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RESEARCH AND CONSULTING

Status of the Currimundi Catchment Fish Community

Final Report

Currimundi Catchment Care Group

Sunshine Coast Council

Unitywater

Document Control

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Distribution

Issue	Distribution record	Date	Prepared by	Reviewed by
Draft report	David Allan	03/05/2013	Kris Pitman	David Allan
Final Report	David Allan	07/06/2013	Kris Pitman, Kyle Tierney	David Allan

Acknowledgements

Currimundi Catchment Care Group partnered with Pitman Research and Consulting, Sunshine Coast Council and Unitywater to plan and deliver this survey.

The success of this survey was achieved through the team work of the following: Kris Pitman, Mark Berndsen (Pitman Research and Consulting), Gordon Agnew, Josh Walton, Kane Ransom (Sunshine Coast Council), David Allan, Bev Tierney, Fred Block, Janine Bedros, Kyle Tierney, Peter Zahnleiter, Tony Brangwin and Tony Moorhead (Currimundi Catchment Care Group).

Thanks to Denise Lindon, Sunshine Coast Council, and Emma Newton, Unitywater, for their support.

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Executive Summary

Pitman Research and Consulting has been commissioned by the Currimundi Catchment Care Group (CCCG) to undertake a fish assessment of Currimundi catchment, located on the Sunshine Coast. The fish communities of Currimundi catchment had previously been assessed by Ray Leggett in 1993, 1997 and 2000. This study was undertaken to provide an update on current catchment conditions, repeat the survey of Ray Leggett's survey sites to obtain suitably comparative data and to provide any recommendations that may arise from the study.

Many changes have occurred since Ray Leggett last studied the Currimundi catchment 13 years ago. The Currimundi Lake has become more urbanised and the upper catchment of the lake has been vastly altered with the construction of Lake Kawana. Historically, Currimundi Lake has previously been identified as being an intermittently closed and open lake or lagoon (ICOLL). However, the management of the lake has been such that the entrance of the system now remains open the majority of the time. Due to the lake being open to the ocean for longer periods, the habitat features displayed in some areas now represent those that would typically be found in an estuarine system, including mangroves and seagrass beds.

Estuarine study

A total of 4,657 fish and one stingray were captured during the single survey of the nine estuarine study sites in Currimundi Lake, with the fish catch represented by a total of 40 fish species and a single stingray species. Non-metric multidimensional scaling (nMDS) and hierarchical clustering analysis using PRIMER showed that the fish communities in the creeks were distinct from the canal and river sites. All lake and canal sites were relatively similar except for site eight at the end of Baroona canal, which was distinctly different.

A total of 50 fish species have been recorded over all of the four surveys (1993, 1997, 2000 & 2013) of the Currimundi estuary. The diversity of fish species caught in the lake has increased consistently over the four surveys, with substantially more fish species caught in this survey than the others (15, 16, 20 and 41 fish species, respectively). Analysis of the results indicate that the surveys from 1997 and 2000 were more similar than either of the other two surveys. The fish communities recorded in the current study are very different to those found in the three historical surveys.

The observed increase in fish species diversity over time is likely to be related to an increase of artificial entrance opening, which has caused the system to become more marine dominated. Studies conducted in NSW have also found that ICOLL's with more frequent marine connectance are likely to support more estuarine and coastal species and have higher fish diversity. The absence of freshwater mullet from the catchment supports the theory that the system has become more marine dominated, with conditions no longer suitable for this freshwater fish to inhabit the Lake, creek and canal sites.

Some observed differences between the current and historical survey could be attributed to the sampling techniques used in the different studies. The gear types and methodologies used in the historical studies were not well described, making exact replication of the previous study near impossible. In addition, seasonal differences between surveys may also have contributed to some of the observed differences in fish assemblages. Further study of seasonality and the impacts of entrance opening on fish assemblages are needed to determine what factors are responsible for the differences between the current and historical studies. Such a study would provide information to make informed management decisions regarding lake opening.

Freshwater Study

A total of 2480 individual fish and two turtles were caught during the current surveys of the three freshwater sampling sites. These fish represented twelve species of freshwater fish and one species of turtle. The survey recorded one introduced species, the plague minnow (*Gambusia holbrooki*). There were a total of 16 freshwater species recorded over all of the four freshwater surveys (1993, 1997, 2000 & 2013).

The diversity of freshwater fish varied over the four surveys with a slightly higher number of species being recorded in the present study (8 species in 1993; 10 species in 1997 and 9 species in 2000 and 12 species in 2013). The survey results of the study found that the fish community has changed over time, with changes in the presence and absence of some fish species. The loss of two sensitive fish species including, Australian smelt (*Retropinna semoni*) and crimson spotted rainbowfish (*Melanotaenia duboulayi*), suggests that the freshwater environments may have become unsuitable for those species since the last survey conducted in 2000. The loss of sensitive fish species often indicates that a system is under stress and may have experienced habitat degradation and/or a reduction in water quality. Clearly, further study is required to assess the status of these sensitive species in the Currimundi catchment.

1. Introduction

1.1 Project description

Pitman Research and Consulting (PRC) have been commissioned to undertake a fish assessment of the Currimundi catchment. This study will focus on both the freshwater and estuarine reaches of the catchment; provide a brief report on the results and any future recommendations arising from the study.

The Currimundi catchment has previously been surveyed three times by Ray Leggett in 1993, 1997, and 2000. These surveys provide a brief but insightful study of the fish communities, invertebrate, and aquatic habitats of the catchment. This current study will be undertaken at the same sites as Ray Leggett's studies to provide a comparative updated status of the fish communities of the Currimundi catchment.

This project is unique in that it was performed in collaboration with the Currimundi Catchment Care Group Volunteers and staff from the Sunshine Coast Regional Council. Over a five day period (15th April to the 19th April, 2013) 12 sites were surveyed, involving 12 people. The project had local 7 news coverage, and was also featured in Caloundra Weekly, Currimundi Lake Catchment News and CCCG's website.

1.1.1 Aims and objectives

The overall aim of this study was to undertake a fish assessment of the freshwater and estuarine reaches of Currimundi catchment. This information will characterise the current state of the system and how it may have changed since previous assessments.

The specific objectives of the study were to:

1. Provide a background on current catchment conditions
2. Undertake a comprehensive fish community survey and record water quality.
3. Provide recommendations arising from the study.

2. Catchment

2.1 Catchment conditions

The Currimundi catchment, originally low-lying coastal wetlands, is today a low-lying, highly urbanised area with an overall length of 8 kilometres in the east-west direction, covering an area of approximately 40 square kilometres. The catchment is bordered by the Mooloolah River to the north and west and Little Mountain to the south. Suburbs either wholly or partly within the catchment include: Aroona, Battery Hill, Birtinya, Bokarina, Currimundi, Little Mountain, Meridan Plains and Wurtulla. The upper half of the catchment is flood prone land which has previously been cleared and includes an estimated 1095 hectare designated sand extractive resource area of which about 714 hectares is potential extraction area (Sunshine Coast Council, 2010). The remaining forested areas to the west comprise a mixture of melaleuca wetlands, rainforest and eucalypt open forest within a conservation reserve running north parallel to the Mooloolah River. On the northern bank of Currimundi Lake, and nesting behind the beach is a conservation park containing a small remnant of wallum heath.

Prior to 2005, the Currimundi catchment comprised a lake, three constructed residential tidal canals and two creeks that interfaced with freshwater tributaries to the west. Historically Currimundi Lake was considered an Intermittently Closed and Open Lake or Lagoon (ICOLL), a common type of estuary on the east coast of Australia. It has become a predominantly open estuary following the connection of Lake Kawana via a small weir to the Currimundi system which brought brackish waters from the Mooloolah River. A study undertaken of the Dynamics of Currimundi Lake found that there has been a fundamental shift in the dynamics of the lake from a traditional mostly closed ICOLL to those more representative of a low-freshwater input estuary (Tomlinson, 2006). This is clearly shown by the consistent high salinity readings throughout the lake and the emergence of habitat features that would more typically be found in estuarine systems including mangroves and seagrass beds.

The management of the lake is regulated by Council for flood mitigation and for intervention in the breeding cycle of biting midge. Should the lake mouth close naturally, Council may keep it closed for periods of up to seven weeks to control the biting midge population and then open it mechanically. Overall the mouth now remains open for extended periods of time compared to ten years ago.

Over the last 10 to 15 years the catchment has experienced increased urbanisation with resultant ecological impacts of sediment and nutrient input from run-off and progressive loss of riparian vegetation. Wildlife habitat areas in the region have also declined across the catchment due to development and urbanisation.

Many areas of Currimundi Lake have intact riparian zones containing stands of mangroves, melaleucas, casuarinas, blood woods, cotton trees and wattles. However, the extent of the riparian zones in many areas of the lake is being reduced by accelerated erosion processes. Stream bank erosion has escalated in recent years, particularly in Currimundi Creek South Arm and along various sections of the northern and southern banks of the lake. The cause of the erosion is not clearly understood, but boat wash, bank slumping after mouth openings and in some cases increased stormwater inputs are likely causes (Tomlinson *et al.* 2010). In the upper reaches of the creeks, trees branches and logs have fallen into the water channel providing important structural habitat for fish.

The three fish surveys conducted by Leggett (1993, 1997 and 2000) were conducted in a very different environment from the current 2013 survey. Legget's 1993 survey was conducted about a fortnight after the lake mouth had been opened, following a considerable period of closure. Leggett (1993) commented that the opening of the mouth "would account for the good range of saltwater fish species caught." According to Leggett the mouth of the lake was open to the sea for the 2000 survey and "a good flow of water passed through into the lake at every change of the tide" (Leggett, 2000: 1). He did not describe the condition of the waterways in the 1997 study. When this survey was conducted in April 2013, the mouth of the lake had been open for six months. This extended period of opening may have provided opportunities for species of estuarine fish that breed in oceanic or coastal waters to enter the Currimundi system as larvae and juveniles.

2.2 Water Quality

Water quality in the Currimundi catchment has been monitored by Council since 2001 and by a community based group of volunteers since 2003. These operate as monthly monitoring programs although additional monitoring is undertaken at times of significant events. Council's program includes 10 sites and the community-based program has 20 sites. The Lake Currimundi Dynamics Study (2010) reported on an analysis of the results of both programs using data collected between 2001 and 2006. In addition, the study conducted monitoring for one month in 2008 and compared the results with Council and community results. The findings of the analysis of Council and community programs included: dissolved oxygen was consistently low; rainfall spiked turbidity; conductivity varied between seawater and fresh water levels; and suspended sediment was consistently high. Data collected after 2005, i.e. after Lake Kawana came on-line and after completion of dredging of Currimundi Lake, showed an increase in dissolved oxygen and conductivity at most sites with a decrease in suspended sediment at upstream sites (Tomlinson *et al*. 2010). The community based water monitoring program shows that dissolved oxygen levels and conductivity decrease with increasing distance of monitoring sites from the mouth of the lake.

3. Methods

3.1 Approach

The previous three surveys undertaken in the lake (Leggett, 1993, 1997, and 2000) used a combination of scoop, seine and gill nets. However, the reports lacked any detail of fish abundance data, methodology, net dimensions and specific use of each gear type. Therefore it is impossible to replicate the previous surveys. Despite these limitations, the species lists from these studies will be used as a comparison to the current study. Because of the lack of recorded detail in the earlier studies, the current study will provide a more thorough baseline of fish communities in the catchment.

The sampling regime used in this study in both freshwater and estuarine environments was designed to collect a representative sample of the fish community, using a standardised sampling protocol. This enables all sites to be directly comparable so that any differences between sites can be clearly demonstrated. This approach will also allow direct comparisons with any future fish surveys undertaken in the catchment.

Standardisation will be achieved through a number of means; firstly, sites will be selected where the fish sampling gear will have similar effectiveness. Secondly, the same gear types and effort will be used at all sites. However, different gear types will be used for the ring tank and freshwater creek sites from those used at the estuarine sampling locations due to constraints such as water depth and area. As a result, abundance data has been categorised according to fresh water and estuarine sites and analysed separately.

3.2 Fish sampling

This project was undertaken under General fisheries Permit number 152671 and animal ethics approval CA 2012/01/579.

Different approaches were used to effectively sample the three different aquatic environments present in the Currimundi catchment. These are outlined in the following sections.

3.2.1 Estuarine fish sampling

Seine nets were used in this study, as they are very effective at sampling estuarine fish communities and are also non-destructive so that fish can be released unharmed. Two different sized nets were used in each site to adequately capture a wide variety of fish species and fish sizes. At each site a standardised sampling approach was used so that any differences in the composition of fish communities between sites could clearly be demonstrated.

To obtain a representative sample of larger bodied fish, a single shot of a large pocket seine net (80m by 4m by 32mm) was used. A single shot involved running the net out from the bank in a semicircle with a boat and slowly pulling it in (See PLATE 1). The net has a pocket that is designed to trap fish as the net is pulled in. Once the net is retrieved, all fish were transferred immediately into large tubs that contained aerated water. This large net was used in six of the estuary sites, where there was sufficient room to utilise it effectively. In the three Currimundi creek sites (north and south arm) a medium seine net was used (30m by 2m by 32mm) due to the limited area preventing the use of the larger net. Two shots of this net were performed to account for the smaller size of this gear type.

PLATE 1. SHOOTING AND RETRIEVING THE LARGE 80M SEINE NET.

To effectively sample smaller fish, a small pocket seine net (8m by 1.5m by 2mm) was used (see PLATE 2). At each site a single 10m haul was made through representative habitat. This net was used in all estuarine sites and the catches from the two nets were pooled to represent these fish communities. All fish species were identified using Kuiter (1996), Allen, (1997), Hutchinson and Swainson (1986) and McDowall, (1996).

PLATE 2. HAULING THE SMALL SEINE NET AT SITE THREE.

3.2.2 Sampling freshwater fish

The freshwater sampling methods used in the survey followed those methods utilised in the Ecosystem Health Monitoring Program (EHMP) as they have been tested for their effectiveness in river health assessments in Queensland waters (Kennard *et al*., 2001).

This methodology uses a combination of backpack electrofishing (See PLATE 14) and, where possible, seine netting. Backpack electrofishing is commonly used during freshwater stream sampling due to its ability to effectively sample complex structures, aquatic vegetation, and depths of less than 0.5m (Dauble and Gray 1980; Vadas and Orth 1993). Electrofishing is an extremely effective way to capture and study freshwater fish populations and has been used in Australia for over 40 years (NSW Fisheries, 1997). Electrofishing works by the creation of an electric field in the water, to which fish respond by some form of immobilisation, making them easy to capture. Seine netting was not considered suitable for use in either of the two freshwater sites of this study.

Where possible an entire pool, riffle run sequence is sampled, incorporating as much hydraulic and habitat diversity as possible. If only one hydraulic unit is present then two or three habitat units are sampled. This usually equates to 75m to 100m of stream length (EHMP, 2004). At each site 800 seconds of on-time power was used to standardise the effort between sites. Ten commercially available funnel traps were also set at each site to increase the catch of small species. All fish species were identified using Kuiter (1996), Allen, (1997), Hutchinson and Swainson (1986) and McDowall, (1996).

3.2.3 Sampling freshwater fish in the ring tank

The ring tank is a large artificial water body that was constructed as a reservoir to supply water to the Caloundra City area. It is no longer used for this purpose, and remains as a sanctuary for water birds. The artificial lake is an elevated structure that has been created by forming lake walls above the ground. The lake itself has steep sides that drop immediately into deep water. The average depth of the lake is around 6m.

To effectively sample the waterbody a number of techniques were used, including four double winged fyke nets, ten bait traps, and three gill nets (consisting of multiple panels of 25mm, 50mm, 75mm, 100mm, and 125mm mesh sizes). The fyke nets and bait traps were set along the edges of the lake and left overnight. The gill nets were set at a 45 degree angle from the bank for two hours in the afternoon and for another two hours the following morning.

3.2.4 Water quality

Water quality was measured at both surface and bottom levels of the water at each site using a Horiba U10 multi-probe. The water quality parameters recorded included temperature (°C), pH, dissolved oxygen (mg/L), turbidity (NTU), and conductivity (mS/cm).

3.3 Sites

This survey consisted of nine estuarine sites and three freshwater sites. The locational data of the 12 study sites is shown below in Table 1. The specific locations of sites were selected so that they corresponded with the locations of the sites previously surveyed by Leggett (1993, 1997, 2000). Photos of each site can be seen in PLATES 3 to 13 and maps of the estuarine and freshwater sites are shown in figures 1 and 2. Maps were prepared in ArcMap using imagery taken from Google Earth™ 2.

TABLE 1. SITE LOCATION AND DESCRIPTION.

Site	Habitat	GPS location	Location Description
1	Estuarine lake	26°45'52.36'' S 153°07'48.29'' E	Southern bank of Currimundi Lake, 100m east of Westaway Parade boat ramp, opposite Alice Street, Currimundi.
2	Estuarine lake	26°45'56.93'' S 153°07'23.03'' E	Southern bank of Currimundi Lake, 200m east of Nicklin Way, opposite storm water drainage area known as 'Oyster Creek'.
3	Estuarine lake	26°45'55.73'' S 153°07'15.07'' E	Southern bank of Currimundi Lake, 100m west of Nicklin Way opposite Currimundi Villas.
4	Estuarine creek	26°45'56.38'' S 153°06'57.28'' E	Currimundi Creek south arm, 20m downstream from Creekside Boulevard Bridge, along eastern bank.
5	Estuarine creek	26°45'53.72'' S 153°06'30.52'' E	Upper reaches of Currimundi Creek south arm, both west and eastern bank, 20m downstream from fork (right arm Kawana Way left arm Halcyon Park).
6	Estuarine canal	26°45'37.77'' S 153°07'00.29'' E	Eastern bank of Pangali Canal, 20m north of the pontoon at Noel Burns Park.
7	Estuarine creek	26°45'28.66'' S 153°06'54.62'' E	Northern bank of Currimundi Creek north arm, 200m from the junction with Pangali Canal.
8	Estuarine canal	26°45'34.86'' S 153°07'20.54'' E	Eastern bank of Baroona Canal, 80m from the end.
9	Estuarine canal	26°45'20.13'' S 153°07'56.33'' E	Eastern bank of Tokara Canal, at the un-named park.
10	Freshwater creek	26° 45' 49.9" S 153° 5' 58.7" E	Stream at culverts at the northern side of Meridan Way overpass of Kawana Way.
11	Freshwater Ring Tank	26° 45' 13.2" S 153° 5' 36.1" E	Situated off Rainforest Drive, Meridan Plains.
12	Freshwater creek	26° 45' 8.9" S 153° 5' 18.4" E	Drainage waters west of the Ring Tank.

PLATE 3. SITE ONE IN CURRIMUNDI LAKE LOCATED ON THE SOUTHERN BANK.

PLATE 4. SITE TWO ON CURRIMUNDILAKE. THIS SITE WAS LOCATED JUST DOWNSTREAM OF THE NICKLIN WAY BRIDGE

PLATE 5. SITE THREE IN CURRIMUNDI LAKE. THIS SITE WAS LOCATED JUST UPSTREAM OF THE NICKLIN WAY BR

PLATE 6. SITE FOUR ON THE CURRIMUNDI CREEK SOUTH ARM.

PLATE 7. SITE FIVE ON CURRIMUNDI CREEK SOUTH ARM. THIS SITE WAS LOCATED IN THE UPPER REACHES OF THE CREEK

PLATE 8. SITE SIX LOCATED AT THE LOWER END OF PANGALI CANAL.

PLATE 9. SITE SEVEN LOCATED IN THE MID REACHES OF CURRIMUNDI CREEK NORTH ARM.

PLATE 10. SITE EIGHT LOCATED AT THE END OF BAROONA CANAL. THE SITE WAS LOCATED ON THE SOUTHERN BANK.

PLATE 11. SITE NINE LOCATED AT THE NORTHERN END OF TOKARA CANAL. THE LARGE SEINE WAS SHOT OFF THE BEACH.

PLATE 12. SITE 10; A FRESHWATER SITE ON THE CURRIMUNDI CREEK SOUTH ARM.

PLATE 13. SITE PHOTO OF THE RINGTANK SITE.

PLATE 14. ELECTROFISHING IN A POOL AT SITE 1

Currimundi Fish Survey Estuarine Sites (April 2013)

Pitman Research and Consulting

Currimundi Catchment Care Group

Sunshine Coast Council

Unitywater

Legend

Survey Site (30m Seine)

Survey Site (80m Seine)

Imagery provided by Google Earth.

Google Earth (Version 7.0.3.8542) [Software]. Mountain View, CA: Google Inc. (2013).

Currimundi Fish Survey Fresh Water Sites (April 2013)

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Fresh Water Sites

Imagery from Google Earth.

Google Earth (Version 7.0.3.8542) [Software]. Mountain View, CA: Google Inc. (2013).

3.4 Data Analysis

In order to examine trends in fish assemblage composition, multivariate statistics were used to identify differences in fish abundance and the presence or absence of fish species between sites and also between the current and historical surveys. All statistical analysis was undertaken using PRIMER v6 (Plymouth Routines in Multivariate Ecological Research). All statistical routines were as advised by Clarke and Warwick (2001) and following Clarke and Gorley (2006).

Ordination by non-metric multidimensional scaling (nMDS), and hierarchical clustering analysis, using Bray–Curtis similarity between the total abundances of each species at each site, or the presence or absence, was carried out using PRIMER v6 (Plymouth Routines in Multivariate Ecological Research).

4. Results

4.1 Site Characteristics

The general site characteristics are shown in Table 2. The depth characteristics of the estuarine sites show that the majority of the sites ranged between 1.7 and 2.8 metres. The majority of the sites lacked large shallow intertidal sand flats, except sites one and three which had larger areas of shallow habitat (Table 2).

The creek sites all had mud banks while all other sites had sandy intertidal areas. The in-stream sediment was very soft and silty at the majority of sites. Coffee rock was evident throughout the system, and prevalent as habitat in several sites. The wetted width of the estuarine sites was greater at the mouth and decreased in the upper sites and creeks (Table 2).

Seagrass habitat was only found at the entrance of the system and a small patch (approximately 5m by 8m) was present within site 1. Several other small patches were also observed within 1200m of the lakes entrance. The seagrass was not identified but it was likely to be *Zostera sp.*

It appears that mangroves have colonised some areas of Currimundi Lake. There are some areas of more established grey mangroves (*Avicennia marina*) in sites two and three. There are also small stands of juvenile red mangroves (*Rhizophora stylosa*) present along the banks especially in Currimundi Creek North Arm (PLATE 13).

TABLE 2. SITE CHARACTERISTICS OF THE 12 SURVEY SITES IN CURRIMUNDI CATCHMENT. DEPTHS RECORDED IN THE ESTUARINE SITES ARE AT HIGH TIDE.

Site Characteristics	Estuarine sites									Freshwater sites		
	1	2	3	4	5	6	7	8	9	10	11	12
Mean Depth (m)	0.9	1.2	0.8	1.5	1.2	1.5	1.0	1.6	1.5	0.8	5.0	1.2
Max Depth (m)	2.0	2.2	1.7	2.1	1.7	2.4	1.8	2.8	2.4	1.1	6.1	1.5
Wetted width	120	70	75	30	30	65	30	65	75	4.5	620	12
Seagrass habitat (%)	10	0	0	0	0	0	0	0	0	n/a	n/a	n/a
Rocky habitat (%)	10	0	0	10	10	10	0	0	0	n/a	n/a	n/a
Mangrove bank (%)	0	5	10	0	0	0	15	0	0	n/a	n/a	n/a
Intertidal beach (%)	100	100	100	0	00	100	0	100	100	n/a	n/a	n/a
Mud bank (%)	0	0	0	100	100	0	100	0	0	n/a	n/a	n/a

4.2 Water Quality

The water quality data is presented in Table 3. There was distinct stratification of water quality within all the estuarine and some of the freshwater sites. In the estuarine sites there was stratification of conductivity with marine water present on the bottom and freshwater water on the surface (Table 3). The presence of freshwater was likely the result of rainfall the week prior to sampling.

PLATE 15. JUVENILE RED MANGROVES THAT HAVE RECENTLY COLONISED THE BANKS OF CURRIMUNDI CREEK NORTH ARM.

TABLE 3. WATER QUALITY READINGS FROM THE 12 SURVEY SITES FOR EACH SAMPLING EVENT.

Site	DO (mg/L)		pH		Conductivity (mS/cm)		Temp (°C)		Turbidity (NTU)	
	surface	*bottom*	*surface*	*bottom*	*surface*	*bottom*	*surface*	*bottom*	*surface*	*bottom*
1	6.58	7.78	6.03	4.53	14.6	46.2	23.6	23.9	8	4
2	6.35	7.11	7.33	7.86	11.4	50.9	24.2	23.8	11	8
3	6.68	7.56	6.87	7.94	23.2	52.0	22.7	23.8	11	10
4	6.28	5.34	7.58	7.86	33.7	51.0	23.8	23.9	5	7
5	5.34	3.84	7.37	7.59	6.04	49.1	23.3	23.6	16	19
6	7.06	6.53	7.66	7.96	27.4	47.4	26.0	24.4	6	6
7	6.49	4.30	7.30	7.55	32.9	48.4	24.2	24.1	5	8
8	8.96	6.34	7.93	7.91	31.4	48.2	26.8	24.5	10	12
9	7.73	4.14	7.39	7.70	24.6	49.2	24.3	24.2	10	14
10	4.36	4.36	6.33	6.33	0.129	0.129	21.5	21.5	10	10
11	10.51	4.60	9.37	8.0	0.087	0.087	25.9	23.0	10	10
12	3.68	1.81	7.16	7.17	0.116	0.116	23.8	23.2	45	65

Stratification of dissolved oxygen was also evident in many of the sampling sites; sites one to three had higher dissolved oxygen on the bottom while the remaining sites had lower dissolved oxygen on the bottom of the water column (Table 3).

Sites located on Currimundi Creek South and North arm and Tokara canal site (site 9) had the lowest readings out of all the sites (Table 3). Freshwater sites had low dissolved oxygen readings especially site 12 (Table 3). The ring tank was very alkaline with a pH reading of 9.37 (Table 3).

4.3 Estuarine fish survey results

A total of 4657 fish and one stingray were captured during the survey of the nine estuarine study sites in Currimundi Lake, creeks and canals (Table 4). This fish catch was represented by a total of 40 fish species and a single stingray species (Table 4).

The fish fauna of Currimundi's estuarine sites was dominated by two species, the estuary perchlet (*Ambassis marianus*), and southern herring (*Herklotsichthys castelnaui).* These two species accounted for 72% of the total fish catch for all estuarine sites (Table 4). The other fish species that were reasonably abundant included tiger mullet (*Liza argentea*) with 16% of the total catch and silver belly (*Gerres subfasciatus*) with 4% of total catch (Table 4).

TABLE 4. FISH FAUNA FROM THE NINE ESTUARINE SAMPLING SITES. THE SPECIES MARKED WITH AN (*) ARE ECONOMICALLY IMPORTANT.

FAMILY Species Name	Common Name	Fish catch	Number of sites	Proportion of total
AMBASSIDAE				
Ambassis marianus	estuary perchlet	1727	8	37.08
BLENNIIDAE				
Petroscirtes lupis	Browns sabre toothed blenny	5	1	0.11
CALLIONYMIDAE				
Repomucenus calcaratus	Spotted stinkfish	1	1	0.02
CARANGIDAE				
*Caranx ignobilis**	Giant trevally	9	5	0.15
*Caranx sexfasciatus**	Big eye trevally	7	6	0.19
CHANIDAE				
*Chandos chandos**	milkfish	2	2	0.04
CLUPEIDAE				
*Herklotsichthys castelnaui**	southern herring	1607	9	34.5
DASYATIDAE				
Pastinachus sephen	Cowtail stingray	1	1	0.02
DINOLESTIDAE				
*Sphraena obtusata**	striped seapike	2	2	0.04
GERREIDAE				
*Gerres subfasciatus**	common silver belly	185	9	3.97
Gerres filamentosus	threadfin biddy	4	4	0.09
GOBIIDAE				
Favonigobius exquisitus	exquisite sand-goby	13	3	0.28
Muligobius platynotus	Mangrove goby	2	1	0.04
Butis Butis	crimson-tipped gudgeon	7	2	0.15
Gobiopterus semivestutus	Glass goby	8	3	0.17
HAEMULIDAE				
*Pomadasys kaakan**	Grunter	4	1	0.09
*Plectorhinchus gibbosus**	Brown sweetlip	1	2	0.02
HEMIRAMPHIDAE				
*Arrhamphus sclerolepis**	snub nosed garfish	4	3	0.09
PARALICHZTHYIDAE				
*Pseudorhombus jenynsii**	Small toothed flounder	1	1	0.02
PLATYCEPHALIDAE				
*Platycephalus fuscus**	dusky flathead	5	4	0.11
PSEUDOMUGILIDAE				
Pseudomugil signifer	southern blue eye	36	3	0.77
LEIOGNATHIDAE				

FAMILY Species Name	Common Name	Fish catch	Number of sites	Proportion of total
Leiognathus equulus	common pony fish	24	4	0.52
LUTJANIDAE				
*Lutjanus argentimaculatus**	mangrove jack	1	1	0.02
*Lutjanus russelli**	moses perch	1	1	0.02
MONODACTYLIDAE				
Monodactylus argenteus	silver batfish	5	2	0.10
MUGILIDAE				
*Liza argentea**	tiger mullet	749	3	16.08
*Mugil cephalis**	sea mullet	78	8	1.67
Myxus elongatus *	Sand mullet	50	4	1.07
SIGANIDAE				
Siganus fuscescens	happy moment	4	2	0.08
SILLAGINIDAE				
*Sillago ciliata**	sand whiting	14	4	0.3
*Sillago maculata**	trumpeter whiting	11	3	0.24
SCIAENIDAE				
*Argyrosomus hololepidotus**	Jewfish	1	1	0.02
SCATOPHAGIDAE				
Selenotoca multifasciata	Striped scat	3	1	0.06
SOLEIDAE				
*Synaptura nigra**	black sole	1	1	0.02
SPARIDAE				
*Acanthopagrus australis**	bream	50	7	1.07
Rhabdosargus sarba	tarwhine	8	4	0.17
TETRAODONTIDAE				
Tetractenos hamiltoni	common toadfish	15	5	0.32
Marilyna pleurosticta	striped toadfish	1	1	0.02
Arothron hispidus	Stars and stripes toad	3	2	0.06
Torquigener pleurogramma	weaping toado	1	1	0.02
TERAPONTIDAE				
Terapon jarbua	crescent perch	7	3	0.15
Total number of fish species				**41**
Total abundance				**4,658**

Many of the species encountered in the survey were present in low abundance. For example, of the 41 fish species caught, 28 of these or 68% of all species were represented by less than ten individuals (Table 4). Ninety five percent or 4,446 of the total catch were accounted for by seven species (Table 4). Of the 41 fish species encountered within Currimundi Lake, creeks and canals, 21 of these are considered to have economic importance, this represents 53% of the fish species caught (Table 4).

4.4 Estuarine fish community structure

To gain a better understanding of how fish communities varied between sites, ordination with non-metric multidimensional scaling (nMDS) and hierarchical clustering analysis using Bray–Curtis similarity was used. Firstly a cluster analysis was performed (refer to Figure 3) and this was over laid on an nMDS plot of the fish community data in each site (Figure 4).

The analysis revealed three broad site groupings (Figures 3 and 4). This showed that the creeks had fish communities that were distinct from the canal and lake sites. It also showed that one of the canal sites (site 8) was very different from all the other sites.

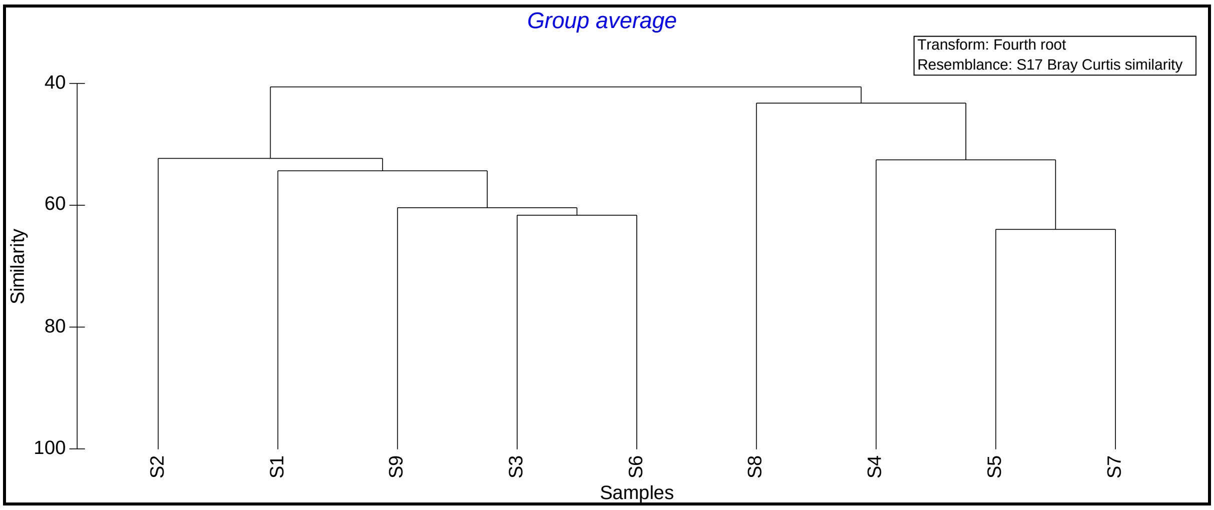

FIGURE 3. A CLUSTER ANALYSIS SHOWING THE SIMILARITY PERCENTAGES OF THE NINE SITES

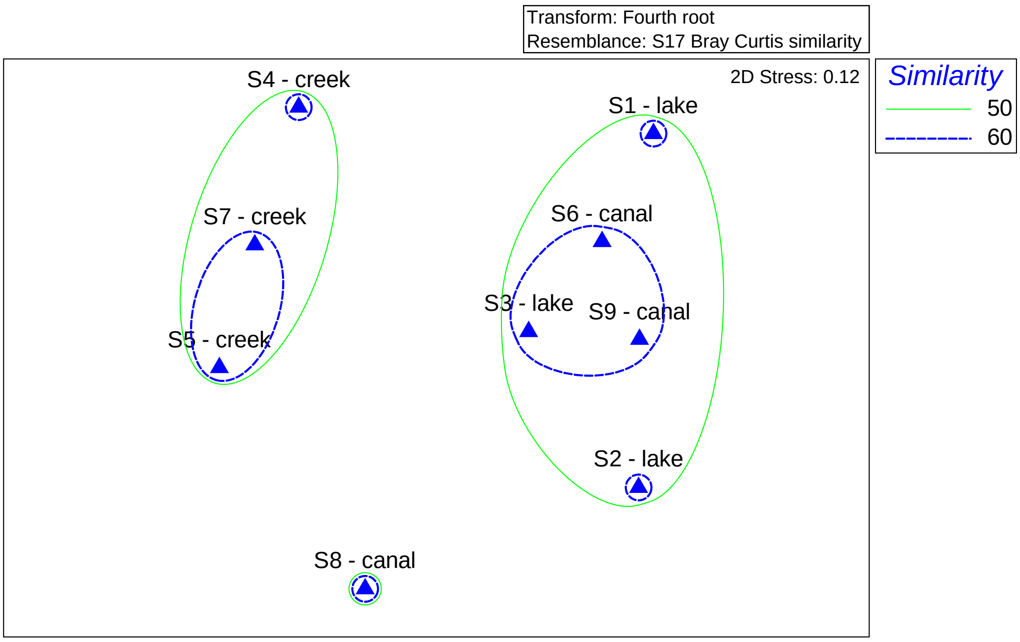

FIGURE 4. A MDS ANALYSIS PLOT WITH THE CLUSTER SIMILARITIES OVERLAID.

4.5 Comparison with previous estuarine fish surveys

Table 5 presents the estuarine fish species occurrences over the three historical surveys from Leggett (1993, 1997 and 2000) and the results from the current study. Across all surveys there was a total of 52 fish species recorded. This included four freshwater fish species, the southern blue eye (*Pseudomugil signifer*), freshwater mullet (*Myxus petardi*), Milkfish (*Chandos chandos*), Oxyeye herring (*Megalops cyprinoides),* all of which frequently occur in brackish estuarine environments.

The diversity of fish species caught in the lake has increased consistently over the four surveys, with substantially more fish species caught in this survey than the others (15, 16, 20 and 41 fish species, respectively) (Table 5).

Of the 52 species only four species were recorded in all four sampling occasions; these included milkfish (*Chandos chandos*), snub nosed garfish *(Arrhamphus sclerolepis*), silver batfish (*Monaactylus argenteus*) and bream (*Acanthopagrus australis*) (Table 5). There were a total of ten species that were recorded in the historical surveys that do not appear in this survey. There were 26 fish species recorded in the current survey that were not found in the historical surveys (Table 5).

The results of an ordination with non-metric multidimensional scaling (nMDS) and an overlaid hierarchical clustering of the presence or absence of fish species over all of the fish surveys conducted in Currimundi Lake, creeks and canals are shown in Figure 4. This figure shows that the surveys from 1997 and 2000 were more similar than either of the other two surveys. The fish communities recorded in the current study are very different to what has been found in the historical surveys

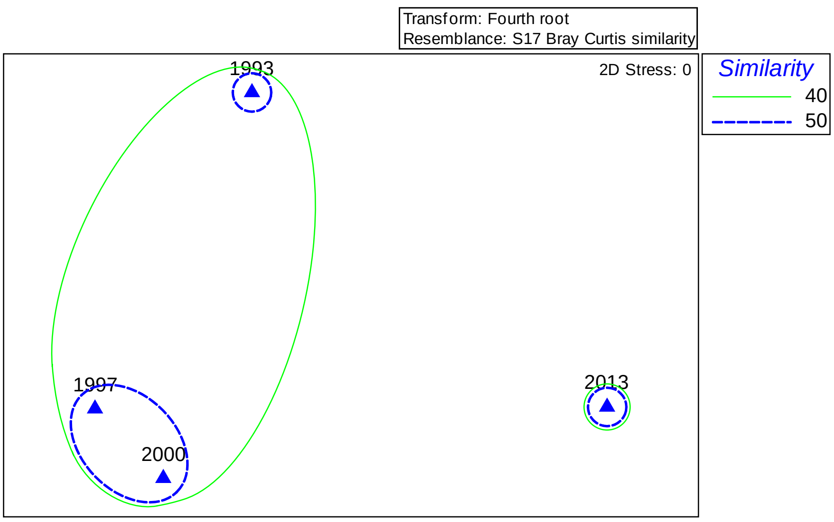

FIGURE 5. A MDS ANALYSIS PLOT WITH THE CLUSTER SIMILARITIES OVERLAID.

TABLE 5. ESTUARINE FISH SPECIES OCCURRENCES CURRIMUNDI LAKE ESTUARY SITES. HISTORICAL DATA FROM LEGGETT (1993, 1997 AND 2000).

Estuarine fish species	Common Name	1993	1997	2000	2013
Ambassis marianus	estuary perchlet	•		•	•
Petroscirtes lupus	sabre toothed blenny				•
Repomucenus calcaratus	spotted stinkfish				•
Caranx ignobilis	giant trevelly				•
Caranx sexfasciatus	Big eye trevally				•
Gnathanodon speciosus	golden trevally	•			
Chandos chandos	milkfish	•	•	•	•
Herklotsichthys castelnaui	southern herring				•
Pastinachus sephen	Cowtail stingray				•
Sphyraena obtusata	striped seapike				•
Gerres subfasciatus	common silver belly		•	•	•
Gerres filamentosus	threadfin biddy				•
Favonigobius exquisitus	exquisite sand-goby				•
Mugilobius platynota	mangrove goby			•	•
Butis Butis	crimson-tipped gudgeon				•
Gobiopterus semivestutus	glass goby				•
Pomadasys kaakan	grunter	•			•
Plectorhinchus gibbosus	brown sweetlip				•
Arrhamphus sclerolepis	snub nosed garfish	•	•	•	•
Hyporhamphus regularis	river garfish			•	
Pseudorhombus jenynsii	small toothed flounder				•
Platycephalus fuscus	dusky flathead	•	•		•
Pseudomugil signifer	southern blue eye	•	•		•
Leiognathus equulus	common pony fish				•
Lutjanus argentimaculatus	mangrove jack	•			•
Lutjanus russelli	moses perch				•
Monodactylus argenteus	silver batfish	•	•	•	•
Liza argentea	tiger mullet				•
Mugil cephalis	sea mullet				•
Myxus elongatus	sand mullet				•
Myxus petardi	Freshwater mullet	•	•	•	
Siganus fuscescens	happy moment				•
Sillago ciliata	sand whiting		•	•	•
Sillago maculata	trumpeter whiting				•
Argyrosomus hololepidotus	Jewfish	•			•
Selenotoca multifasciata	striped scat				•
Synaptura nigra	black sole				•
Acanthopagrus australis	bream	•	•	•	•
Rhadbosargus sarba	tarwhine		•	•	•
Tetractenos hamiltonii	common toadfish			•	•
Marilyna pleurosticta	striped toadfish			•	•
Arothron hispidus	Stars and stripes toad				•
Torquigener pleurogramma	weaping toado				•
Terapon jarbua	crescent perch		•	•	•
Rhinogobius sp.	marine goby	•	•	•	
Craterochalus sp.	hardyhead	•	•	•	
Diagramma picta	painted sweetlip	•			
Trygonoptera testacea	common stingray		•		
Trachurus maccullochi	yellowtail		•	•	
Megalops cyprinoides	oxeye herring		•	•	
Pseudogobius sp.	blue spot goby			•	
Redigobius bikolanus	large mouthed goby			•	
Total species	52	15	16	20	41

4.6 Freshwater fish survey results

A total of 2480 individual fish and two turtles were caught during the surveys of the three freshwater sampling sites. These fish represented twelve species of freshwater fish and one species of turtle. The survey recorded one introduced species, the plague minnow, also known as the mosquito fish (*Gambusia holbrooki*).

Overall the sites were numerically dominated by olive perchlets (*Ambassis agassizii)* and empire gudgeons (*Hypseleotris compressa*), with these species representing 92.1% of the total catch. All of the other species were in lower abundance and two of the fish species were only represented by a single individual. These were the short finned eel (*Anguilla australis)* and flatheaded gudgeon (*Philypnodon grandiceps*) (Table 5).

TABLE 6. FISH FAUNA FROM THE THREE FRESHWATER SAMPLING SITES. THESE NUMBERS OF FISH INCLUDE THOSE THAT WERE POSITIVELY IDENTIFIED DURING THE ELECTROFISHING SURVEYS. THE SPECIES MARKED WITH AN (#) ARE INTRODUCED.

FAMILY Species Name	Common Name	Fish catch	Proportion of total
ANGUILLIDAE			
Anguilla reinhardtii	Long finned eel	4	0.16
Anguilla australis	Short finned eel	1	0.04
ATHERINIDAE			
Craterocephalus stercusmuscarum	Fly specked hardyhead	77	3.1
CHANDIDAE			
Ambassis agassizii	Olive perchlet	1520	61.24
CHELIDAE			
Emydura krefftii	Kreft turtle	2	0.08
ELEOTRIDAE			
Hypseleotris galii	Firetail gudgeon	9	0.36
Hypseleotris compressa	Empire gudgeon	766	30.86
Gobiomorphus australis	Striped gudgeon	8	0.32
Philypnodon grandiceps	Flat headed gudgeon	1	0.04
MUGILIDAE			
Mugil cephalus	Sea mullet	2	0.08
PLOTOSIDAE			
Tandanus tandanus	Freshwater catfish	2	0.08
POECILIIDAE			
Gambusia holbrooki #	Plague minnow	86	3.47
TERAPONTIDAE			
Leiopotherapon unicolor	Spangled perch	4	0.16
Total number of fish species			**13**
Total abundance			**2482**

4.7 Comparison with previous freshwater fish surveys

Table 4 presents the freshwater fish species occurrences over the three historical surveys from Leggett (1993, 1997 and 2000) and the results from the current study. There were a total of 16 freshwater fish species recorded including one marine migrant, the sea mullet (*Mugil cephalus*) which frequently occurs in freshwater environments.

There were seven fish species that were recorded in the current survey and were not recorded in the previous surveys including glassfish (*Ambassis agassizii*), longfinned eels (*Anguilla reinhardtii*), short finned eels (*Anguilla australis*), striped gudgeons (*Gobiomorphus australis*), spangled perch (*Leiopotherapon unicolor*), sea mullet (*Mugil cephalus*) and flathead gudgeons (*Philypnodon grandiceps*) (Table 6).

Five species were captured in the historical surveys but do not appear in the current survey. These include Oxeye herring (*Megalops cyprinoides),* freshwater mullet (*Myxus petardi*), smelt (*Retropinna semoni*), Crimson spotted rainbowfish (*Melanotaenia duboulayi*) and southern blue eyes (*Pseudomugil signifier*) (Table 4).

TABLE 7. FRESHWATER FISH SPECIES OCCURRENCES IN THE FRESHWATER SITES OF THE CURRIMUNDI CATCHMENT. HISTORICAL DATA FROM LEGGETT (1993, 1997 AND 2000). # INDICATES INTRODUCED SPECIES.

Freshwater species	Common Name	1993	1997	2000	2013
Ambassis agassizii	Agassiz's glassfish				•
Anguilla reinhardtii	Long finned eel				•
Anguilla australis	Short finned eel				•
Craterocephalus stercusmuscarum	Flyspecked hardyhead	•	•	•	•
Gobiomorphus australis	Striped gudgeon				•
Gambusia holbrooki #	Plague minnow	•	•	•	•
Hypseleotris galii	Firetail gudgeon	•	•	•	•
Hypseleotris compressa	Empire gudgeon	•	•	•	•
Leiopotherapon unicolor	Spangled perch				•
Megalops cyprinoides	Oxeye herring		•	•	
Melanotaenia duboulayi	rainbow fish	•	•	•	
Mugil cephalus	Sea mullet				•
Myxus petardi	Freshwater mullet	•	•	•	
Philypnodon grandiceps	Flathead gudgeon				•
Retropinna semoni	Australian smelt	•	•	•	
Pseudomugil signifer	Blue eye		•		
Tandanus tandanus	Eel-tailed catfish	•	•	•	•
Total species count	16	8	10	9	12

5. Discussion

This study documents the present day fish communities in the Currimundi Catchment. The fish communities of the catchment have not been surveyed since Ray Leggett undertook surveys in 1993, 1997 and in 2000. The presence of these historical records provides a good benchmark to which the present study can be compared. To make comparisons to the previous studies the estuary and freshwater fish species were separated to make interpretation easier.

5.1 Estuarine fish communities

A total of 50 fish species and two species of stingray have been recorded in the Currimundi estuary over three historical surveys and the current study. With further sampling effort over different seasons it is likely that this number of species would increase. This is because estuarine systems are characterised by generally being highly variable seasonally and often contain high proportions of temporary residents (Quinn, 1980; Bell *et al*. 1984; Robinson and Duke, 1990; Smith and Sinerchiab, 2004). This characteristic of estuarine fish communities highlights the importance of having a suitable number of sampling events to sufficiently capture this seasonal variability.

The numbers of fish species encountered in this study were similar to those collected in other estuaries within eastern Australia, but lower than those found in the tropics. For example:

- 36 species from Moreton Bay mangrove and seagrass (Laegdsgaard and. Johnson, 1995)
- 46 species from a mangrove creek in Botany Bay NSW (Bell *et al*. 1984).
- 45 species from Serpentine creek, Brisbane (Quinn, 1980).
- 42 species during a survey of seagrass and mangrove habitats in Pittwater, NSW (Jebart *et al.* 2007).
- 42 species caught in a mangrove forest in Tin Can Bay, Qld (Halliday and Young, 1996).
- 30 species from McCoys Creek on the Gold Coast (Pitman, 2013).
- 49 species in the Nerang River (Australian Wetlands, 2013).
- 52 species recorded during a study of artificial canal and lake environments in Southern Moreton Bay (Waltham and Connolly, 2007).
- 51 species of fish during a survey of canal and river sites in Tallebudgera Creek (Moreton, 1992).
- 52 species recorded during a survey of eight estuaries across Northern NSW, investigating differences in fish assemblages between seagrass and sand (Grey *et al*. 1996).
- 128 species Alligator Creek in northern QLD (Robertson and Duke 1990).
- 50 species Lockhart River in northern QLD (Robertson and Duke 1990).
- 52 species Escape River in northern QLD (Robertson and Duke 1990).
- 55 species in a Mangrove Creek on Cape York: (Vance *et al*. 1996).

Many of the species found in Currimundi Lake, creeks and canals are commonly found in marine and freshwater environments. For example, four freshwater fish species were caught as well as at least

10 species of marine migrant or 'marine straggler' fish species. These findings are not uncommon, with many estuaries in Australia commonly being utilized by transient, marine and freshwater species (Quinn 1980; Bell *et al.* 1984; Loneragan *et al*. 1987).

A large proportion of fish species caught in this study were present as juveniles. The importance of shallow estuarine environments as nursery areas has been well documented (Morton *et al.* 1987; Laegdsgaard and. Johnson, 1995). The seasonal variation in fish assemblages in ICOLL's is often directly related to migration patterns of fish. With the extended periods in which the entrance to the lake remains open, there is increased opportunity for juvenile and larval fish to enter from the ocean (James *et al.* 2007)

Many of the species caught in the present study were species that have recreational and commercial fishing importance. For example, of the 41 fish species encountered in the present study, 21 were considered to have economic importance, representing 52% of the fish species caught. Large numbers of economically important fish species are commonly found in estuarine and ICOLL environments (Bell *et al*. 1984; Laegdsgaard and Johnson, 1995; Grey *et al*. 1996; Waltham and Connolly, 2007; Pollard 1994; Roy *et al.* 2001).

There were some interesting differences between the fish communities observed in the current study. The main difference was that the creek sites had fish assemblages that were distinct from the lake and canal sites. The creek sites were characterised as having two unique species of fish, including the mangrove goby (*Muligobius platynotus*) and southern blue eye (*Pseudomugil signifier*) and generally had lower fish diversity and abundance. The unique fish assemblages of the creek sites may be attributed to differences in habitat and water quality, with the creek sites being characterised by low dissolved oxygen and muddy substrata.

The differences between the canal and lake sites were less defined, as these sites all contained similar fish assemblages. This has been found in two studies undertaken in riverine and canal estates in the Nerang River and Tallebudgera Creek, where the river sites and their interconnected canals generally supported similar fish communities (Moreton, 1989 and 1992).

There were substantial differences between the results of the current study and the historical studies. The major difference being that nearly double the numbers of fish species were recorded in the present study. There were also distinct differences between the historical fish assemblages and the present day assemblages. For example, only four species of fish were recorded in all the four sampling occasions. These included milkfish (*Chandos chandos*), snub nosed garfish *(Arrhamphus sclerolepis*), silver batfish (*Monaactylus argenteus*) and bream (*Acanthopagrus australis*). In addition, many species recorded presently were not recorded previously and vice versa.

The reasons for the vastly different results from the historical survey could be due to the increase in the frequency of artificial entrance opening. Council policy for the management of biting midges means that the lake does not remain closed for more than seven weeks (Tomlinson *et al*. 2010).

Increasing the frequency of entrance opening not only provides increased opportunity for juvenile and larval fish to enter from the ocean (James *et al.* 2007), but also has changed the salinity characteristics of the lake causing it to become a more marine dominated environment (Tomlinson *et al*. 2010). Both of these factors are likely to have contributed to the occurrence of a more diverse fish assemblage. For example, the first survey undertaken in 1993 had the lowest numbers of estuarine species present, interestingly the lake had only been open approximately one month before the survey was undertaken (Leggett, 1993). More species were captured in the second and third surveys; however Leggett does not give any indication of management of the lake entrance leading up to these surveys (Leggett 1997 and 2000). Before the current study the lake had been open for six months. Studies conducted in NSW have also found that ICOLL's with more frequent marine connectance are likely to support more estuarine and coastal species and have higher fish diversity (Pollard 1994; Gray 2001; Gray and Kennelly 2003).

In the historical surveys, freshwater mullet were well distributed in Currimundi Lake, canal and creek sites (Leggett, 1993, 1997 and 2000). Because of the lower frequency of lake opening in the historical surveys, it is likely that many of these sites were brackish and even fresh in the upper reaches. These conditions were suitable to support populations of freshwater mullet. However, these sites are now more marine dominated and it would appear that the current conditions are currently not suitable for the species to occur. The absence of the species is likely because it is primarily a freshwater species (McCdowal, 1996) and their presence supports the idea that the system has changed to become more marine dominated.

It is also possible that some of the observed differences could be attributed to the different sampling techniques used between the historical and present study. The previous surveys used a combination of scoop, seine and gill nets. There was no detail of net dimensions and specific use of each gear type making it impossible to exactly replicate the previous studies. The current study used small and large seine nets that are proven to be effective in capturing a good range of fish species and sizes in estuaries (Waltham and Connolly, 2007) and replicate the historical studies as closely as possible.

Some of the differences could also be attributed to seasonal differences between the surveys. The historical studies were completed in November, December and February, while the current study was undertaken in April. Studies of estuarine fish communities have shown seasonal cycles of fish abundance and diversity that peak in autumn and bottomed out in spring (Quinn, 1980). Further research into the timing of recruitment and seasonality trends would be required to determine the differences between the current and historical studies.

5.2 Freshwater fish communities

A total of 2480 individual fish and two turtles were caught during the surveys of the three freshwater sampling sites. These fish represented twelve species of freshwater fish and one species of turtle. The survey recorded one introduced species, the plague minnow or mosquitofish (*Gambusia holbrooki*).

There were a total of 16 freshwater fish and two turtle species recorded over all of the freshwater surveys. The diversity of freshwater fish varied over the four surveys with a slightly higher numbers of species being recorded in the present study (8 in 1993; 10 in 1997; 9 in 2000 and 12 in 2013).

The total number of freshwater fish species has not varied greatly between the historical and current surveys. However, the presence and absence of fish species has changed. Seven fish species that were recorded in the current survey were not recorded in the previous surveys including glassfish (*Ambassis agassizii*), longfinned eels (*Anguilla reinhardtii*), short finned eels (*Anguilla australis*), striped gudgeons (*Gobiomorphus australis*), spangled perch (*Leiopotherapon unicolor*), sea mullet (*Mugil cephalus*) and flathead gudgeons (*Philypnodon grandiceps*). All of these species are capable of withstanding a wide range of water qualities and are considered tolerant and hardy species (McDowal, 1996; Pursey *et al*. 2004).

There were also five species that were captured in the historical surveys that do not appear in the current survey. These were the Oxeye herring (*Megalops cyprinoides),* freshwater mullet (*Myxus petardi*), smelt (*Retropinna semoni*), Crimson spotted rainbowfish (*Melanotaenia duboulayi*) and southern blue eye (*Pseudomugil signifier*). Of these species, smelt and rainbowfish are considered to be more sensitive species and prefer well oxygenated environments and specific habitat (McDowall, 1996; Pursey *et al*. 2004). The loss of sensitive fish suggests that the freshwater environments may have become unsuitable for those species in the last 13 years. A loss of sensitive fish species would normally indicate that the system is under stress and may indicate that the freshwater habitats of Currimundi Creek south arm have experienced habitat degradation and/or a reduction in water quality. Clearly, further study is required to assess the status of those sensitive species in the Currimundi catchment.

5.3 Recommendations

This study found that the fish communities of Currimundi Lake are very different to what was found there historically. As such further research into the effects of the current lake opening regime on the fish community of Currimundi Lake is required to better inform lake management decisions, within the constraints of the local community and land use requirements. Such a study would help inform a management plan with the aim to maintain the health of the modified lake ecosystem.

Additional long term annual monitoring of the Currimundi catchment would provide an on-going assessment of the status of the fish community and the health of the ecosystem. Periodic mapping of mangrove and seagrass habitats would also inform how the lake habitats may be changing in response to lake openings.

It is recommended that any future assessments of the catchment include areas which have not been surveyed previously. For example, Lake Kawana has never been surveyed for fish and additional survey sites would provide a benchmark of the ecological condition of this area. Tooway Lake (located just south of Currimundi Lake) has also never been surveyed, and study sites located in this ICOLL may be used as a reference system to compare with Currimundi Lake; this is because Tooway Lake would appear to be less impacted by artificial entrance opening. It is recommended that future assessments of the catchment follow the standardised sampling protocol used in this study where possible. This will allow for more accurate comparisons between future surveys and the baseline presented in this study.

Surveying additional freshwater sites in the freshwater reaches of Currimundi Creek North and South Arm would also provide information on the status of the sensitive fish species that were not captured in the current survey of the Currimundi catchment.

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