom left). The wetland was completely dry during rehabilitation works in late 2022, so this tarpon has migrated into the wetland via the rock ramp fishway as a juvenile and grown to a sub-adult in 6 months. A selection of fish species recorded during post rehabilitation surveys, including striped scat (diadromous), spangled perch, empire gudgeon (diadromous), bony bream, fly-specked hardyhead and Olive perchlett (center image). A sub-adult giant herring which had successfully migrated into the lowland wetland as a juvenile and grown into a subadult. Giant herring utilise lowland wetlands as nursery habitats before migrating back to marine waters to spawn.

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Project Background

Reef Catchments Limited (RCL) contracted Catchment Solutions (CS) to undertake remediation works to improve aquatic connectivity and in-stream habitat at two wetland complexes. The wetlands are located in the lower Alligator Creek Catchment on a property south of Mackay, QLD (**Figure 1**). Two fishways were constructed by CS on the bund wall outlets of Macs and Alligator Creek wetlands in December 2022. RCL approached CS to undertake fish community assessments at both sites which were conducted on 26th of June 2023. The fish community surveys aimed to assess the effectiveness of the wetland rehabilitation works on resulting native fish communities and wetland health. The surveys were carried out after two flow events that allowed fish to migrate into the remediated wetlands via the recently constructed fishways. The two flow events occurred in January and April 2023 and lasted for approximately 14 and 7 days respectively.

Figure 1: Map showing location of Macs and Alligator creek wetland complexes.

In December 2022 the recently rehabilitated wetland complexes were completely dry with no fish present. All fish recorded in the current surveys have either entered the wetlands during the two flow events (approximately 21 flow/access days), or successfully recruited via spawning events within the wetlands. For all diadromous fish species which reproduce in marine waters and were recorded during the surveys e.g., tarpon, giant herring, sea mullet, striped scat and empire gudgeon, their occurrence within the wetlands can be directly attributed to fish passage improvements (e.g., rock ramp fishway) which occurred in December 2022. For all potamodromous fish species (breed in freshwater) e.g., eastern rainbowfish, bony bream, fly-specked hardyhead and spangled perch, their presence within the wetlands can be attributed to both connectivity improvements allowing access for adults to enter, and in-stream habitat improvements e.g., refuge pools, large woody debris, invasive aquatic weed management providing the correct conditions for spawning and recruitment. Therefore, all fish communities currently within the wetland are a direct result of the fish passage connectivity improvements in combination with in-stream wetland rehabilitation works. In unison, these habitat rehabilitation works have provided essential access, shelter, and food resources to sustain the fish communities currently within Macs and Alligator Creek wetlands that are detailed below within this report. Over the succeeding years its anticipated that fish species richness and abundance will increase

in-line with increased access opportunities in combination with spawning and recruitment within the wetlands.

The surveys aimed to gather data that can be used for various purposes. This includes gaining an understanding of fish species richness, abundance (Catch per unit effort (CPUE)), and size distributions throughout the recently remediated habitats. Fish are excellent indicators of aquatic ecosystem health, so obtaining this data will provide an indication of the health of the rehabilitated ecosystems in the early stages since remediation works were undertaken. A fish community survey was undertaken in Macs wetland before the remediation works occurred in September 2021. Data obtained in the previous survey and the current survey will be compared to determine changes since remediation works were carried out.

Before the remediation works, both wetlands often completely dried up or suffered from anoxic conditions as a direct result of excessive hymenachne growth. This shallow, hot and low dissolved oxygen environment impacted fish community condition and overall aquatic ecosystem health. To mitigate this, deep pool refuge habitats (>2.5 m) and channels (>1.2 m) were excavated throughout the wetlands in December 2022. The construction of deep pool refugia has multiple benefits. The deep pools assist with mediating water temperatures, particularly in tropical environments, provide water during the dry season, and reduces the prevalence and growth of invasive aquatic weeds, particularly hymenachne. Hymenachne is a semi-aquatic grass species which is capable of setting roots within the substrate in wetlands less than 1.5 m in depth. If left unmanaged, hymenachne can form floating rafts allowing this invasive species to occupy deeper wetlands up to 3 m in depth e.g., Tedlands wetlands (550 ha) at Koumala, central QLD. Furthermore, the landholder is implementing control measures including a rotational grazing strategy that allows livestock to feed on the hymenachne periodically during the dry season when water levels are reduced, and intermittently spraying herbicides as a control measure. Included as part of the remediation works, large woody debris' were installed within the wetlands to provide habitat complexity, and for fish and other aquatic fauna to seek shelter and food resources.

Figure 2: Drone captured photo of Macs wetland, facing West.

Electrical conductivity (EC) was tested at each wetland prior to undertaking fish community surveys. Unfortunately, the Alligator Creek wetlands were unsuitable for electrofishing due to EC exceeding the tolerable limits (6500 µs/cm). As a result, additional survey sites were completed in Macs wetlands. Due to funding requirements, the surveys had to be completed prior to June 30, 2023. If

funding becomes available in the future, it's recommended that water quality analysis is undertaken later in the year and/or following rainfall events which may reduce EC at the Alligator Creek site an allow electrofishing surveys to occur. Notwithstanding this, fish community monitoring of the Alligator Creek wetland fishway occurred using fish traps in April 2023. The same surveys were also completed concurrently at the Macs wetland fishway. At the Macs wetland fishway site, 12 of the 13 fish species recorded ascending the fishway were monitored during electrofishing surveys. Therefore, the fishway assessment at Alligator Creek would likely provide a good indication of the fish species present in the wetlands. Six sites were sampled within the Macs wetlands complex (Figure 3).

This report briefly presents an overview of the methodologies used and the outcomes obtained from the fish community survey. Additionally, an evaluation of the effectiveness of the remediated habitat in supporting native fish species will be provided.

Methods

Electrofishing

Electrofishing was conducted within Macs wetland to provide an indication of fish populations and size distributions. The area surveyed was approximately 5.0 ha. The electrofishing survey was conducted using a small boat electrofishing unit (the 'electrolyte'). Electrolyte is a 3.7 m vessel which operates A Smith-Root 2.5GPP electro-fisher unit, equipped with a single boom arm, six dropper anode array, and hull cathode. An operator and single dip-netter were utilised during operations on Electrolyte.

Throughout electrofishing operations, control settings were adjusted based on the electrical conductivity of the water on-site to maximise the efficiency of electrofishing operations. Sampling was conducted at various depths and encompassed all in-stream habitats within the site reach. During sampling, the boat was manoeuvred in and out from the streambanks as well as parallel to the banks in deeper water. The electrofishing methodology used was a combination of power on, and power off for the duration of the sampling effort. Power-on time was recorded to standardise results by Catch Per Unit Effort (CPUE). The effective electric field of the unit was approximately a 2 m radius (centred on the anode) to a depth of 2 m below the water surface.

Fish positively identified during electrofishing operations but not netted were also recorded and contributed towards abundance and assemblage data. All fish captured during electrofishing sampling were identified to species level, counted, and measured to the nearest millimetre (fork length of forked-tail species, total length for all other species). If large numbers of a species were captured during a single operation, a random subset of 20 individuals were measured, with the remaining fish counted and contributing only to abundance data. After processing, all native fish were released within the reach or waterbody they were captured from. Pest fish species caught were measured and euthanised as per Biosecurity Queensland legislation and ANZCCART procedures and disposed of in an appropriate manner.

Figure 3: Map showing sites which were sampled in Macs wetland.

Water Quality Parameters

Before commencing electrofishing, water quality measurements were taken throughout the survey area at each wetland. Parameters were measured at 0.6 m below the water surface. Readings were allowed to stabilise before parameters were recorded. The parameters recorded were;

- Ph
- Dissolved Oxygen (mg/L & % saturation)
- Electrical Conductivity (µs/cm)
- Temperature (°C)
- Depth (m)

Results

Fish Community

Fish community assemblage within Macs wetland consisted of a broad range of diadromous (reproduce in marine waters) and potamodromous (reproduce in freshwater) species. In total, 13 species were recorded post wetland remediation, comprising 6 diadromous, 6 potamodromous, and 1 invasive species (*Gambusia holbrooki* ;Table 1). Species richness increased by two since pre wetland rehabilitation monitoring, with the only species not captured during the post monitoring being Rendahl's catfish (*Porochilus rendahli)* and barramundi (*Lates calcarifer*). It should be noted however that a barramundi was recorded successfully ascending the fishway during fishway monitoring studies in early April 2023. The four additional species recorded during post wetland rehabilitation surveys included three diadromous species; giant herring (*Elops hawaiensis)*, sea mullet (*Mugil cephalus)*, and banded scat (*Selenotoca multifasciata)* and one potamodromous species; bony bream (*Nematalosa erebi)*.

Total catch per unit effort during post monitoring equated to 75.3 fish/min (of electrofishing power on time). This is a decrease of 3.17 fish/min since pre monitoring. It's anticipated with additional breeding and access opportunities into the wetlands in the succeeding years that both species richness

and relative abundance will continue to increase. Invasive species were in reasonably low numbers, accounting for only 17.2% of the total catch (n=2131). The most abundant species within the wetland was bony bream (*N. erebi)* with 26.43 fish/min followed by mosquito fish (*G. holbrooki*) recorded at 12.97 fish/min.

Table 1: Macs wetland – Pre and post remediation works. Fish species, migration classification, and Catch Per Unit Effort (CPUE/mins)

Migration Class	Species Name	Common name	Pre CPUE	Post CPUE
Potamodromous	*Ambassis agassizii*	Agassizi's glassfish	12.01	7.00
	Craterocephalus stercusmuscarum	Flyspecked hardyhead	41.46	4.31
	*Gambusia holbrooki***	Mosquito fish	0.13	12.97
	Leiopotherapon unicolor	Spangled perch	1.89	6.11
	Melanotaenia splendida splendida	Eastern rainbowfish	3.89	6.01
	Mogurnda adspersa	Purple-spot gudgeon	0.16	0.07
	Nematalosa erebi	Bony bream	-	26.43
	Porochilus rendahli	Rendahl's catfish	3.34	-
Diadromous	*Anguilla reinhardtii*	Long-finned eel	0.17	0.04
	Elops hawaiensis	Giant herring	-	0.07
	Hypseleotris compressa	Empire gudgeon	15.22	9.22
	Lates Calcarifer	Barramundi	0.13	-
	Megalops cyprinoides	Tarpon	0.08	0.71
	Mugil cephalus	Sea mullet	-	0.04
	Selenotoca multifasciata	Banded scat	-	2.33
** Invasive Species		**Total CPUE**	**78.48**	**75.30**
		Total Species	**11**	**13**

Figure 4: Some of the fish species captured during Macs wetland fish community survey. Left to Right - Banded scat (*S. multifasciata*); Spangled perch (*L. unicolor*); Empire gudgeon (*H. compressa*); Bony bream (*N. erebi*); Fly-specked hardyhead (*C. stercusmuscarum*); Agassizi's glassfish (*A. agassizii*).

The largest fish captured during post remediation monitoring was a giant herring (*Elops hawaiensis)* with two individuals recorded at 272 mm and 290 mm. These diadromous fish have rarely been captured in the region during previous waterway and wetlands surveys. Giant herring utilise lowland wetlands as nursery habitats during their early life-history before migrating downstream to estuarine and near shore marine habitats associated with the Great Barrier Reef. Bony Bream (*N. erebi*) were the next largest fish and ranged from 45 mm and 288 mm in length, with a median size of 53 mm. The broad size range of these fish may indicate that they are successfully breeding in the wetland. A

comparison in the median lengths of the fish captured during fishway monitoring in early April 2023 (Figure 5) and the fish community survey suggests that aside from Agassizi's glassfish (*Ambassis agassizii*) all fish species recaptured in the electrofishing program had increased considerably. This shows that the rehabilitated wetlands are providing ideal conditions (food resources and shelter) for the growth and reproduction of coastal freshwater fish communities.

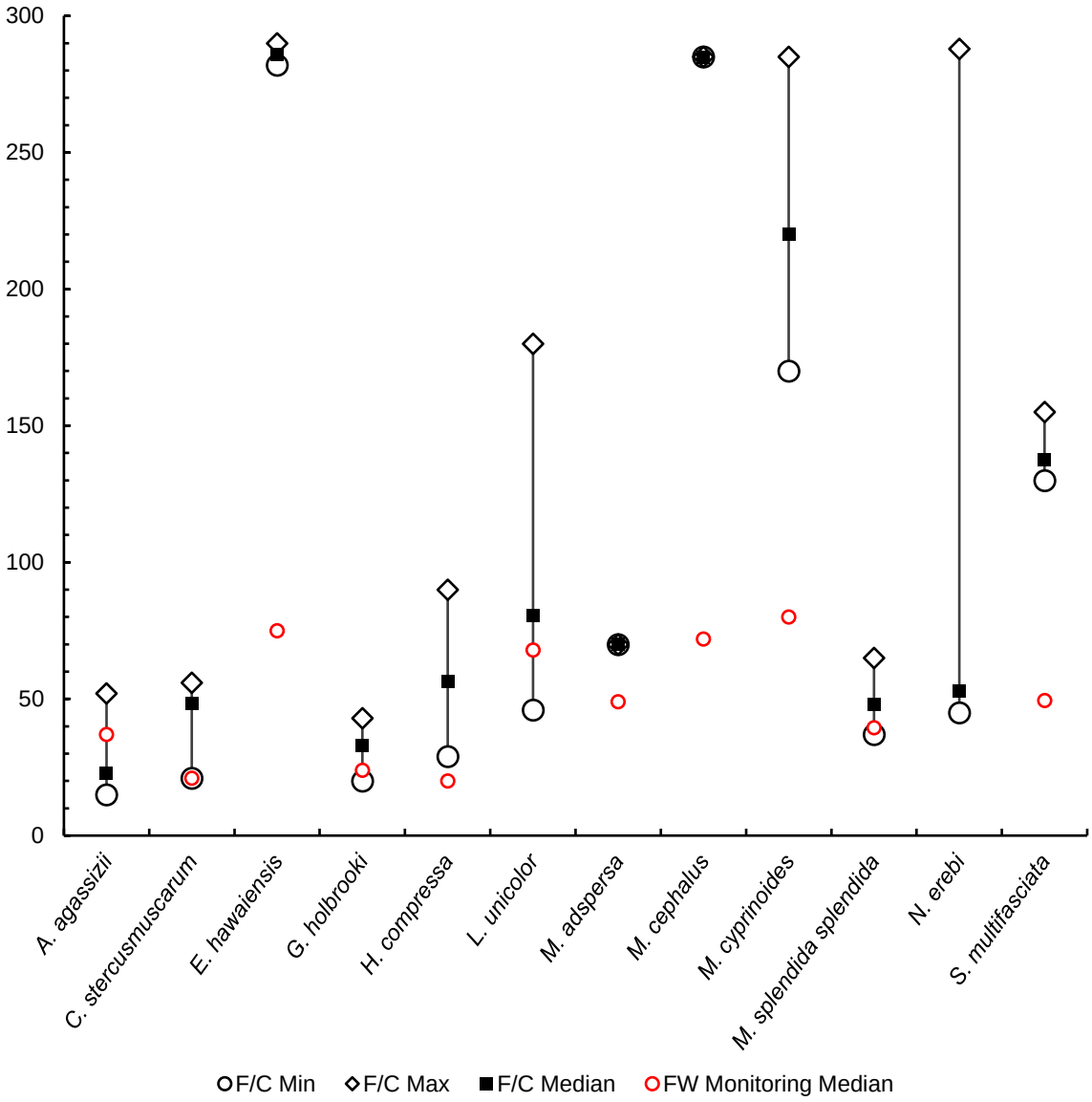

Figure 5: Chart showing the minimum, maximum, and median lengths of fish species captured during fish community surveys (Black). The red circles show the median lengths of fish species captured during fishway monitoring in early April 2023.

Figure 6: Largest fish captured during fish community monitoring. Top: giant herring (*E.hawaiensis*); bottom left: bony bream (*N.erebi*); bottom right: Sea mullet (*M. cephalus*). All of the fish shown here were captured at Site 5 at Macs wetland.

Water Quality

The water quality parameters were relatively uniform throughout all the sites sampled in Macs wetland. A gradual increase in DO and temperature could be seen between the first and last recordings. This is likely due to photosynthesis (increasing dissolved oxygen) increasing in the wetlands in-line with light exposure. The water quality is excellent for sustaining the fish species and populations recorded in the wetland.

Table 2: Water quality parameters recorded during Macs wetland sampling.

Date/Time of reading	Location	Temperature (°C)	DO (mg/L)	DO (%sat)	EC (us/cm)	pH
27/06/2023 9:50	Site 1	20.3	2.57	28.5	340	7.83
27/06/2023 10:30	Site 2	21.4	4.02	47.9	355	7.59
26/06/2023 11:45	Site 3	22.7	4.57	55.1	368	7.49
26/06/2023 13:00	Site 5	25.1	5.08	60.5	350	7.45

Discussion and Conclusion

The results of the fish community survey at Macs wetland indicate a highly productive ecosystem suitable for sustaining coastal fish populations. A diverse range of fish species, sizes, and life-stages were recorded in the wetland. This demonstrates that the wetland rehabilitation works (in-stream habitat and improved connectivity) are providing ideal conditions (food resources and shelter) for coastal wetland fish communities. There is also evidence of substantial breeding within the wetlands, with electrofishing surveys recording large schools of bony bream, eastern rainbowfish, Agassiz's perchlett and fly-specked hardyhead comprising different cohorts (size ranges), including many

juveniles. High growth rates were also noted, particularly for tarpon and giant herring. A giant herring recorded during fishway monitoring in April 2023 measured 72 mm. Giant herring breed in marine waters before migrating into freshwater wetlands as juveniles e.g. 72 mm. Two giant herring recorded during electrofishing surveys measured 272 and 290 mm. It's likely that these giant herring belong to the same cohort of fish recorded moving through the fishway. This would indicate rapid growth of approximately 50 mm per month (from 72 mm to 272 mm in 2 months).

Figure 7. Showing juvenile giant herring. Left; 72 mm giant herring recorded successfully ascending the Macs wetland fishway in April 2023. Right, potentially a giant herring belonging to the same cohort recorded in the wetland during electrofishing surveys in late June 2023 now at 272 mm, representing a potential growth rate of approximately 50 mm per month. Giant herring cannot breed in the freshwater wetland and the wetland was completely dry in December 2022. The only way giant herring could access the wetland was via the fishway during the approximately 21 flow days across two events in January and April 2023.

Water quality, particularly dissolved oxygen levels (D.O), were within expected parameters considering current hymenachne extent within the wetland. Hymenachne biomass and extent is expected to reduce as grazing opportunities increase when the water levels gradually recede during the dry season. Despite this, the wetland still has the ability to self-sustain D.O levels due to the rehabilitation works creating favourable conditions for the growth of submergent aquatic macrophytes. Furthermore, the recently constructed deep open water refuge pools provide suitable conditions for wind waves to provide oxygen to the wetlands surface water layers via diffusion. This diffusion would not have been possible without the constructed refuge pools reducing the prevalence and extent of hymenachne. Prior to these deep refuge pools, the wetland was less than 800 mm in depth, and this allowed hymenachne to grow completely across the wetland, resulting in minimal to no open water areas, and inadequate conditions for the formation of wind waves.

Figure 8: Left- Removing hymenachne from shallower sections of Macs wetland during electrofishing; Right- The deep channel excavated along the southern side of the wetland successfully prevented hymenachne from growing across.

While fish community surveys could not be carried out at the Alligator Creek wetlands, the water quality measurements suggest that the conditions are suitable for sustaining fish populations (Table 3). Visual observation of the wetlands was undertaken, and mullet species and tarpon were observed. There was very little hymenachne growth when compared to Macs wetland, which may be due to the higher salinity in the water. A diverse range of fish species were recorded entering the Alligator Creek wetland during fishway monitoring, which occurred concurrently with the Macs wetland fishway monitoring in early April 2023. The species captured during this monitoring can be seen in

Table 4, and provide an indication of the fish communities likely present within the rehabilitated wetlands.

It's recommended that water quality analysis be undertaken in the future to determine conductivity levels and identify whether conditions improve to allow electrofishing surveys to occur. It's also recommended that fish community monitoring of the wetlands (fishway trap sampling and wetland electrofishing) occur on an annual or bi-annual basis to assess potential improvements in fish species richness and abundance within the rehabilitated wetlands over time. This will provide important information to government funding bodies, land managers, farmers and interested local community members and highlight the importance of coastal wetlands and the benefits derived from rehabilitation. The benefits include but are not limited too; increasing populations of socio-economic fish species, improvements in water quality flowing to downstream receiving environments including the Great Barrier Reef, improved wetland health and resilience, improved biodiversity (e.g. birds and another aquatic fauna) and improved grazing management and farm productivity.

Table 3: Water quality parameters recorded at Alligator creek wetland 26/06/2023.

Temperature (°C)	24.9
DO (mg/L)	5.33
DO (%sat)	65.6
EC (us/cm)	6527
pH	7.35

Table 4: Fish species and CPUE recorded during Alligator creek wetland fishway monitoring April 2023

Common Name	Species Name	CPUE (fish/day)
Agassizi's glassfish	*Ambassis agassizii*	127.52
Banded scat	*Selenotoca multifasciata*	8.60
Barramundi	*Lates calcarifer*	0.96
Crescent perch	*Terapon jarbua*	4.78
Empire gudgeon	*Hypseleotris compressa*	49.67
Estuary glassfish	*Ambassis Marianus*	0.48
Midgley's carp gudgeon	*Hypseleotris species 1*	0.48
Mosquito fish	*Gambusia holbrooki*	98.87
Mullet	*Mugil sp.*	31.04
Pacific blue-eye	*Pseudomugil signifer*	1.43
Platy	*Xiphophorus maculatus*	9.07
Purple-spot gudgeon	*Mogurnda adspersa*	11.94
Spangled perch	*Leiopotherapon unicolor*	7.64
Spotted scat	*Scatophagus argus*	3.34
Tarpon	*Megalops cyprinoides*	50.63
Threadfin silver-biddy	*Gerres filamentosus*	7.16
Unknown goby species	*Gobiidae sp.*	0.48

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