Use of 12 Mile Creek by Barramundi: Effects of Local Climate 1984-2007
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History of Data Collection at 12 Mile Creek

Accumulating a dataset over a 23 year period, especially where much of the data collection has been done voluntarily, involves a large number of people and it would be impossible to acknowledge all those that have contributed. Most individuals that have contributed have done so over a number of years but there are very few people that have contributed over the total time. However there are a number of organisations and programs that have contributed over a significant period of that time.

The accumulation of this dataset has been carried out under the Suntag program (previously Recreational Sportfish Tagging Program). Initially tagging at 12 Mile Creek was undertaken as part of a broad list of species, including Barramundi, being tagged under Suntag, however in the mid 1990s it was recognised that an important dataset was emerging. From that time tagging at the 12 Mile became a project in its own right and part of a project on Barramundi nursery areas in Central Queensland. Without the continued support for Suntag by the Department of Primary Industries and Fisheries over that time this would not have been possible.

Captag (Capricorn Tag and Release Sportfishing Club), Gladstone Sportfishing Club, Keppel Bay Sportfishing and other fishing clubs under the Australian National Sportfishing Association Qld Branch have been largely responsible for the tagging of fish. Other clubs that have contributed include SEQTAR (South East Queensland Tag and Release Club) and Brisbane Sportfishing Club.

Because of the uniqueness of this dataset there have been a number of projects since the mid 1990s that have focused on 12 Mile Creek. In 1997 a Natural Heritage Trust (NHT) project under the Fishcare program was initiated to examine the effects of freshwater flows on fish in the Fitzroy River system and this was the first time data from the Fitzroy River and adjacent creek systems, including 12 Mile Creek, were assessed (Sawynok 1998).

This project was followed by another NHT project from 1998-2001 for the revegetation of 12 Mile Creek. While not contributing fisheries data this project was a direct result of the identification of this as an important Barramundi nursery area and the need to maintain and improve its functioning. This project was to restore riparian vegetation that had been removed from the lower reaches of the creek. A report was produced on this revegetation project (Sawynok 2001).

While tagging was providing a significant amount of data on Barramundi in the creek it was not providing data on when, what size and what were the triggers (if any) for Barramundi to enter the creek. To understand how wetlands and creeks were being used by fish a series of projects were undertaken from 1999 onwards to collect data on Barramundi nursery areas in Central Queensland (Sawynok 2002, 2003, 2004, Sawynok and Platten 2005). This data collection is continuing at 12 Mile Creek.

As part of a review of wetlands along the Great Barrier Reef coastline the importance of freshwater wetlands to marine fishes was undertaken. This again identified the importance of 12 Mile Creek as a freshwater wetland (Veitch and Sawynok 2005).

In 2006 and 2007 further survey work was undertaken to examine fish use of Fitzroy floodplain wetlands. This work included electrofishing surveys at a number of sites including 12 Mile Creek. This was the first time electrofishing has been used to expand the available dataset. The electrofishing surveys were carried out by the Department of Primary Industries and Fisheries.

However, to determine how Barramundi use the creek, requires an understanding of the environmental conditions over that time. The most critical factors are rainfall and tidal movement as these factors determine when and for how long the creek is connected to the marine system. This is necessary for fish to recruit to and migrate from the creek. Data on tides was readily available from tide charts while rainfall data was provided by the Bureau of Meteorology, Cheetham Saltworks and local landowner Nelson Howkins. The contributions of all those are acknowledged.

This report is another in a series of reports that examines the data collected at 12 Mile Creek. It is expected that collection of this data will continue as, due to its long timeframe, it is one of the few continuous datasets that can provide data on the longer term effects of climate change on fish, especially Barramundi.
Summary

There are few datasets available that can be used to look at the effects of climate change on fisheries at a creek level. Data have been collected on the use of 12 Mile Creek by Barramundi for 23 years and provide a unique opportunity to examine the effects of climate change on this creek.

Data have been collected by a number of methods including fish tagging, castnetting and electrofishing. Each of these datasets provides an insight into the use of the creek by Barramundi. However when combined and compared to weather, particularly rainfall, it provides a timeline of the effects of change.

Fish tagging commenced in 1984 and has continued since that time. Monitoring by castnet commenced and has been ongoing since 1999. Electrofishing surveys were carried out in 2006 and 2007.

Over the 23 years a total of 5,287 Barramundi have been recorded at 12 Mile Creek with 5,004 tagged and lengths available for 4,985 fish. Of these 1,179 (23.6%) have been recaptured with 573 fish recaptured more than once. One Barramundi was recaptured 10 times.

Monthly rainfall data from 1984 to 2007 shows a steady decline in annual rainfall from around 800mm in 1984 to 500mm in 2007. This has been a decline of around 30%. At the same time mean annual air temperatures have increased by about 1°C. This means that evaporation is likely to have increased. Consequently average water levels in the creek have decreased significantly. High temperatures reduce dissolved oxygen levels and this may have also contributed to habitat stress in the waterholes.

Barramundi spawn in the adjacent Fitzroy River delta and then travel up the river to recruit to adjacent creeks and waterways, including 12 Mile Creek. The creek is mostly a closed system comprising 4 waterholes that need freshwater flows from rainfall and/or king tides to connect the creek to the delta.

Internally within the creek Barramundi use all 4 waterholes when conditions allow. Barramundi were recorded from all 4 waterholes in the years leading up to and for some years after the 1991 flood. Barramundi have only been recorded in waterhole 1 since 2001. This has reduced the habitat in the creek used by Barramundi by 75%.

Peak recruitment of Barramundi occurs when rainfall in January exceeds 200mm. Good rainfall a month either side allows a moderate level of recruitment and at other times results in little or no recruitment. Over the 23 years there were 3 years where conditions allowed peak recruitment. These were 1991, 1996 and 2001 or about every 5 years. It has been 6 years since the conditions were last right so the time span between peak years may be expanding. The Barramundi fishery in the Fitzroy River is very dependent on these years of peak spawning to sustain catches.

Not only is recruitment important it requires good conditions to prevail to ensure fish survival and growth. Since 2001 there have been 3 major fish kills including 2 complete kills. All these fish kills occurred in the past 7 years in waterhole 1 which is the most used by Barramundi. This has reduced the creek’s contribution to fish stocks in the Fitzroy River to negligible levels over that time.

Data on growth of new recruits indicates that in years of high recruitment (also high rainfall) there is a reduction in growth rate of first year recruits up
to winter in the first season. This is likely to be the result of increased competition for a limited food supply rather than any effect from the rainfall.

Winter is a difficult time for Barramundi as water temperatures get as low as 16-18°C which is at the lower end of their survival range. Food supply becomes scarcer although Barramundi eat much less during that time and have little or no growth. In a closed system like the 12 Mile the food supply over winter is finite and larger Barramundi feed on smaller fish as the food supply dwindles.

Data from 1996 suggest a level of mortality of juvenile fish over winter. The percentage of smaller fish recaptured after winter was significantly down from a high recapture rate of around 40% for 220-240mm fish before winter to as low as around 5% after winter.

The numbers of fish are reduced after winter by predation and mortality and in years of higher rainfall the growth rates of remaining fish are higher. Overall growth of fish by the end of winter in the second year is highest in high rainfall years and reduces by roughly the same percentage as the reduction in rainfall in other years.

Not only does connectivity to the marine system allow recruitment to the creek it allows fish to migrate elsewhere. While only a small percentage of recaptured fish (3.1%) were taken outside the creek of these 81% were fish tagged prior to 1992. In the 16 years since then only 7 (19%) fish have been recaptured elsewhere. This indicates a significant reduction in migration from the creek.

Fish leaving the creek have been mostly caught in the adjacent Fitzroy River and delta creeks. However a number of fish have been recaptured, mostly to the south, in areas around Gladstone Harbour and as far south as the Kolan River (200km) and the Burnett River (250km).

The effects of climate change on the use of 12 Mile Creek by Barramundi over the past 23 years can be summarised as:

- A reduction by 75% of the waterholes used by Barramundi;
- A possible increase in the time span between peak recruitments;
- Catastrophic fish kills in the 7 years since 2001 have reduced the contribution of the creek to Fitzroy River fish stocks to negligible levels;
- A lowering of survival of first year recruits post winter;
- A reduction in overall growth rates of fish that is related to a reduction in rainfall;
- A reduction in the distribution of Barramundi genetics to other populations, especially those to the south.

In the 1980s and 1990s 12 Mile Creek was considered to be one of the most important Barramundi nursery areas in Central Queensland. Its contribution to Central Queensland fish stocks has been significantly reduced since then, especially over the last 7 years.
Use of 12 Mile Creek by Barramundi: Effects of Local Climate 1984-2007

1. Background

Understanding the interaction between fish species and their environment generally requires monitoring over a long period of time. However there are very few examples of datasets that extend beyond a few years making it difficult to observe changes over longer periods of time.

Under the Suntag program data on Barramundi has been collected from 12 Mile Creek at Marmor in Central Queensland since 1984. Local rainfall data has also been collected over the same period of time providing a unique opportunity to examine the use of this creek by Barramundi and the effects of changes in rainfall over the past 23 years.

A relationship has been established between Barramundi recruitment and freshwater flows (Sawynok 1998, Halliday and Robins 2007, Staunton-Smith et al 2004) and this dataset provides an opportunity to examine that relationship further.

2. Description of 12 Mile Creek

12 Mile Creek is located to the east of Marmor about 50km south of Rockhampton (figure 1). The creek has a catchment area of around 80km² and runs after localised rainfall events of over 100mm. It flows northwards to the delta of the Fitzroy River where it flows into Inkerman Creek. Much of the catchment has been cleared and is used for farming and grazing.

Figure 1: Location of 12 Mile Creek catchment
Figure 2: 12 Mile Creek showing permanent waterholes and primary data collection site (waterhole 1)

Figure 3: Waterhole 1 on 12 Mile Creek which is the most used waterhole by Barramundi

The creek has 4 permanent waterholes in its lower reaches (figure 2). Three of these are freshwater (waterholes 2-4) while the fourth (waterhole 1) is on the edge of the delta and is mostly brackish but ranges from highly saline to freshwater depending on flows in the creek. These waterholes are known
habitats for both juvenile and adult Barramundi with importance increasing the closer they are to the Fitzroy delta.

Figure 4: Waterhole 2 on 12 Mile Creek is permanent freshwater

Figure 5: Waterhole 3 on 12 Mile Creek is permanent freshwater
Waterhole 1 is the most used by Barramundi and each year about 4-6 of the highest spring tides push saltwater up from the estuary into this waterhole. These tides generally occur from January to March. This waterhole is around 800m long and abuts the saline flats of the Fitzroy delta. Below waterhole 1 is a shallow channel that takes the creek north over the tidal flats to where it joins Inkerman Creek.

Waterhole 1 was largely devoid of riparian vegetation however a project was undertaken to revegetate the Camping Reserve (Lot 409/DS612) from 1998 to 2001 (Sawynok 2001) and this has improved the status of the adjacent vegetation.

The distance from the lower end of waterhole 1 to the top end of waterhole 4 is around 4km so the habitat available to Barramundi is limited. However it is considered to be one of the most important remaining habitats adjacent to the Fitzroy delta (Veitch and Sawynok 2005).

Conditions over the 23 years have varied from very wet in the late 1980s to very dry at various times since then, with that being reflected in the state of the habitat (figures 7 and 8).
Figure 7: Waterhole 1 on 12 Mile Creek under good conditions

Figure 8: Waterhole 1 on 12 Mile Creek under dry conditions
3. **Objectives of this report**

Over the 23 year period data on 12 Mile Creek have been collected in relation to a number of projects which have had their own specific short term objectives. The objectives of this report are to:

1. Describe the use of 12 Mile Creek by Barramundi over the 23 year period from 1984-2007.
2. Describe the influence of local climatic conditions, especially rainfall, on the use of the habitat by Barramundi.
3. Review long term trends on the use of 12 Mile Creek by Barramundi in relation to changes in the local climate.

4. **Methods**

Over the 23 years there have been a number of methods that have been used to collect data on Barramundi. Most data collected was on fish in waterhole 1.

The data does not include details of all fish caught as there has been significant recreational and some indigenous fishing in waterhole 1. The majority of tagged fish were reported, however there are no records of untagged fish kept or any untagged fish that were released. Therefore the dataset only covers those fish where records are available.

Data have been collected over the entire period through the tagging of Barramundi by members of local Sportfishing Clubs as part of the Suntag program. This data included date of tagging and length of fish.

As well as data from tagging, details of recaptures of tagged fish have also been recorded. This has allowed the growth of fish to be calculated and movement from the 12 Mile Creek to other locations to be assessed (Sawynok 1998).

Data have been collected through castnet surveys from 1999 as part of a project examining the use of wetlands by Barramundi. Details of Barramundi and other species were recorded including length and date of capture. Fish larger than approximately 150mm were tagged while smaller fish were released without tagging. This has provided information on when, and under what flow conditions, fish migrate to the 12 Mile Creek and their likely time of spawning (Sawynok 2002, 2003, 2004, Sawynok and Platten 2005).

Data was also collected by electrofishing in waterhole 4 in 2006 and 2007 (Power and Marsden 2006, 2007). This survey was to collect data on use of the waterhole by fish prior to and after the wet season. Unfortunately the wet season failed and there was no flow in the creek connecting the waterholes.

Data on tagging and recaptures is stored in the web based database Infofish 2006 available at [http://database.info-fish.net](http://database.info-fish.net) however access is limited to authorised users.

Data from the castnet surveys is stored in an Access database held by Infofish Services. Data from the electrofishing survey is stored and maintained by the Department of Primary Industries and Fisheries.

Data have been collected by 3 different methods however the key data used in this report, length of fish and date caught, were consistently collected by each method and the methods were consistent used over the years. The only possible exception is data obtained from the fish kills.
There is some size bias as the majority of fish were taken by angling. This is not really effective until fish reach 200mm, so that the number of fish below that size is small. However they are only below that size for a short time in the creek, probably around a month or so. The castnet surveys sample fish from around 50-350mm so provided an indication of when smaller fish were present. No Barramundi were taken by electrofishing however this method can sample the fish range of fish sizes from 50-1,000mm.

Length data and date were used to provide a timeline of the size of fish in waterhole 1. This allowed an assessment to be made of when fish recruited to the creek and the subsequent growth of those fish over time.

Tag and recapture data was assessed to determine growth. In the fish kill in 2001 otoliths were collected from both tagged and untagged fish. This allowed the age of a number of fish to be determined from otolith analysis and this was then compared to aging from tag and recapture data (Sawynok 2002).

There are 3 sources of rainfall data over the timeline of this project. Data was available from the Department of Meteorology Raglan Station rain gauge No: 039079 at latitude 23°42’58”S and longitude 150°49’18”E from January 1985 to July 1995 (excluding May to December 1994). This gauge was shut down at that time.

Rainfall data was also available from local landowner, Nelson Howkins, with the gauge within the 12 Mile Creek catchment at latitude 23°41’18”S and longitude 150°44’45”E from July 1984 to June 1997. Rainfall records from these 2 sources were compared and no significant differences were found between the datasets (Sawynok 1998).

Rainfall data was also available from Cheetham Saltworks which has a number of gauges in the area. The gauge closest to 12 Mile Creek is at latitude 23°39’19”S and longitude 150°48’46”E and rainfall data was obtained from June 1994 to June 2007.

Rainfall data from Howkins was used from July 1984 to June 1994 and from Cheetham Saltworks from July 1994 to June 2007 to provide monthly rainfall data over the 23 years. Rainfall data was analysed to determine long term trends in rainfall.

Temperature data was obtained from the Bureau of Meteorology website www.bom.gov.au for Rockhampton Aer site number: 039083 located at Lat 23°38’S and Long 150°48’E. This recording station is around 50km north of 12 Mile Creek however the temperatures are considered to be indicative of the temperatures experienced at the site.

Flow data was obtained from the Department of Natural Resources and Water website www.nrw.qld.gov.au/watershed/ for the Fitzroy River at the Gap recording station 130005A Lat 23°05’ S Long 150°06’ E GZ 8.869m Datum AHD AMTD 142.1km.

Data from the electrofishing surveys was collected from waterhole 4 (Toonda Lagoon) and this provided data on the access by fish to the most distant waterhole from the marine system. In turn this allowed an assessment of connectivity along the creek and a comparison of fish species in waterholes at each end of the permanent water in the creek.
5. Local Climate Trends

5.1 Rainfall and Historic Trend

Monthly rainfall data was available for the period July 1984 to June 2007. Figure 9 shows the annual rainfall each year over the 23 years and the trend in that rainfall. This shows that there has been a steady decline from around 800mm per annum in the mid 1980s to around 500mm in mid 2007. This is a reduction of around 300mm (30%) over that time.
While average annual rainfall is useful in assessing the trend in rainfall over time, monthly rainfall is more important in determining recruitment of Barramundi to the creek from the marine system. Figure 10 shows the monthly rainfall over the 23 years while figure 12 shows the actual rainfall each month over that period.

### 5.2 Temperature and Historic Trend

As well as rainfall the other aspect of local climate that is likely to affect the creek is temperature. Some data are available for water temperature however this is limited to 2000-2005. Data on mean annual air temperature was used to determine any effect from changes in temperature.

The long term mean annual temperature from 1939-2006 was 28.3°C. The mean temperature in 1984 was around that average however has steadily risen by about 1°C to around 29.3°C in 2006 (figure 11). The effect of such a temperature increase would have been an increase in the evaporation rate and a decrease in dissolved oxygen levels. These in turn would have increased stress on the creek, especially during periods of low rainfall and low tidal influence.

![Mean Annual Temperature 1984-2006](image)

**Figure 11**: Trends in mean annual temperature at Rockhampton from 1984 to 2006 (fish kill years highlighted)

### 6. Use of 12 Mile Creek by Barramundi

#### 6.1 Introduction

12 Mile Creek has 4 permanent waterholes that have all been used by Barramundi when conditions allow fish to reach them.

There is no evidence that Barramundi breed in 12 Mile Creek and therefore populations are reliant on breeding in the adjacent Fitzroy River delta. Barramundi spawning occurs primarily between October and December (Sawynok 2005) near the mouth of the Fitzroy River. Juvenile fish then make their way up river and into adjacent waterways when conditions are right.
12 Mile Creek only flows intermittently when there is a significant rainfall event or is connected to the marine system by king tides during summer. Most flows last from a few days to several weeks. This limits the opportunities for fish to recruit to the creek. Summer rainfall in January of around 200mm, particularly if it coincides with large spring tides provides the conditions required for fish to recruit to the creek and for adult fish to migrate back to the marine system (Sawynok 1998).

6.2 History of Barramundi in 12 Mile Creek

Over the 23 years a total of 5,287 Barramundi have been recorded in 12 Mile Creek (mostly in waterhole 1) with 5,004 fish tagged and lengths available for 4,985 fish. Of these 1,179 (23.6%) have been recaptured with 573 fish recaptured more than once. One Barramundi was recaptured 10 times.

The high recapture rate results from the creek being a closed system much of the time where fish are confined to the waterholes in the creek for extended periods of time. There is also public access to the creek (particularly waterhole 1) so that the level of fishing effort is high when Barramundi are present in the creek.

Along with rainfall data this has allowed an accurate record of use of the creek by Barramundi to be developed.

*Figure 13* shows the timeline of Barramundi sizes compared to monthly rainfall. The density of dot indicates the number of fish there at any particular time. Time gaps in the data coincide with winter periods when Barramundi are very difficult to catch and so very few are recorded over winter months.

From 1984 to 1993 there was a healthy population of fish ranging in size from less than 200mm to around 1000mm. From 1984 to 1988 Barramundi smaller than around 300mm were not tagged so do not show up in the data. In 1988 smaller tags allowed smaller fish to be tagged as well.

From 1993-1996 the population was reduced to much lower numbers comprising mostly larger fish. This was a particularly dry period with poor recruitment of fish to the creek. Recruitment events show up on the timeline as fish below 250mm (first year recruits). Following each recruitment event the timeline shows the fish increasing in size over time with some fish reaching around 1m.

Following a rainfall event in January 1996 there was significant recruitment of fish to the creek. From March-May 1996 over 1,400 Barramundi around 200mm were tagged in the creek. This was the largest recruitment event over the 23 years of data collection. Following that recruitment a good population of fish remained through to 2001.

There was also strong recruitment in 2001 following good rainfall in late 2000 and early 2001. However in May-June 2001 there was a total fish kill over several weeks. Following the fish kill there was limited recruitment with very few fish in the creek over the next 2 years. In January 2003 another flow event allowed fish to again recruit to the creek with further recruitment in 2005. A reasonable population of fish existed from 2003 to 2006. However dry conditions from mid 2005 to mid 2007 resulted in the lowest water levels recorded and another fish kill occurred in late 2006. From late 2006 to June 2007 water levels remained very low. Rainfall in June 2007 filled all the waterholes in the creek however no Barramundi have been recorded returning to the creek to the end of 2007.
MONTHLY RAINFALL AT 12 MILE CREEK

Figure 12: Monthly rainfall at 12 Mile Creek from 1984 to 2007

BARRAMUNDI AND RAINFALL AT 12 MILE CREEK

Figure 13: Sizes of Barramundi in 12 Mile Creek compared with monthly rainfall
6.3 Recruitment of Barramundi

Recruitment of Barramundi to 12 Mile Creek is dependent on the success of spawning in the adjacent Fitzroy River delta. In turn the success of spawning in the delta and the subsequent recruitment of fish is dependent on river flows and coastal rainfall. Recruitment in the Fitzroy River system and river flows is shown in figure 14. This indicates that peak recruitment occurs in years of high river flow when those flows occur in January/February. Coastal localised rainfall then determines if fish can recruit to adjacent creeks such as 12 Mile Creek.

![Barramundi recruits vs flow](image)

Figure 14: Recruitment of Barramundi in Fitzroy River system related to river flows (Note that 1996 recruitment was actually 1,271 and has been reduced to 400 to allow a more meaningful scale)

Table 1 shows the flow and timing in the Fitzroy River, rainfall and timing in 12 Mile Creek and the number of Barramundi recruits (<250mm) recorded overall in the Fitzroy River system and in 12 Mile Creek. These fish are considered to be recruits from that year (0+ fish). In years where both flow and timing conditions were in the prime range (green) then recruitment was significantly elevated in both the river and in 12 Mile Creek. There were 3 years when these conditions occurred. These were 1991, 1996 and 2001. Over the 23 years the peak recruitment year for 12 Mile Creek was 1996.

In years when either the timing or the flow at 12 Mile Creek was outside the range (red) then recruitment was low. There were 7 years where these conditions occurred which were 1993, 1995, 1998, 2000, 2002, 2006 and 2007. As well in 1990, 1992 2006 and 2007 conditions in the river were not favourable for strong recruitment.

In the remaining years when conditions were close (yellow/green) to the range there was a moderate level of recruitment.
### Table 1: Relationship between Barramundi recruitment, river flows in the Fitzroy River, rainfall at 12 Mile Creek and timing of flows

<table>
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Legend:
- Conditions outside range
- Conditions close to range
- Conditions inside range

### 6.4 Juvenile Barramundi Survival over Winter

Over the 23 years there have been 1,628 juvenile Barramundi of less than 250mm (year recruits) that were tagged between 1 January and 31 May in each year. Of these there were 329 (20.2%) individual fish recaptured (excluding multiple recaptures) before winter the same year. This compares with 70 (4.3%) fish that were recaptured after winter. Figure 15 shows the percentage recaptured each year before and after winter. Figures for individual years need to be treated with caution as in most years, except 1996, individual numbers of fish tagged were low. The only year where a higher recapture rate was recorded after winter was in 1991. The lack of recaptures after winter in 2001 was as a result of the fish kill that occurred at the start of winter.

Sufficient data were available from 1996 to determine recaptures before and after winter based on the size of the fish when tagged. From March–May that year there were 1,482 fish tagged with 1,475 less than 360mm in length. Figure 16 shows the rate of recapture of these fish before and after winter that year. Before winter the rate of recaptures of smaller fish below 280mm was high with recapture rates near 40% for fish from 220-280mm. However after winter the recapture rate dropped significantly to around 5-15% for fish from 220-280mm.
There are several explanations as to why this may have occurred in 1996. It may be that the fish moved out of the area, but the system tends to be closed with insufficient rain or tides high enough to release fish over winter. It could also be that some fish may have grown faster and it could be that these along with other larger fish already present were preying on the smaller fish. This is not unusual particularly where food supply is limited as is likely in a closed system where a large number of predators inhabit a confined area. It could be that the fish died from other factors but no fish kills were reported over winter.

In 1991, the only year when the post winter recaptures was higher, there was major flooding in the Fitzroy River which included 12 Mile Creek and the subsequent food supply would have been above normal. This may account for the higher survival rate post winter that year.

![Figure 15: Recaptures rates of juvenile Barramundi before and after winter each year](image1)

![Figure 16: Recapture rates before and after winter 1996 based on size of fish when tagged](image2)
6.5 Growth of Barramundi

The availability of fish data over 23 years provides a unique opportunity to examine the growth of Barramundi. Two methods were used to estimate growth, length frequency analysis and the growth observed between initial tagging and recapture.

The estimation of fish growth patterns is a complex process. Fish grow at variable rates throughout life and there is great variability between fish. To accurately assess growth requires a dedicated and extensive investigation. However tagging programs can provide useful data. The increase in total length between the time of tagging and recapture is a direct measure of growth by individual fish.

Because fish tend to be spawned at particular times of the year, when the length frequency distribution of fish are plotted the graph appears as a series of peaks corresponding to the modal length at each age class. The difference between these peaks is a measure of the growth from one age class to the next. These can be compared with the growth rates calculated from the tagging and recapture analysis.

To estimate growth from recapture data the average growth of fish from the time of tagging to the time of recapture was calculated as the average growth in mm per day from the increase in length (mm) divided by the days elapsed. This was then converted to an annual growth rate by multiplying by 365. Some fish showed small negative values of growth either related to errors in measurement or shrinkage due to trauma related to capture. These fish were deemed to have no growth and not included in the calculations. In addition fish where the difference between the time of tagging and the time of recapture was less than 10 days were not considered in the calculations.

The length frequency distributions were prepared for fish captured in autumn in years where over 100 fish were taken. The difference in length between the modes in the years available is shown in figure 17. The estimated growth is summarised in table 2.

<table>
<thead>
<tr>
<th>Year</th>
<th>Modal length mm</th>
<th>Estimated growth mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>410</td>
<td></td>
</tr>
<tr>
<td>1988</td>
<td>240, 390, 460</td>
<td>150, 70</td>
</tr>
<tr>
<td>1991</td>
<td>190, 330</td>
<td>140</td>
</tr>
<tr>
<td>1992</td>
<td>430</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>190</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>210, 360, 430</td>
<td>150, 70</td>
</tr>
<tr>
<td>1999</td>
<td>240, 370</td>
<td>130</td>
</tr>
<tr>
<td>2001</td>
<td>290</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Average annual growth from length frequency and from recaptured tagged fish

As a third check on growth, the otoliths were collected from a number of fish found dead after the fish kill in May 2001. These were sectioned and the number of growth rings for fish of varying length recorded (Sawynok 2002). This information showed an average size of the 0+ fish of 282mm with a 95% confidence interval of 10mm (exactly the same as the modal length from the length frequency plot).
Figure 17: Length/frequency of Barramundi in 12 Mile Creek in years from 1987-2001
The results suggest that fish reach a length of 190-280mm in autumn of their first year, between 330-390mm in their second and between 410-460mm in the third. The estimated growth of 140-150mm per year between autumn of the first year of life and autumn of the second year is comparable with the growth of recaptured fish (142mm see table 2).

Most new recruits appear to become catchable by fishing methods between April-May (figures 18 and 19). They are present in greatest numbers and of smallest size in April but enter the creek earlier in January-March at a size too small to catch or tag.

Figure 18: Number of Barramundi tagged below 250mm in each month

Figure 19: Average size of fish captured (smaller than 250mm) in each month of the year
The size distribution of fish suggests there is a rapid decrease in the number of fish tagged at lengths greater than 360mm. This may suggest that Barramundi tend to use the waterholes for their first 2 years of life and most will die, leave before 3 years of age or are kept by fishers once they reach the legal size of 580mm. Some fish however remain and grow to around 1m in length.

### 6.6 Growth of Barramundi in Wet and Dry Years

Typical growth rates for recruit fish in their first year of life are inversely related to rain, that is growth is lowest in years with high rainfall (*figure 21*). The explanation for this probably relates to the number of fish present, rather than the influence of rain. The wet years (particularly where rainfall occurs in January or February) result in high levels of recruitment and as a result high numbers of fish in the 12 Mile waterholes and large numbers of tagged fish. This is likely to result in increased competition for food amongst fish. So that if the number of fish tagged is compared with the growth rate of the young recruits, the higher the number of fish present, the lower the growth rate (*figures 22 and 23*). This suggests that the amount of food in waterhole 1 can be a limiting factor in high recruitment years. As a result, if the full benefit of high recruitment is to be achieved, it is important that the young fish have access to all of the waterholes. However the slower growth of young fish in wet years (where there is strong recruitment) is not the full story.

The relationship between growth and rainfall changes completely once fish have survived their first winter. As discussed in section 6.4 the number of fish present falls significantly over winter so that competition for food drops dramatically. Without this limiting factor, growth is in fact greater for these fish in wet years. This is best illustrated by looking at the growth displayed by fish tagged as young recruits and then recaptured in the following year. This analysis was limited to fish of less than 250mm that were tagged in any year and then recaptured prior to winter in the following year. There is little or no growth of fish over winter so this provided growth data over the growing period immediately after they were tagged and then over the following growing season (spring to autumn). This growth was then compared with rainfall over the same period.
Figure 21: Comparison between growth of fish in 12 mile waterholes in their first year of life and rainfall (the fitted line provides a guide to trends in the data).

Figure 22: Comparison between the number of fish tagged (expressed as a logarithm to enable illustration) and the growth of fish in their first year of life.

Figure 23: Comparison between corrected abundance of fish tagged (catch rate of tagged fish) and the growth of fish in their first year of life (the fitted line provides a guide to trends in the data).
There were only 4 years where there were sufficient data. This indicated that a 21.9% reduction in rainfall for 1995/96, compared with 1990/91, saw a reduction in growth of 34.9%. In 1996/97 the rainfall reduction, compared with 1990/91, was 43.7% while growth was down by 54.7%. In 2000/01 the growth rate appears to have increased while rainfall has decreased however these data needs to be discounted as a fish kill at the start of winter 2001 saw all these fish die so the growth rate is only for the growing period prior to winter and cannot be compared to the other years (table 3 and figure 24). Care needs to be taken with data interpretation because of the small sample sizes.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>DAILY GROWTH mm/day</th>
<th>RAINFALL mm</th>
<th>ANNUAL GROWTH mm</th>
<th>% DIFF RAINFALL</th>
<th>% DIFF GROWTH</th>
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<tr>
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<td>0.52</td>
<td>1095</td>
<td>190.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995/96</td>
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<td>855.5</td>
<td>124.1</td>
<td>-21.9%</td>
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<tr>
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<td>616.8</td>
<td>86.3</td>
<td>-43.7%</td>
<td>-54.7%</td>
</tr>
<tr>
<td>2000/01</td>
<td>0.90</td>
<td>511.5</td>
<td>328.6</td>
<td>-53.3%</td>
<td>+72.5%</td>
</tr>
</tbody>
</table>

Table 3: Comparison of growth with rainfall with percentage differences compared to 1990/91

Figure 24: Growth rates of fish <250mm when tagged compared with rainfall
6.7 Dispersal of Barramundi from 12 Mile Creek

Over the 23 years a total of 5,004 Barramundi have been tagged in 12 Mile Creek (mostly in waterhole 1). Of these 1,179 (23.6%) have been recaptured with 573 fish recaptured more than once. However of those recaptures only 37 (3.1%) have been recaptured from waterways other than 12 Mile Creek. This is mainly due to the creek being a closed system much of the time.

While juvenile Barramundi use freshwater flows and large spring tides to recruit to the creek adult Barramundi also use the same flows to migrate from the creek to the Fitzroy River and adjacent systems. Of the 37 fish that migrated from the creek 24 (65%) were tagged in the wet years leading up to the 1991 flood. A further 6 (16%) fish tagged in 1991 were also recaptured elsewhere. By contrast in the 16 years since then only 7 (19%) have been recaptured elsewhere (figure 25).

The majority of recaptures outside the creek have occurred in the Fitzroy River and Raglan Creek. There has only been one fish recaptured to the north in the Fitzroy River and that was in Coorooman Creek near Emu Park. By contrast a number of fish have been recaptured to the south as far down the coast as the Kolan River (200km south) and the Burnett River (250km south).
6.8 Fish Kills

Over the 23 years of data collection there were 3 major fish kills, one in early winter 2001, another in November 2005 and the other in late 2006. All kills were in waterhole 1 and no kills were reported from the other waterholes.

Anecdotal information suggests that fish kills have happened in the past however there were no previous kills over the 23 years that could be substantiated. There were reports of minor kills in the mid 1990s in the dry years after the 1991 flood but no evidence of these was able to be collected.

The 2001 fish kill (figure 26) which occurred in May–June was documented at the time (Sawynok 2002). This kill lasted for several weeks and was complete with no fish alive when it ended. This kill involved around 3,200 fish including 150 Barramundi from 120-955mm.

![Figure 26: Part of the 2001 fish kill showing a large dead Barramundi](image)

The 2005 fish kill (figure 27) occurred in November after a very dry winter and spring (Sawynok 2005). It was estimated that over 5,600 fish were killed which included 133 Barramundi from 180-1020mm. This was not a total fish kill however the number of fish surviving was estimated as low. A small flow in December and spring tides in January saw fish recruit back to the creek from the marine system.

Some Barramundi were recorded in the creek during 2006 however low rainfall saw the creek drop to the lowest levels in the 23 years, this was despite reasonable rain in June (145mm). By October the water was estimated to be 1m lower than any previous recording. Prior to December 2006 another fish kill occurred. However this was not able to be documented as it was estimated to be at least 4 weeks after the kill when it was discovered. This kill was total and by mid 2007 there were no records of fish in the creek.
In January 2004 a minor fish kill was recorded with around 100 Bony Bream found dead. No Barramundi were observed to be involved in this kill. In October 2007 a further minor fish kill was recorded with around 20 Eels found dead (figure 28). No other fish species were involved.

Three major fish kills and 2 minor ones recorded since 2001 are of particular concern. It should be noted that this corresponded with years of low rainfall (figure 9) and higher than average temperatures (figure 11). This resulted in lower water levels due to lower inflows and increased evaporation, fewer flushing events and likely lower dissolved oxygen levels. This situation should be continuously monitored, particularly if local climate conditions change.
7. The Effects of Local Climate on Barramundi in 12 Mile Creek

Having 23 years of continuous data on a creek and its use by Barramundi has provided a unique opportunity to examine the effects of local climate. While 12 Mile Creek is very small compared with the Fitzroy River it is likely that similar effects to those observed here would be seen in other creeks that are adjacent to the river.

As the habitat that used to be available to Barramundi has been significantly reduced by the Barrage on the Fitzroy River, dams and weirs on smaller creeks on the floodplain and pondage for improved pastures it is important to understand how the remaining creeks and wetlands function. This dataset has allowed an examination of the added effect of local climate on these habitats.

The most significant effect of local climate has been the steady reduction in average annual rainfall over the 23 years. This has seen rainfall steadily decline from around 800mm per year in the mid 1980s to around 500mm now. This is a reduction of around 30% over that time.

As well as a drop in rainfall there was also a rise in average temperature of around 1°C over that time. In combination with the drop in rainfall this means that evaporation rates from the pools is likely to have increased. It is likely that by the end of the dry season water levels in the pools will be lower, salinity in waterhole 1 higher and dissolved oxygen levels lower. This may well have been associated with increased stress in the pools and at least some of the fish kills recorded.

12 Mile Creek only flows intermittently when there is rainfall in the catchment of around 125mm or more. A small number of the largest spring tides in summer also connect the creek to the Fitzroy delta. This level of connection is the determining factor as to whether Barramundi can enter or leave the creek.
The Barramundi life cycle revolves around spawning from October to January at the mouth of the Fitzroy River. Juvenile fish then make their way up the river and adjacent waterways awaiting an opportunity to enter creeks and wetlands where there is a reduced risk of predation and a good food supply.

The 30% reduction in rainfall over the 23 years has reduced the connectivity of the creek and reduced the times, both in frequency and duration, when fish can enter or exit the creek. This has resulted in less connectivity to the Fitzroy estuary and consequent reduction of its value as a Barramundi nursery area.

Internally in the creek Barramundi mostly use waterhole 1 adjacent to the tidal flats. However Barramundi were known to have used all 4 waterholes in the past. Barramundi were recorded in waterhole 4 (Toonda Lagoon) following the 1991 flood but have not been recorded there since. However in the electrofishing surveys in 2006 and 2007 Tarpon (Megalops cyprinoides) and 3 other diadromous species were recorded in waterhole 4 (Power and Marsden 2006, 2007) indicating that these species were still accessing the upper waterhole of the creek.

Use of 12 Mile Creek by Barramundi is determined by the spawning success of fish in the Fitzroy River and then the ability of juvenile fish to enter the creek. Strong recruitment to the creek occurs when the right conditions exist. Recruitment peaks when rainfall of over 200mm occurs in January and is reduced if these conditions are not met. Over the 23 years there were 3 years when these conditions were met. This was in 1991, 1996 and 2001 or about every 5 years. It has been 6 years since the last time the conditions were right so the time span between years where the right conditions occur may be increasing.

Not only are the right conditions for recruitment important, it requires good conditions to prevail to ensure fish survival and growth. Since 2001 there have been 3 major fish kills including 2 complete kills. While anecdotal evidence exists of fish kills in the past there have been no other major kills confirmed over the 23 years. All 3 major fish kills have occurred in the past 7 years.

Two other important lagoons that link to the Fitzroy River are Woolwash and Frogmore Lagoons. Woolwash Lagoon completely dried in May 2005 resulting on a total loss of fish including large Barramundi (no estimate of numbers available). Frogmore Lagoon did not dry until April 2006 and again that resulted in a total fish kill including Barramundi (no estimate of numbers available).

Data on growth of new recruits indicates that in years of high recruitment (also high rainfall) there is a reduction in growth rate of recruits in the first season. This is likely to be the result of increased competition for a limited food supply rather than any effect from the rainfall.

Winter is a difficult time for Barramundi as water temperatures get as low as 16-18°C which is at the lower end of their survival range. Food supply becomes scarcer although Barramundi eat much less during that time and have little or no growth. In a closed system like the 12 Mile the food supply over winter is finite and larger Barramundi feed on smaller fish as the food supply dwindles. There has been no evidence of tagged juvenile Barramundi being recaptured after winter since 1999 although the numbers are low and care needs to be taken with any interpretation.

Data from 1996 suggests a level of mortality of juvenile fish over winter. The percentage of smaller fish recaptured after winter was significantly down from
a high recapture rate of around 40% for 220-240mm fish to as low as around 5% after winter.

The numbers of fish are reduced after winter by predation and mortality and in years of higher rainfall the growth rates of remaining fish are higher. Overall growth of fish by the end of winter in the second year is highest in high rainfall years and reduces by roughly the same percentage as the reduction in rainfall in other years.

As the Fitzroy River is an open system compared to 12 Mile Creek growth of first year recruits is not limited to the same extent by food supply. Halliday and Robins (2007) found that growth rates in the Fitzroy River were related to freshwater flows with high flow events during the growing period producing the greatest growth.

Not only does connectivity allow juvenile fish to recruit to the creek it also allows adult fish to migrate elsewhere. While only a small percentage of recaptured fish (3.1%) were taken from outside the creek, of these 81% were fish tagged prior to 1992. In the 16 years since then only 7 (19%) fish have been recaptured elsewhere. This indicates a significant reduction in migration from the creek.

There can be no doubt that the use of 12 Mile Creek by Barramundi has been significantly impacted by changes in the local climate. In the mid 1980s when data collection commenced it was considered to be one of the most significant Barramundi nursery areas in Central Queensland but the effects of climate change have reduced its ability to maintain a fish population with several catastrophic fish kills reducing its value considerably, particularly over the past 7 years.

The changes in rainfall patterns and temperatures may well be variable and further monitoring of the system may provide a valuable guide to changes in other wetland systems.

With moderate flooding in the Fitzroy River in early 2008 and above average wet season rainfall it is possible that there may be recovery in the system. Data are continuing to be collected to determine the extent of any recovery.

Datasets such as this one are important if we are to understand the impacts of climate variability or change and can provide information on how some of the impacts can be mitigated.
8. References


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