Looking into the "Crystal Bowl"

FITZROY BASIN ASSOCIATION

CRYSTALBOWL

CARING FOR OUR COUNTRY

Looking into the "Crystal Bowl"

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ACKNOWLEDGEMENTS

This project is about shifting the focus of attention from the past and onto the future. However in order to do that there is a need to have information from the past.

Tagging data have been collected under the Suntag program for over 25 years. Suntag is a joint program between the Australian National Sportfishing Association Qld Inc (ANSAQ) and Fisheries Queensland. Funding provided by Fisheries Queensland (FQ) has allowed a continuous timeline of data to be collected that underpins this project. Members of local ANSAQ clubs in Central Queensland have largely been responsible for the tagging of fish and providing the details of their fishing trips. Those clubs are Capricorn Tag and Release Sportfishing Club (Captag), Gladstone Sportfishing Club and Keppel Bay Sportfishing Club.

From 2005-09 additional data were collected under the CapReef project. This expanded data collection to obtaining catch and effort data of recreational fishers. The initial focus of CapReef was collecting data in the Great Barrier Reef Marine Park but expanded to estuaries, including the Fitzroy River, in 2007. Funding for CapReef was provided by a number of sources including Fitzroy Basin Association, Natural Heritage Trust, Great Barrier Reef Marine Park Authority, Fisheries Queensland and NRG. This has extended the data available to this project.

As well as the contribution of fishers providing tagging data and details of their fishing trips local fishers, both commercial and recreational, have provided details of recaptured fish. Local fishers have also provided valuable information on juvenile Barramundi caught while collecting bait. These data have provided valuable additional information for monitoring recruitment and assessing the status of fish stocks.

The collection of data on the fishery is complemented by a sophisticated web based database developed by One Pixel. This database has been continually upgraded to meet changing needs and was recently linked to Google Earth to provide an improved visualisation of data so that it can be better understood by the community.

The initial Crystal Bowl project was funded by the Fisheries Research and Development Corporation (FRDC) and the current project has been funded by the Fitzroy Basin Association as part of a larger Caring for our Country project.

Naming individuals runs the risk of omitting important contributors so the acknowledgement has been limited to the organisations that have contributed in terms of voluntary assistance or funding. They have all made it possible for us to take this step into the future.

SUMMARY

This project has engaged recreational (and commercial) fishers in the development of the capacity to predict Barramundi stocks in the Fitzroy River. Considered essential to that engagement was involving them in data collection and providing them with an information service based on the data collected. Using their data to assist in predicting the future provides a greater sense of purpose and their involvement will improve their acceptance of the predictions, especially if they sit comfortably with their own observations.

Having an understanding of what future stocks will look like allows fishers to make investment decisions both in terms of the time and resources they wish to commit over the next few years. This is similar to the way that farmers use weather predictions.

The "Crystal Bowl" has been developed based on monitoring Barramundi stocks, recruitment and the environmental drivers of the stocks. At this stage the prediction is qualitative but can be further developed if fishers value the service.

Based on the data collected the first prediction was made in 2011 for stocks in 2012. The stock level in 2011 was the highest in 25 years so will be used as a baseline from which to measure future stocks. A prediction has been made in 2012 for 2013 with a further prediction for 2014 however this is far less certain and will depend on what actually happens in 2013.

Crystal Bowl prediction in 2011 for Barramundi in the Fitzroy River in 2012

- ***Barramundi stocks will be high***
- ***3-5 years old fish (580-850mm) will dominate the legal catch***
- ***Large numbers of juvenile fish aged 2-3 years (450-580mm)***
- ***Low numbers of 0-1 year old fish (0-450mm)***

Crystal Bowl prediction in 2012 for Barramundi in the Fitzroy River in 2013

- ***Barramundi stocks will be moderate/high and 50-70% of level in 2011 but moderately uncertain***
- ***3-5 years old fish (580-850mm) will dominate the legal catch***
- ***low numbers of fish aged 2-3 years (450-580mm)***
- ***Low numbers of 0-1 year old fish (0-450mm)***
- ***Stocks will be confined to the river with low levels of fish in lagoons***
- ***Moderate numbers of fish above the Barrage***
- ***Stocked fish levels in estuary will be low***
- ***Probability of good recruitment is low but moderately uncertain***

Data collected that was used to underpin the predictions:

- Commercial catch of Barramundi of 70.8t in 2011
- Recreational catch estimate of Barramundi of 17.0t in 2011
- Recruitment model that predicted low recruitment
- Recruitment surveys undertaken to confirm the level of recruitment as low
- Catch rates from the Rocky Barra Bounty
- Length, growth and age data to link age groups to fish lengths
- Tagging data shows that the stocks of fish in offstream lagoons and creeks is low
- Numbers of stocked tagged fish recorded in the estuary
- Tagged fish recaptured above the Barrage and anecdotal information on fishing above the Barrage
- Rainfall, river flows and timing
- Climate predictions of an El Nino forming towards the end of spring 2012

While the 2012 year is only halfway though, a preliminary assessment was made of the 2011 prediction for 2012 based on data that has been collected. Data on percentages of fish in sizes ranges indicates that the actual percentages were close to those predicted however there is no current measure of actual relative stock levels.

1. BACKGROUND

The concept of a "Crystal Bowl" to predict Barramundi stocks emerged in 2007 when monitoring of Barramundi stocks in the Fitzroy River indicated that stocks were low at the end of a drought period that lasted from 2003-08. Fortunately the drought broke in 2008 and there was a rebound in stocks with 3 good recruitment years in 2008, 2009 and 2010.

In 2010-11 the first project to develop the Crystal Bowl was undertake through project 2009/094 titled 'Topping up the "Crystal Bowl" for Barramundi'[1] funded by the Fisheries Research and Development Corporation (FRDC). This was the first attempt to collect the data required to predict stocks for the Fitzroy River and included an estimate of recreational catch. This was also seen as important to provide a baseline which could be used to measure the impact on fish and fishing of 2 coal port developments proposed for the mouth of the Fitzroy River.

That project was completed in mid 2011 and was then replaced by this current project funded by the Fitzroy Basin Association to engage recreational fishers in the Fitzroy River. That engagement was viewed as being primarily through involving them in data collection and in turn using that data to provide fishers with information on Barramundi and the future of stocks.

2. WHY DEVELOP A CRYSTAL BOWL?

We live in a world where we need to be aware of what the impact of what we do now will have on the environment we will live in tomorrow. More and more our views of the future are moulded by predictions of what we can expect to happen. A good example is the weather.

Back in the early part of the 20th century weather predictions were fairly crude with most people sceptical or distrustful of them. However over the decades leading to this century the ability to predict the weather improved to the extent where most of us rely on and trust the predictions in one way or another.

Yet in many areas of dealing with other natural resources we are still more focused on understanding the past rather than developing the ability to predict the future. While it is true that understanding the past is a key to predicting the future, in fisheries we tend to spend too much time on the past and too little on the future. This means that we continue to head into the future with little understanding of what is in store. There is a need to shift our thinking and efforts to better understand where we are headed.

Being able to predict what fish stocks might look like in the next few years will pay significant dividends. Commercial and recreational fishers should be able to make investment decisions in terms of both the time and resources they wish to commit based on what stocks might look like over the next few years.

While fisheries managers are constrained by current legislation and tools at their disposal there will be a need for more flexibility in the future if we are to continue to manager stocks sustainably. Knowing what stocks are likely to be in the future will provide a greater lead time for response and avoid some of the kneejerk reactions that are taken when a crisis emerges.

[1] Available at www.info-fish.net/crystal-bowl

The impact of resource and infrastructure development, in this area port development associated with mining, will be better understood if we know the dynamics of fish stocks so that we can measure any changes. Being able to differentiate between natural fluctuations in populations and externally induced changes is important if we are to understand those impacts.

Yet we will not move in that direction until we can predict the future to a level that engenders confidence within fishers and managers. In that sense fisheries are at the level weather forecasting was at the start of the 20th century and we have a lot of catching up to do.

Predicting the future relies on long term monitoring of the parameters that determine the status of stocks. However this type of monitoring is notoriously difficult to maintain as funding commitment tends to wane over time, especially if there is no clear objective of what is to be delivered.

Linking monitoring to predicting the future more clearly is likely to lead to a stronger foundation for keeping this going. Involving the fishing community in monitoring will reduce costs, extend the longevity of the data collection and greater acceptance of the results.

With this in mind there is a need to experiment with predicting the future, starting off on a small scale and using a qualitative approach. If the approach is successful and valued by stakeholders then this will provide momentum for improving the quality of the prediction and extending the scale.

The Barramundi fishery in Queensland is important to both recreational and commercial fishers and with around 25 years of data and research available for the Fitzroy River this has proven to be the ideal place to test the concept of a "Crystal Bowl" to predict the future of Barramundi stocks.

4. OBJECTIVES

The aim of this project was to engage recreational fishers in the Fitzroy River. The following were the objectives for the project:

1. Engage recreational fishers in developing the capacity to predict Barramundi stocks in the Fitzroy River for the next 2 years through involving fishers in data collection
2. Provide a service to recreational (and commercial) fishers that will improve investment decisions in the future
3. Provide information that can be used to assess the impact of resource and infrastructure developments on fish, fishers and the environment

5. WHAT IS A CRYSTAL BOWL?

A "Crystal Bowl" is simply a term coined for predicting fish stocks. It is a combination of 'crystal ball' and 'fish bowl' to give predicting a fisheries flavour.

In order to be able to read the future in the Crystal Bowl it is necessary for it to be filled with information which can then be used to predict the future. The Crystal Bowl needs to be filled with the following if the vision of the future is to be clear:

- Size of the fish population (biomass) at any time
- New fish entering the population (spawning and recruitment)
- Fish exiting the population (natural and fishing mortality)

However it is no easy task to obtain this information as fish are generally 'invisible' and cannot be counted like sheep in a paddock. Also unlike sheep that can be confined to a paddock fish are generally free to roam around in the aquatic environment. This makes collecting information on fish difficult and very costly. The more accurate the estimates the more costly it is to collect the necessary data. For all but the most valuable fisheries the cost of collecting the data will exceed the value of the fishery making accurate estimates impossible.

In order for the Crystal Bowl to be useful it is necessary to use 'surrogates' to fill the bowl. This means that the water in the bowl will be a bit murky rather than being clear and making the image of the future a little hazy. However it is possible to get a clear enough picture to understand what stocks might look like at any time. In order to get that picture we can use:

- Commercial, recreational and indigenous catch
- Estimate of natural and fishing mortality
- Recruitment estimate
- Input from stocked fish
- Rocky Barra Bounty catch rates
- Length, growth and age
- Movement
- Habitat use

However in order to predict the future we need to know a little more. We need to know the 'environmental drivers' that influence the size of the population and particularly recruitment as this will directly affect the population size in the future. For many species the environmental drivers are little known or uncertain however in terms of Barramundi the main drivers are:

- Local rainfall
- River flows and flooding
- Timing of flows
- Forward predictions of rainfall

The Crystal Bowl developed here is a qualitative one at this stage. This allows a prediction to be made in relative rather than absolute terms. However it can be developed into a more quantitative model if fishers support this approach.

6. DYNAMICS OF BARRAMUNDI IN THE FITZROY RIVER

The Fitzroy estuary extends from the mouth of the river 60km upstream to the Barrage in Rockhampton. This includes a series of adjacent tidal channels in the lower reaches of the river around Port Alma. Connected to the river are a number of offstream creeks and wetlands that mostly act as nursery areas for juvenile Barramundi. These are connected to the river intermittently during high local rainfall events or flooding in the river.

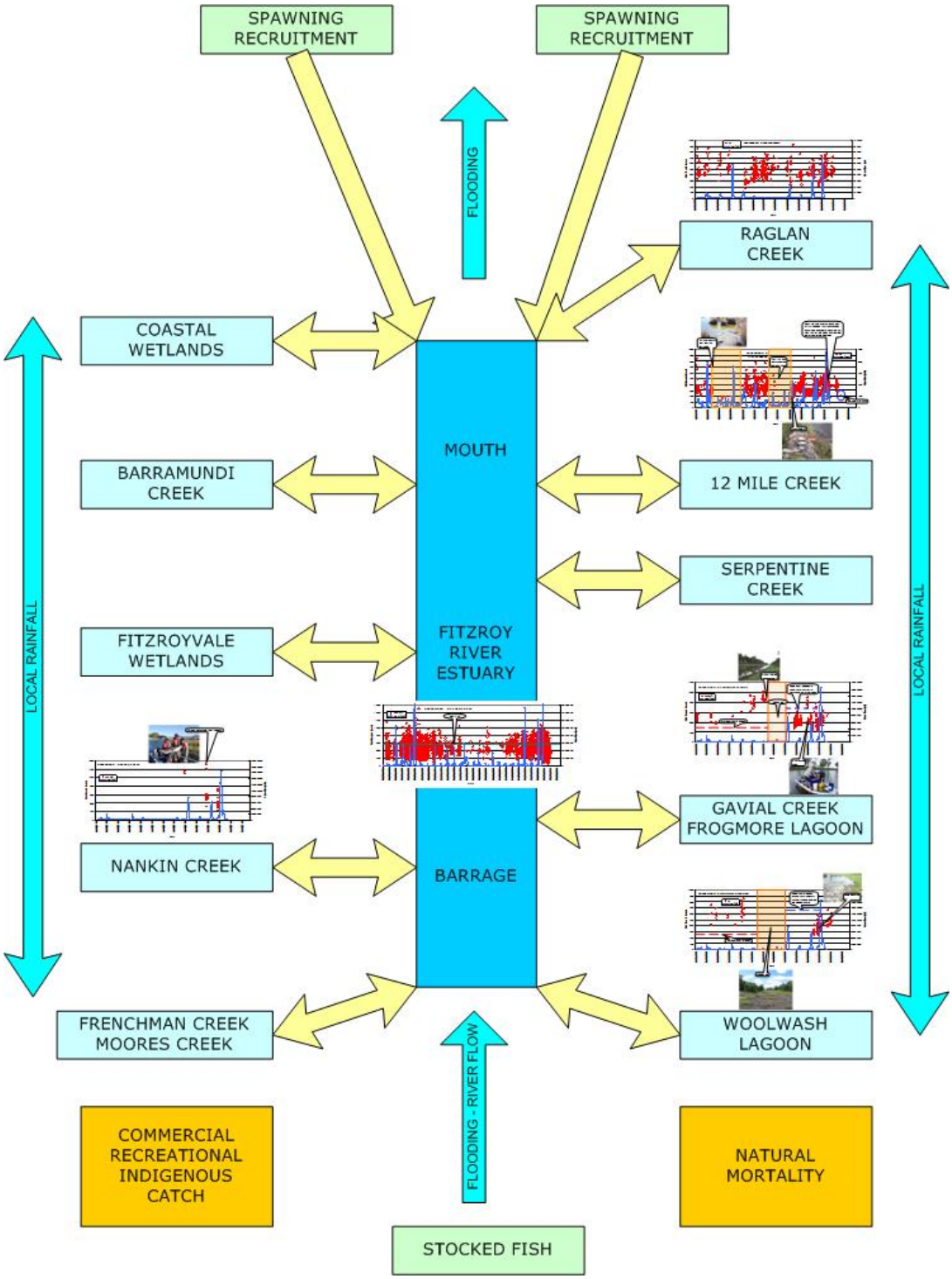

Figure 1: Conceptual model of Barramundi in the Fitzroy River (graphs indicate data available)

Spawning occurs outside the river along the coastal strip to the north and on adjacent areas of Curtis Island, generally from Oct-Jan. Juvenile fish (recruits) then make their way upriver and into the offstream habitats if conditions allow from Jan-May.

Barramundi are periodically stocked in the Fitzroy basin above the Barrage and migrate down to the estuary during high river flows and flooding.

This provides inputs into the population. The population is then reduced over time through mortality which includes natural mortality and fishing mortality. Fishing mortality occurs through the commercial, recreational and indigenous catch and fish that are released that do not survive.

Figure 1 shows a conceptual model of the Fitzroy River and its use by Barramundi. The graphs indicate the locations where data are available.

7. FILLING THE CRYSTAL BOWL

In order to fill the Crystal Bowl data on the following are required:

- Commercial, recreational and indigenous catch
- Estimate of natural mortality and fishing mortality
- Estimate of recruitment
- Input from stocked fish
- Rocky Barra Bounty catch rates
- Length, growth and age
- Habitat use

Data are also required on environmental conditions that influence stocks:

- Local rainfall
- River flows and flooding
- Timing of flows
- Forward predictions of rainfall

Commercial Catch

Commercial catch data are collected through logbooks and are available from Fisheries Queensland (FQ), part of the Department of Agriculture, Fisheries and Forestry. As these data are collected routinely to monitor commercial catch it is a long term dataset that is available at low cost.

Catch data are available on a monthly or annual basis. There is a closed season for Barramundi from Nov-Jan so that a fishing year is from Feb-Oct each year. Historical commercial catch data are available for the last few decades.

Where commercial fishing occurs is recorded on CFISH grids that cover the whole state. Grids are 30' of latitude x 30' of longitude or approximately 51km x 56km in the Rockhampton area. Grids R29 and R30 cover the Fitzroy River delta and the

coast north to just south of Corio Bay as shown in *figure 2*. While grid R29 covers some coast to the north of the river most of the effort within that grid occurs within the river.

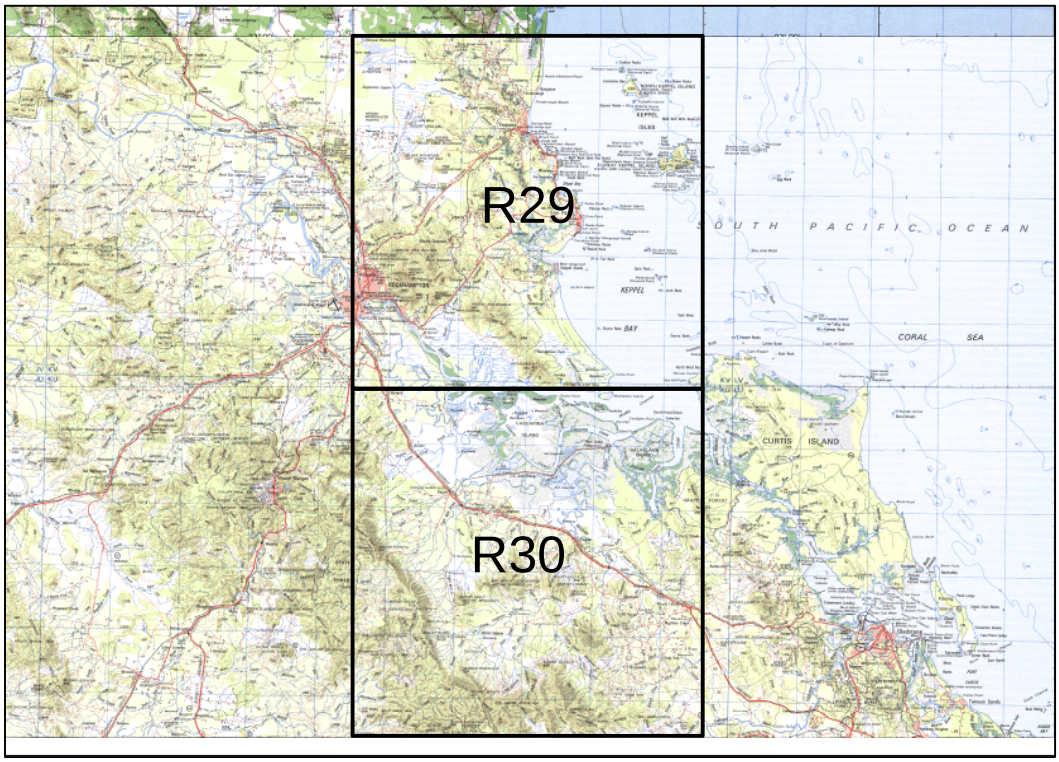

Figure 2: CFISH grids for commercial fishing in the Fitzroy River

Recreational Catch

Recreational catch data are not collected through any ongoing data collection program so estimates of recreational catch are not available that can be directly related to the Fitzroy River. This issue was addressed in project 2009/094 where an initial estimate of recreational catch was made.[2] That project provided a detailed picture of recreational fishing in the river and an estimate of Barramundi catch for 2010-11.

The methods used to estimate recreational catch were used to collect data for the 2011-12 year. These data were then used to obtain an estimate of the recreational catch for the 2011 Barramundi season. This provides the first estimate of recreational catch for a season that can be compared with the commercial catch.

Recreational fishing occurs throughout the river and adjacent offstream waterways and details of fishing trips have been recorded as being within the Suntag grid maps as shown in *figure 3*. The maps are:

- Fitzroy River FRR
- Raglan Creek RAG
- Curtis Island CIS

[2] See Topping up the "Crystal Bowl" for Barramundi: Sawynok, Platten and Parsons (2011)

Catch rates for Barramundi caught and kept were calculated for each season for both boat based and landbased trips. This allowed an estimate of the numbers of fish caught and kept each season. The average length of fish kept over each season was then used to estimate an average weight from the Suntag database which was then used to calculate a total weight of the kept catch.

While there are some differences in the areas for commercial and recreational fishing trips in the river most of the fishing occurs in the common area. This allowed the recreational catch to be compared with the commercial catch.

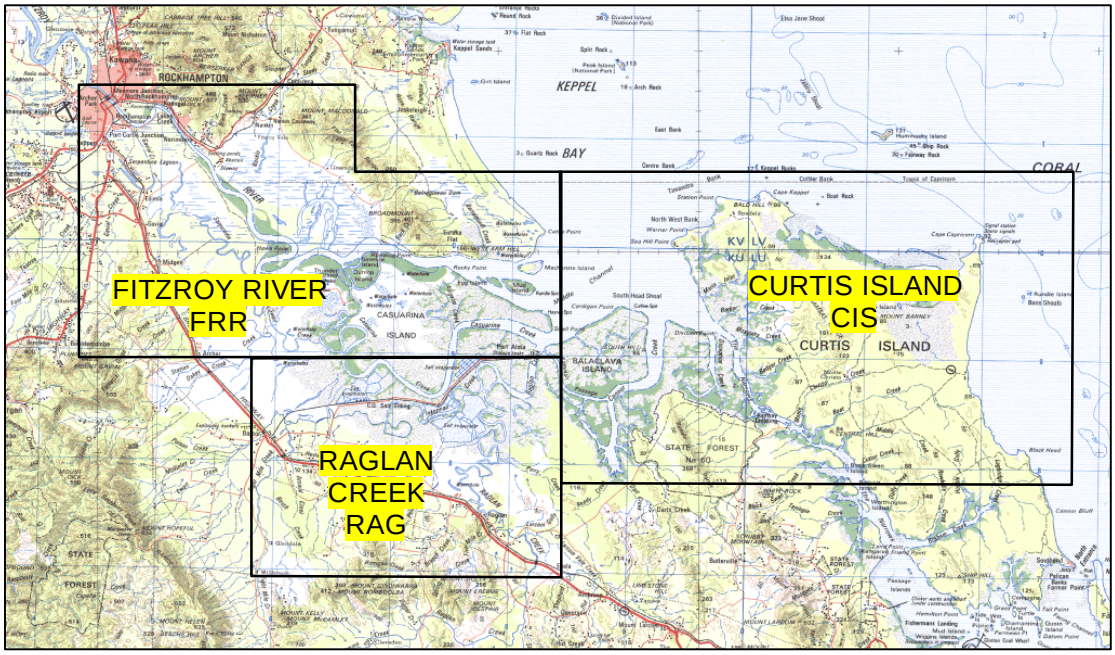

Figure 3: Suntag grid maps used to record recreational fishing trips in the Fitzroy River

Indigenous Catch

No data have been collected on indigenous catch except where this has been collected as part of the recreational catch. It is likely that the indigenous catch is less than the recreational catch.

Estimate of Fish Mortality

Mortality is the loss of fish from a stock due to death and is a combination of natural and fishing mortality. In fisheries models instantaneous mortality is represented as:

Fish mortality (Z) = natural mortality (M) + fishing mortality (F)

Fishing mortality is the result of harvest by commercial, recreational and indigenous fishers and the death of fish that are released. There is also likely to be an element of illegal take as well but this is almost impossible to measure. Data are available for the commercial and recreational catch which provides an

estimate of the catch. Data are available on the mortality of Barramundi released by recreational fishers however no estimate is available of the mortality of fish released by commercial fishers.

Natural mortality is the result of fish dying through natural causes which include old age, predation, disease, pollution or any other natural factor that causes the death of fish at all times though their life cycle. Natural mortality varies through time and cannot be directly measured so that various estimates need to be made. There are many methods available for estimating natural mortality and a review of these were made by Siegfried and Sanso.[3] Some methods use tagging models to estimate natural mortality.

As the stock predictions are qualitative at this stage there has been no estimate made of total mortality. It is considered that there are sufficient data available to make that estimate and a number of methods are currently being evaluated.

Estimate of Recruitment

Recruits are defined as fish below legal size that have yet to 'recruit' to the fishery. Recruitment surveys have been undertaken in the Fitzroy River system since 1999 and tagging data have provided information on recruitment since the mid 1980s. Recruitment was compared with rainfall and river flows to determine any collection. Based on these data a recruitment predictor was developed that uses environmental cues to predict recruitment.

Figure 4: Sites for recruitment surveys in 2012 in the Fitzroy River system

Recruitment surveys are conducted at a range of sites when new recruits (50-350mm) in their first year can be found. These surveys check actual recruitment against that predicted. The surveys are undertaken using standardised castnet

[3] A Review for Estimating Natural Mortality in Fish Populations: Siegfried and Sanso: University of California (undated)

methods that have been described in detail in a number of reports.[4] *Figure 4* shows the sites where castnet surveys were undertaken from Jan-May 2012.

Input from Stocked Fish

In the 2000s fish stocking groups in local communities upstream in the catchment commenced stocking Barramundi in their local waterways to re-establish a local Barramundi fishery.

Locations that were stocked[5] were:

- Lake Callide at Biloela (1999-)
- Moura Weir at Moura (2003-06)
- Baralaba Weir at Baralaba (2000-)
- Bedford Weir at Blackwater (2005-06)
- Lake Maraboon at Emerald
- Lake Theresa at Clermont (2002-07)
- Hedlow Creek and Serpentine Lagoon at Rossmoya (1996-2003, 2009-12)
- Alligator Creek at Yaamba (2005)
- Fitzroy River at Laurel Bank (2006)

The peak period for stocking of Barramundi was from around 2000-07. From 2004-07 there were batches of Barramundi stocked at sizes of 150-300+mm that were all tagged to allow these fish to be tracked over time. Tagged fish from all sites except Lake Callide and Lake Maraboon[6] have been recaptured in the estuary following flood events.

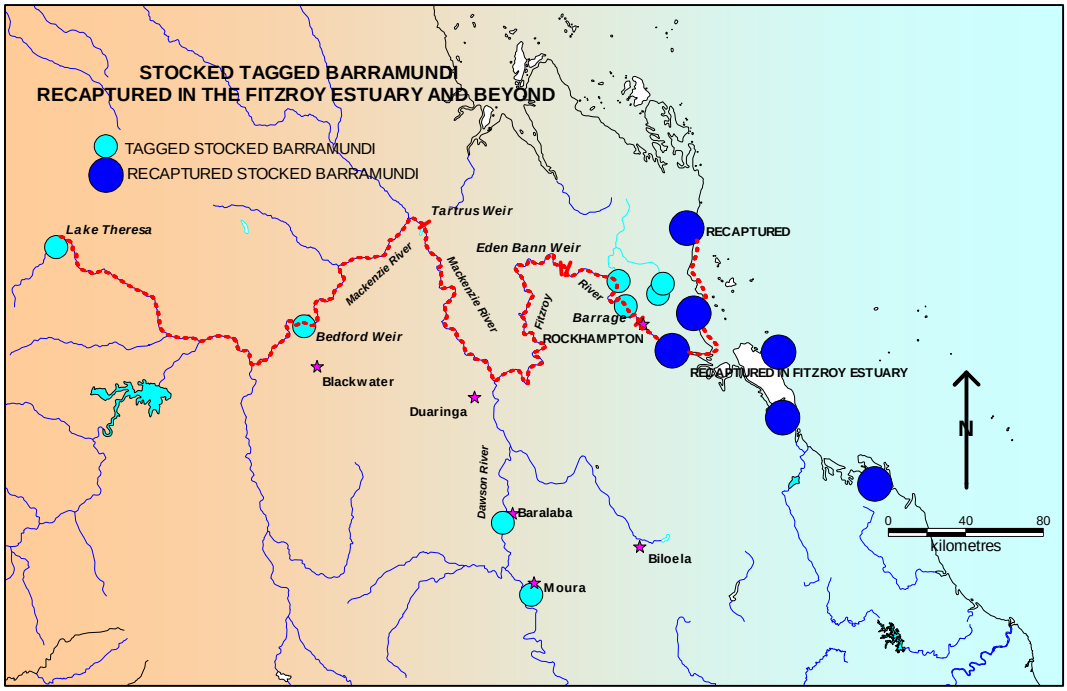

Figure 5: Locations of tagged stocked Barramundi recaptured in the Fitzroy estuary and beyond

[4] See Topping up the "Crystal Bowl" for Barramundi: Sawynok, Platten and Parsons (2011) for latest details

[5] From Summary of Tagging of Stocked Fish in Impoundments and waterways of Queensland: Sawynok (2009)

[6] Lake Callide has never overtopped the spillway and there were no Barramundi tagged in Lake Maraboon

These stocked fish have contributed to the overall Barramundi stocks in the river. *Figure 5* shows the locations where stocked fish were tagged and recaptured in the Fitzroy estuary and beyond.

Rocky Barra Bounty

The Rocky Barra Bounty is a tag and release fishing competition that has been carried out on the Fitzroy River from 1999-2011. It has been held around the same time each year in Sep-Oct. In 2010 the event was not able to be held in the river due to flooding and a smaller event was held in the lagoons. Catch and effort data are collected during the event providing a snapshot each year. Data for 2010 should be considered separately due to the different location for the event.

Length, Growth and Age

Length and age data are collected by FQ through the Long Term Monitoring Program (LTMP). Barramundi frames are collected from both commercial and recreational fishers[7]. Otolith analysis is undertaken by FQ to determine the age of the fish.

Lengths and growth of Barramundi are also available from the recreational catch where fish have been measured and from tagging and recapture records. Growth and length allow estimates of age class of fish to be made. While this does not provide as accurate an estimate of age as from otolith analysis lengths are much more readily available.

Habitat Use

To understand the dynamics of Barramundi in the Fitzroy River it is important to understand how and when they use different habitats. There are 2 primary habitats being instream (Fitzroy estuary) and offstream (creeks and lagoons).

Locations where fish are caught, tagged or surveyed provide data on use of different habitats. Data are available on the use of both instream and offstream habitats from tagging records. *Figure 1* shows the various key habitats for the Fitzroy. Data are available for the instream river habitat and for a number of key offstream habitats both on the north and south side of the river:

- Coastal wetlands (no data available)
- Barramundi Creek (no data available)
- Fitzroy Vale wetlands (limited data)
- Nankin Creek (limited data last 5 years)
- Frenchman/Moores Creek (15 years of data)
- Raglan Creek (23 years of data)
- 12 Mile Creek (25 years of data)
- Serpentine Creek (no data available)
- Gavial Creek/Frogmore Lagoon (23 years of data)

[7] Frames from recreationally caught Barramundi are collected through the CapReef-Crystal Bowl project

- Woolwash Lagoon (23 years of data)

Movement are available from tagging and recapture data. Movement data are used to determine the use of different habitats by Barramundi. This allows an assessment of use of offstream habitats. This is a key area where recreational fishers contribute to data collection through the tagging of fish.

Rainfall and River Flow

Rainfall data are obtained for Rockhampton Aero station 039083 from the Bureau of Meteorology[8] and for 12 Mile Creek from Cheetham Saltworks[9]. River flow data are obtained for the Fitzroy River at the Gap station 130005A, for Raglan Creek at Old Station 130004A and for Gavial Creek at Glenlands 30943 from Department of Natural Resources and Mines.[10]

In order to provide more accurate predictions of the stocks for the next 2 years it is an advantage to have longer term weather forecasts, particularly rainfall. Future rainfall is predicted as probability of exceed average rainfall figures however these are generally only available for the next 6 months which is not sufficient to assess the probability of a good recruitment year. Climate models that look at predicting El Nino and La Nina events provide a better option for assessing future rainfall into the longer term.

Assessing stock levels

In the assessment of stocks 2011 has been used as the baseline year. Stocks in 2011 were considered to be at their highest levels for 25 years based on the commercial catch and catch rates from the Rocky Barra Bounty, so forms a reasonable base for comparison. Future predictions of overall stocks will be made relative to the stock levels in 2011 based on:

$$\textit{Relative stock level}_{\textit{year}} = \textit{Relative stock level}_{\textit{previous year}} + \textit{recruitment} - \textit{fish mortality}$$

Recruitment is based on the relative proportion of new recruits compared with other size/age groups. A qualitative estimate of total fish mortality has been made for predictions however as the 2012 season is still in progress no estimate of fish mortality has been made.

[8] From www.bom.gov.au
[9] Rainfall data from Inkerman Creek recording station at 23.63°S and 150.8°E
[10] From www.derm.gov.au

8. 2011 PREDICTION FOR 2012

In 2011 a Crystal Bowl prediction of Barramundi stocks was made for 2012. The prediction for 2012 was:

Crystal Bowl prediction for Barramundi in the Fitzroy River in 2012

- ***Barramundi stocks will be high***
- ***3-5 years old fish (580-850mm) will dominate the legal catch***
- ***Large numbers of juvenile fish aged 2-3 years (450-580mm)***
- ***Low numbers of 0-1 year old fish (0-450mm)***

This prediction was based on monitoring of fish stocks and recruitment in the Fitzroy River during 2011. Sections 10-16 outline the data collected that underpins these predictions.

How did the prediction compare with reality?

As the season is only midway through it is too early to make a comparison however there are some indicators that can be used. Predicted percentages of fish in various age groups (size ranges) were compared with actual percentages in Feb-Apr as shown in *figure 6*.

The overall predicted stock levels compared with 2011 is also shown however there is no current measure of actual relative stock levels. Recruitment for 2011 and 2012 was low so the overall stocks are lower than in 2011.

Figure 6: Predicted and actual percentages of size classes in Feb-Apr 2012

9. 2012 PREDICTION FOR 2013 AND 2014

The 2012 Crystal Bowl prediction of Barramundi stocks for 2013 is:

Crystal Bowl prediction for Barramundi in the Fitzroy River in 2013

- ***Barramundi stocks will be moderate/high and 50-70% of level in 2011 but moderately uncertain***
- ***3-5 years old fish (580-850mm) will dominate the legal catch***
- ***low numbers of fish aged 2-3 years (450-580mm)***
- ***Low numbers of 0-1 year old fish (0-450mm)***
- ***Stocks will be confined to the river with low levels of fish in lagoons***
- ***Moderate numbers of fish above the Barrage***
- ***Stocked fish levels in estuary will be low***
- ***Probability of good recruitment is low but moderately uncertain***

These predictions are based on monitoring of stocks in the Fitzroy River and climate model predictions from the Bureau of Meteorology. Climate models are predicting an El Nino forming in late spring 2012. When an El Nino forms it generally persists for a number of years. Therefore recruitment predictions for 2013 and 2014 have been indicated as low but actual recruitment will be very dependent on actual conditions during those wet seasons.

For 2013 the largest size range will be 580-800mm however overall stocks are expected to be 50-70% of stock level in 2011. *Figure 7* shows the predicted percentages of fish in each size range for 2013 and an estimate of overall stock levels compared with 2011.

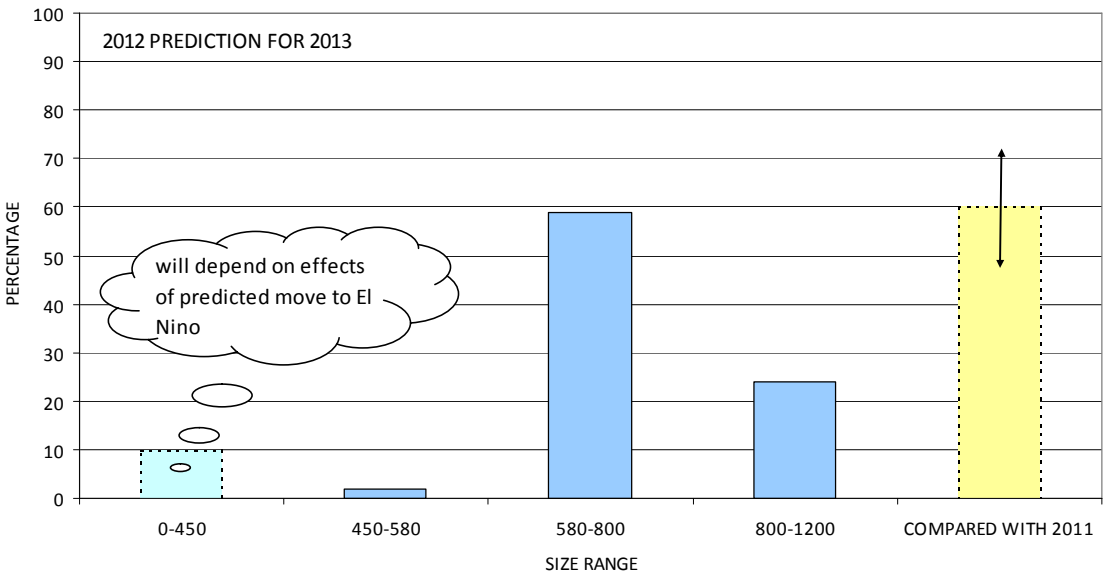

Figure 7: Predicted percentages of size ranges for 2013 and overall stock level compared with 2011

For 2014 the largest size range will be 800-1200mm however overall stocks are expected to be 40% of stock levels in 2011. *Figure 8* shows the predicted percentages of fish in each size range for 2014 and an estimate of overall stock

levels compared with 2011. However, predicting recruitment that far out means that the prediction cannot be made with any level of confidence. It is made on the basis of the El Nino forming in late 2013 and then persisting through to the 2014 wet season.

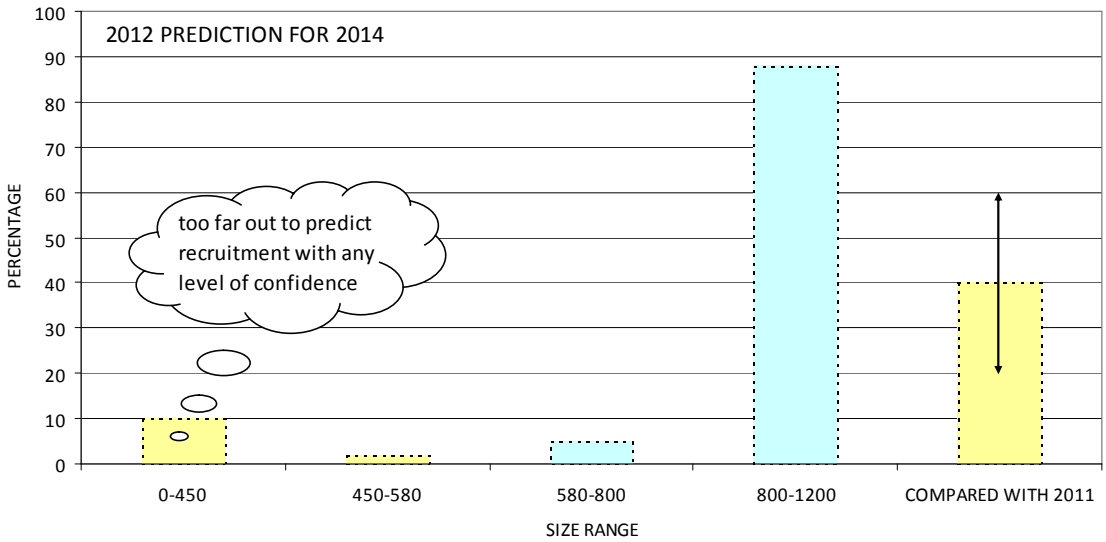

Figure 8: Predicted percentages of size ranges for 2014 and overall stock level compared with 2011

10. COMMERCIAL CATCH

Figure 9 shows the annual commercial catch of Barramundi in tonnes from CFISH grids R29 and R30. The annual catch for 2011 was 70.8t which is the highest annual catch and the highest CPUE for any year since 2000. The previous highest catch was 49.8t in 2003. The catch in 2011 was 87% higher than the catch in 2010.

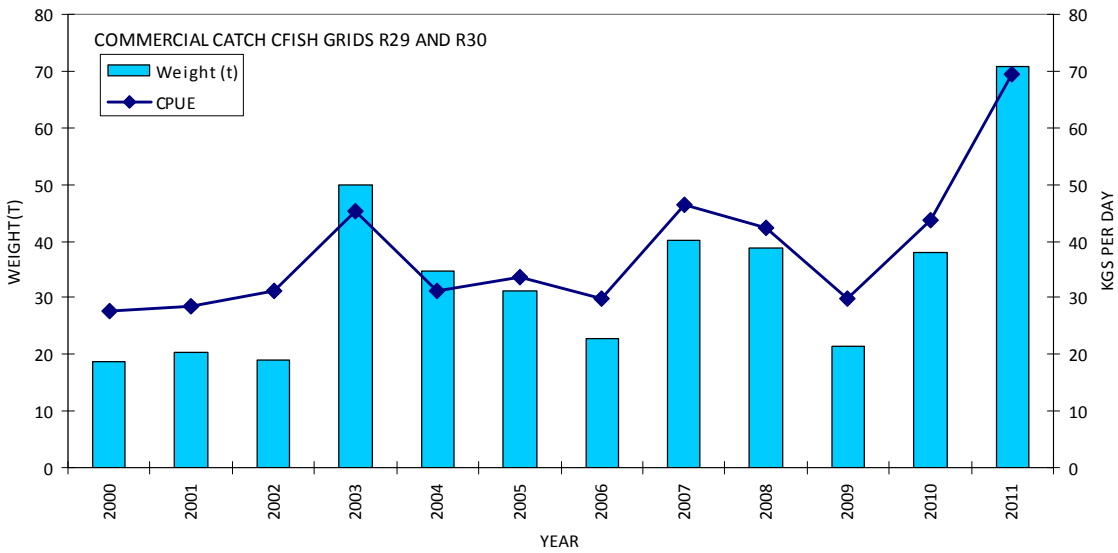

Figure 9: Annual commercial catch of Barramundi for CFISH grids R29 and R30

11. RECREATIONAL CATCH

The recreational catch was calculated for the 2011 Barramundi season (Feb-Oct) so that a comparison could be made with the commercial catch.

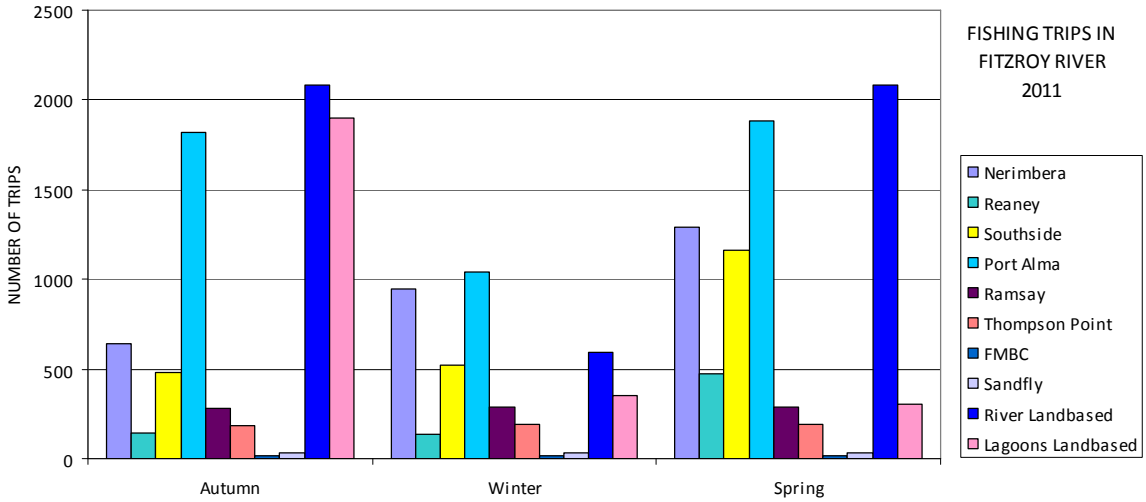

Figure 10: Number of recreational fishing trips in the Fitzroy River in 2011

Figure 10 shows the number of trips in the Fitzroy River in 2011 from each boat ramp and for locations fished by landbased fishers. *Table 1* provides the number of trips each season. It was estimated that there were a total of around 7,300

landbased trips and 12,100 boat trips or 19,400 trips in total.

Season	Autumn	Winter	Spring	Total
Nerimbera	637.04	946.65	1286.32	2870.00
Reaney	143.56	134.25	471.80	749.61
Southside	479.82	523.21	1158.84	2161.87
Port Alma	1817.50	1037.90	1880.41	4735.82
Ramsay	280.35	289.80	289.80	859.95
Thompson Point	186.90	193.20	193.20	573.30
FMBC	15.00	15.00	15.00	45.00
Sandfly	30.00	30.00	30.00	90.00
River Landbased	2085.44	593.57	2084.26	4763.27
Lagoons Landbased	1900.70	353.94	304.25	2558.88
Landbased	3986.14	947.51	2388.50	7322.15
Boat trips	3590.18	3170.00	5325.38	12085.55

Table 1: Number of trips in the Fitzroy River from boat ramps and at landbased locations in 2011

Catch rates were calculated for each season for landbased and boat trips combined including max and min catch rates at the 95% confidence level. Catch rates were multiplied by the number of trips to estimate fish caught and kept. It was estimated that a total of around 111,500 Barramundi were caught of which 5,200 were kept and 106,200 were released.

The average length of kept catch and estimated weight was then used to calculate total weight as shown in *table 2*. The total recreational kept catch of Barramundi for the 2011 season was estimated at 17.1 tonnes but could range from 9.0-27.0 tonnes using min and max catch rates. Mortality of released fish was also estimated using a 95% survival rate of released fish which results in a mortality estimate similar to the kept catch.

Season	Autumn		Winter		Spring		Total
	Caught	Kept	Caught	Kept	Caught	Kept	
Trip catch rate max	9.045	0.618	5.242	0.262	7.312	0.327	
Trip catch rate min	5.090	0.244	2.056	0.036	4.850	0.097	
Trip catch rate average	6.940	0.417	3.501	0.136	5.768	0.196	
Total trips	7576.31	7576.31	4117.51	4117.51	7713.88	7713.88	12085.55
Total Barramundi	52579.74	3156.11	14416	561.66	44490.68	1515.38	5233.15
Release mortality (5%)		2471.18		692.72		2148.77	5312.66
Total mortality		5627.29		1254.38		3664.14	10545.82
Recreational catch	Autumn		Winter		Spring		Total
Barramundi kept		3156.11		561.66		1515.38	5233.15
Average length (mm)		666		617		673	
Estimated weight (kg)		3.3		2.8		3.4	
Total catch weight (kg)		10415		1573		5152	17140

Table 2: Estimate of recreational catch for 2011 season

Using the estimated average recreational catch this is around 24% of the commercial catch.

However to estimate total mortality it is necessary to include the mortality of released fish by both recreational and commercial fishers. This has been estimated for recreational fishers for the 2011 season but needs to include an estimate for the summer season as Barramundi are incidentally caught by recreational fishers during the closed season. No estimate of the mortality of fish released by commercial fishers is available as no data are available on the numbers of fish released by commercial fishers and there are no estimates of their survival. Commercial fisher as not able to net during the closed season so there is no additional commercial mortality for summer.

12. RECRUITMENT

Barramundi recruitment is strongly linked to local rainfall and river flows. Strong recruitment has been recorded in years where:

- wet season (Dec-Mar) monthly flows exceed 0.5GL
- total wet season flows exceed 1.5GL
- maximum flows occur in Jan-Feb
- monthly rainfall exceeds 150mm in Jan-Feb to allow recruits to access offstream lagoons and wetlands
- low total flows of less than 0.5GL from Sept-Nov[11]

YEAR	FLOW AND TIMING					RECRUITS		FITZROY RIVER				12 MILE	
	monthly flow >0.5GL	wet season flow >1.5GL	Max flow Jan-Feb	low flow previous Sept-Nov <0.5GL	12 mile rain>150mm Jan-Feb	Fitzroy recruits <350mm Jan-May	12mile recruits <350mm Jan-May	monthly flow	wet season flow	flow timing	low flow previous Sept-Nov	12 mile rain	rain timing
1988	√	√	√	√		19	18						
1989	√	√		√		85	0						
1990				√		8	0						
1991	√	√	√	√	√	397	199						
1992				√	√	25	3						
1993				√		7	0						
1994				√	√	4	0						
1995			√	√	√	1	0						
1996	√	√	√	√	√	1485	1469						
1997		√		√	√	24	11						
1998				√		10	6						
1999	√	√	√		√	67	65						
2000				√		17	9						
2001	√	√	√	√	√	837	807						
2002				√		24	5						
2003	√	√		√	√	16	2						
2004	√		√	√	√	153	17						
2005		√		√	√	105	27						
2006				√		18	4						
2007				√		3	0						
2008	√	√	√	√	√	524	380						
2009	√	√	√	√	√	289	79						
2010	√	√	√	√	√	778	253						
2011	√	√	√		√	16	11						
2012				√		9	0						

Conditions outside range
Conditions close to range
Conditions inside range

Figure 11: Predictor for Barramundi recruitment in the Fitzroy River from 1985-2012 (all green indicates years of strong recruitment)

[11] New parameter added in 2011

Figure 11 provides the predictor for recruitment in the Fitzroy River with 12 Mile Creek being used as an offstream site. Years when all the parameters for good recruitment are met are shown in green with the number of actual recruits surveyed each year shown under recruits. This shows that strong recruitment occurs on average once every 5-7 years, however there were 3 consecutive years of strong recruitment in 2008, 2009 and 2010. This was followed by 2 years of poor recruitment in 2011 and 2012.

Recruitment surveys are undertaken from Jan-May each year to check actual recruitment against what was predicted. In 2012 there were 21 surveys at 9 sites. These data are supplemented by any new recruits that are recorded during fishing trips or tagging.

From those surveys there were 6 new recruits recorded during recruitment surveys and a further 3 recorded during fishing trips. *Figure 12* shows the number of first year recruits per fisher day recorded from 1999-2012. This shows that the level of recruitment for 2011 and 2012 was poor.

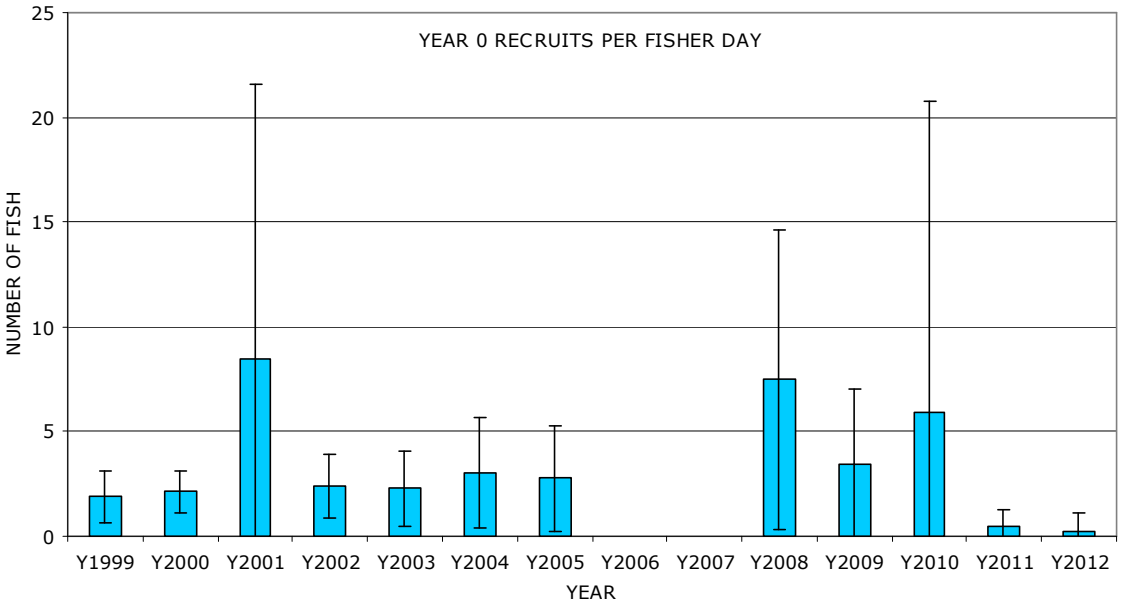

Figure 12: First year recruits recorded each year at Fitzroy River sites from 1999-2012

Figure 13 shows the number of recruits recorded from 1998-2012. This shows the strong recruitment recorded in 2008, 2009 and 2010 and then the poor recruitment in 2011 and 2012. In 2006 and 2007 recruitment was low however there were insufficient survey days to provide a result. This was largely due to drought conditions with many of the offstream locations dry or not connected back to the river.

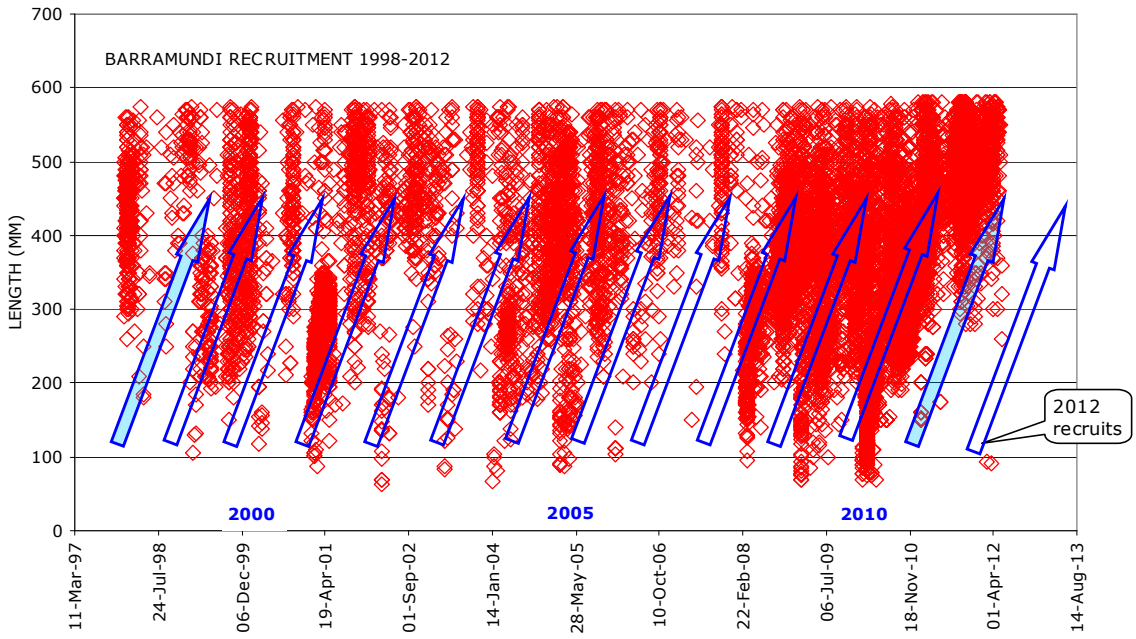

Figure 13: Barramundi recruits recorded each year in the Fitzroy River from 1998-2012 (arrows show the growth of fish over time and density of dots indicates strength of recruitment)

13. INPUT FROM STOCKED FISH

Barramundi from fish stocked upstream in the basin were first recaptured in the Fitzroy estuary in 2003 and fish have been recorded every year since. From 2008-12 there have been 140 stocked fish recaptured in the Fitzroy estuary or beyond. *Figure 14* shows the number of stocked fish compared with the number of wild fish recaptured in the Fitzroy River from 2008-12[12]. As well as fish stocked in the Fitzroy River in 2012 there were 7 fish recaptured in the Fitzroy River which were fish stocked in Lake Awoonga and tagged there or in the Boyne River just below the dam.

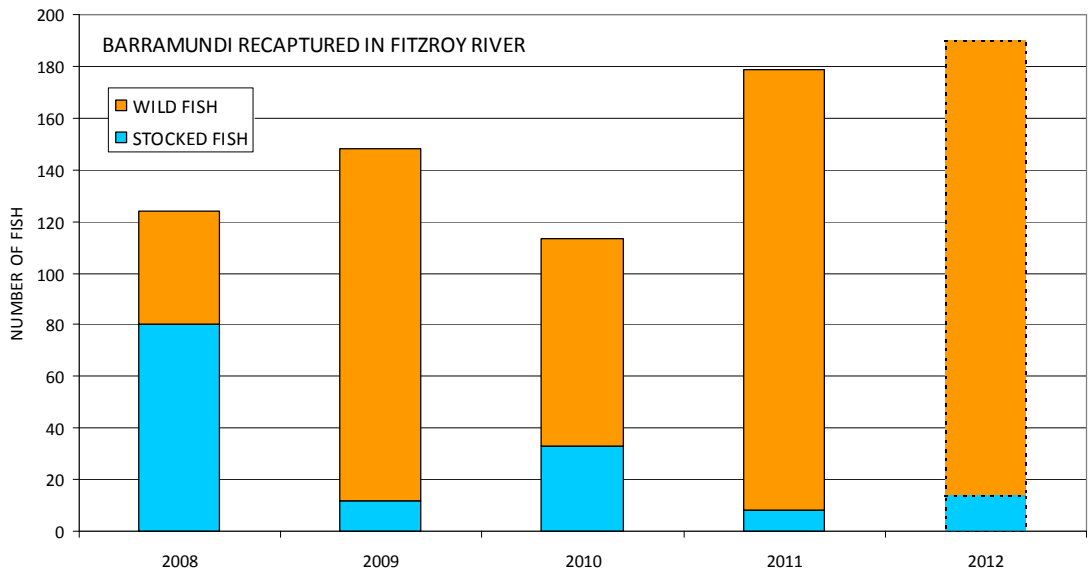

Figure 14: Number of stocked and wild fish recaptured from 2008-12 in the Fitzroy River

[12] Recaptures for 2012 are for half a year only

This indicates that the largest number of recaptures of stocked fish occurred from 2008-10. This is consistent with the stocking that occurred upriver and the number of stocked fish remaining in the estuary is low compared to wild fish with only 8% of fish recaptured in 2012 being stocked fish compared with 64.5% in 2008.

14. ROCKY BARRA BOUNTY

Figure 15 shows the catch rate each year in fish/hour. This shows the catch rate was over 5 times the rate in previous years showing the high level of stocks in that year. Another statistic was that the event lasted 1,200 minutes and there were 1,210 fish tagged.

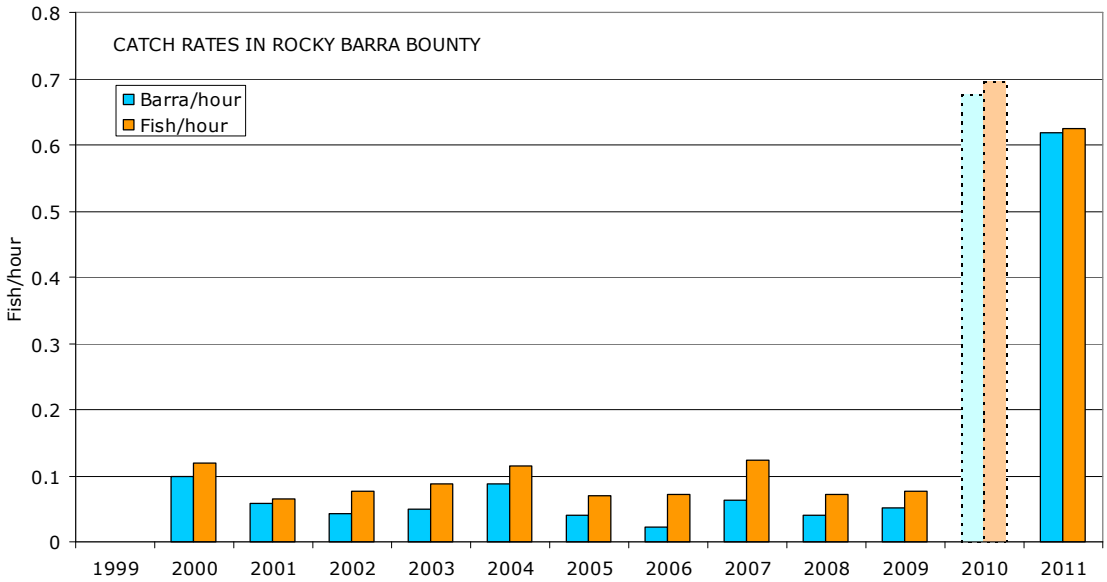

Figure 15: Catch rates in fish/hour in the Rocky Barra Bounty from 1999-2011

15. LENGTH, GROWTH AND AGE

Age of fish were determined by the LTMP program based on samples collected from the commercial and recreational catch from the Fitzroy River from 2005-2010 (data from 2011 not yet available) with *figure 16* showing length at age.

Age and growth data from tagging were used to determine the size range of fish for various age groups as shown in *table 3*.

Age group (years)	Length range (mm)
0-1	0-450
2-3	450-580
4-5	580-800
5-	800-1200

Table 3: Age groups and size range of Fitzroy River Barramundi

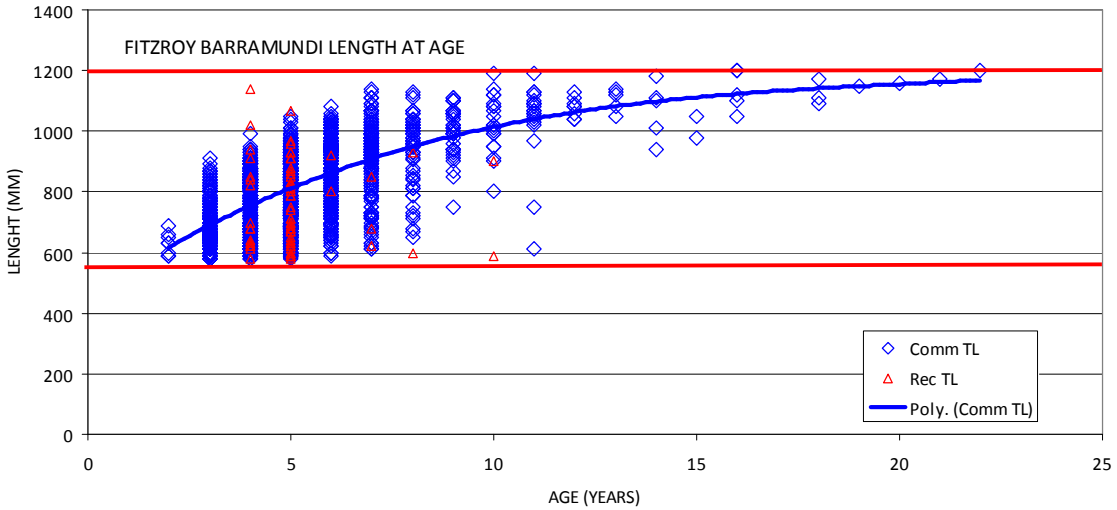

Figure 16: Length at age of commercial and recreational catch from Fitzroy River 2005-10

Fish caught and measured by recreational fishers in autumn (Feb-Apr) and categorised by size ranges to determine the percentage of fish within each size range.

16. HABITAT USE

There is a record of use of the various habitats that span up to 25 years. Barramundi move into offstream wetlands and creeks as juvenile fish, stay there for a number of years and return to the river when flow conditions allow.

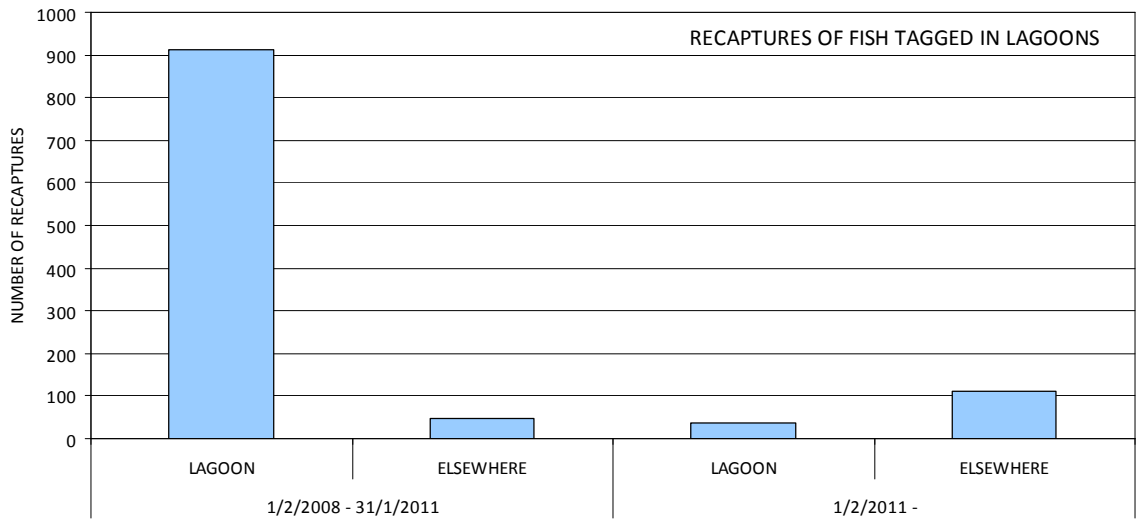

Figure 17: Recaptures of fish tagged in lagoons from 2008-2102

Figure 17 shows where fish were recaptured since the start of the 2008 season (Feb). From then to the start of 2011 season (Feb) 95.1% of recaptures of fish tagged in the lagoons were recaptured in the same lagoon indicating that most fish remained within the lagoons. From the start of the 2011 season (Feb) 25.5% of recaptures were in the lagoons while from Apr 2011 100% of recaptures have been from elsewhere. This indicates a significant movement of fish from the lagoons back to the river associated with the flooding in 2010-11.

Since the start of the 2011 season (Feb) there have been no fish tagged in the river that have been recaptured in the lagoons and no new recruits recorded to have entered the lagoons. Also there have been very few fish tagged in the lagoons since then.

This suggests that most fish previously in the lagoons have migrated back to the river and there has been little recruitment of fish back to the lagoons. Populations of Barramundi in all lagoons except Raglan and 12 Mile Creek are considered to be low.

A graphical and pictorial record of the use of each habitat has been developed. Details of these habitats are contained in the previous report.[13]

Raglan Creek

Raglan Creek has continuous data on its use since 1989. In 2012 the Barramundi population is low-moderate with 30 fish tagged in 2012. Since Apr 2011 there have been 3 fish tagged in Raglan Creek that were recaptured elsewhere. *Figure 18* shows the creek flows and use of Raglan Creek by Barramundi from 2000-12.

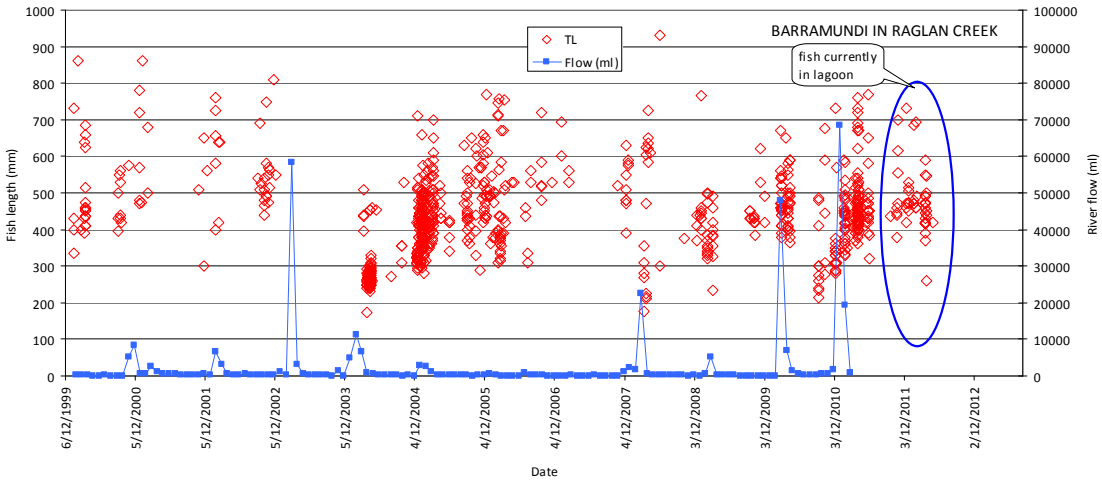

Figure 18: Creek flows and Barramundi in Raglan Creek from 2000-12

[13] See Topping up the "Crystal Bowl" for Barramundi: Sawynok, Platten and Parsons (2011) for latest details

12 Mile Creek

Twelve Mile Creek has continuous data on its use since 1985. This is the longest timeline of data showing the importance of this site as a Barramundi nursery. In 2012 the Barramundi population is low-moderate with 20 fish tagged in 2012. Since Apr 2011 there have been 33 fish tagged in 12 Mile Creek that were recaptured elsewhere with no fish tagged in the creek recaptured there.

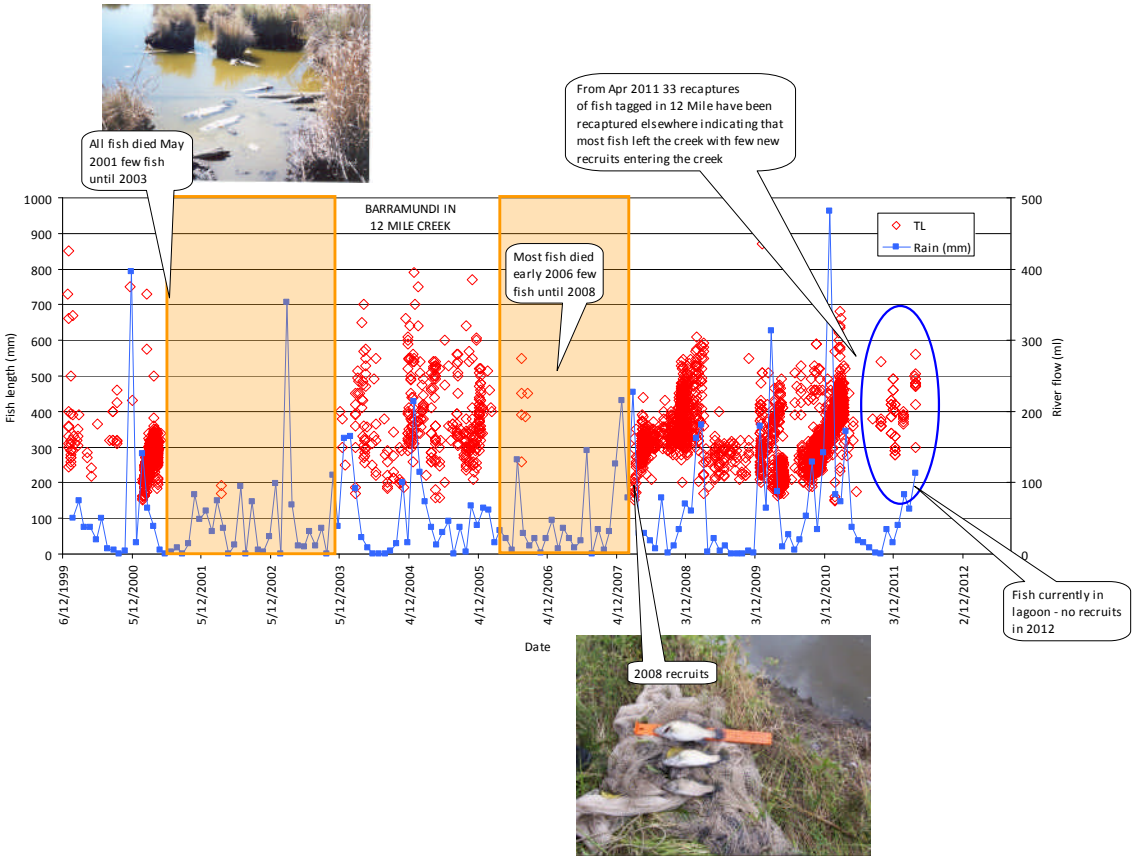

Figure 19: Rainfall and Barramundi in 12 Mile Creek from 2000-12

No new recruits were recorded in the creek during recruitment surveys in 2012 which is the first time none have been recorded since 2007. *Figure 19* shows the rainfall and use of 12 Mile Creek by Barramundi from 2000-12.

Frogmore Lagoon

Frogmore Lagoon has continuous data on its use since 1989. In 2012 the Barramundi population is low with no fish tagged in 2012. Since Apr 2011 there have been 36 fish tagged in Frogmore Lagoon that were recaptured elsewhere with no fish recaptured there. *Figure 20* shows the river flows and use of Frogmore Lagoon by Barramundi from 2000-12 including the fish rescued from the lagoon in 2009. The lagoon was connected back to the river during flooding in 2008, 2010, 2011 and 2012.

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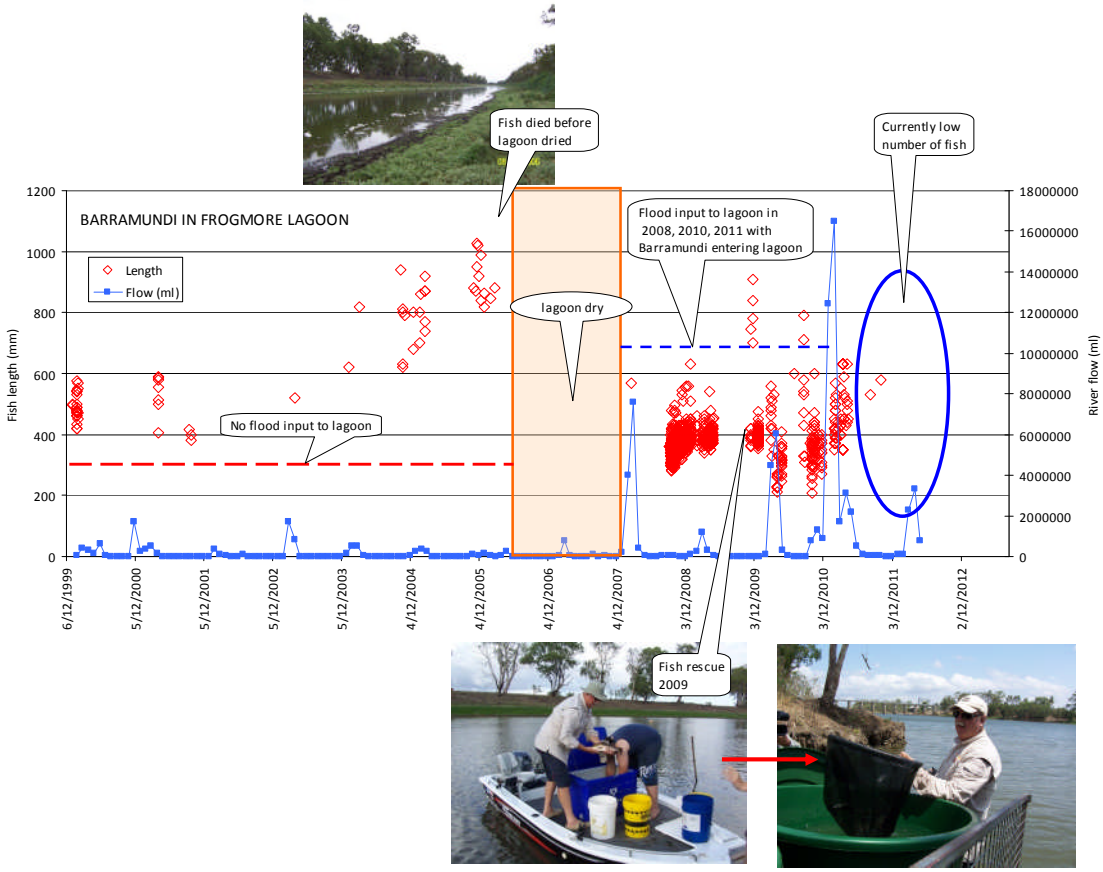

Figure 20: River flows and Barramundi in Frogmore Lagoon 2000-12

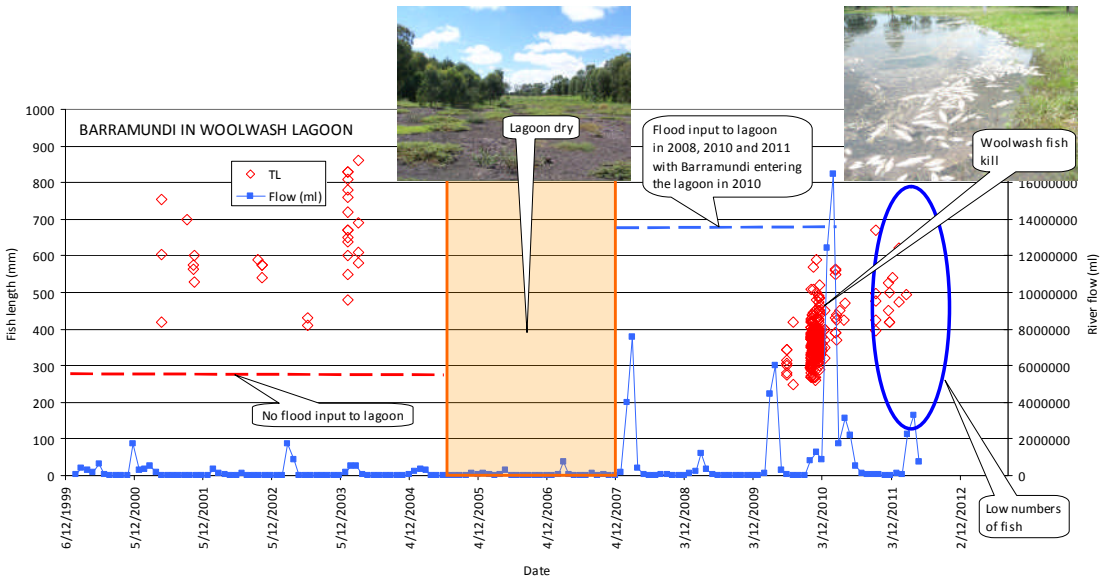

Figure 21: River flows and Barramundi in Woolwash Lagoon in 2000-12

Woolwash Lagoon

Woolwash Lagoon has continuous data on its use since 1989. In 2012 the Barramundi population is low with 3 fish tagged in 2012. Since Apr 2011 there have been 6 fish tagged in Woolwash Lagoon that were recaptured elsewhere with no fish recaptured there. *Figure 21* shows the river flows and use of Woolwash Lagoon by Barramundi from 2000-12 including the fish kill in 2010. The lagoon was connected back to the river during flooding in 2008, 2010, 2011 and 2012.

Nankin Creek

Nankin Creek has limited data on its use since 2007. The largest fish recorded from a Fitzroy lagoon was a fish of 1.32m in 2009. Since the flooding in 2010-11 there have been 6 fish tagged in this lagoon that have been recaptured back in the river. *Figure 22* shows the river flows and fish recorded in the lagoon from 2000-12.

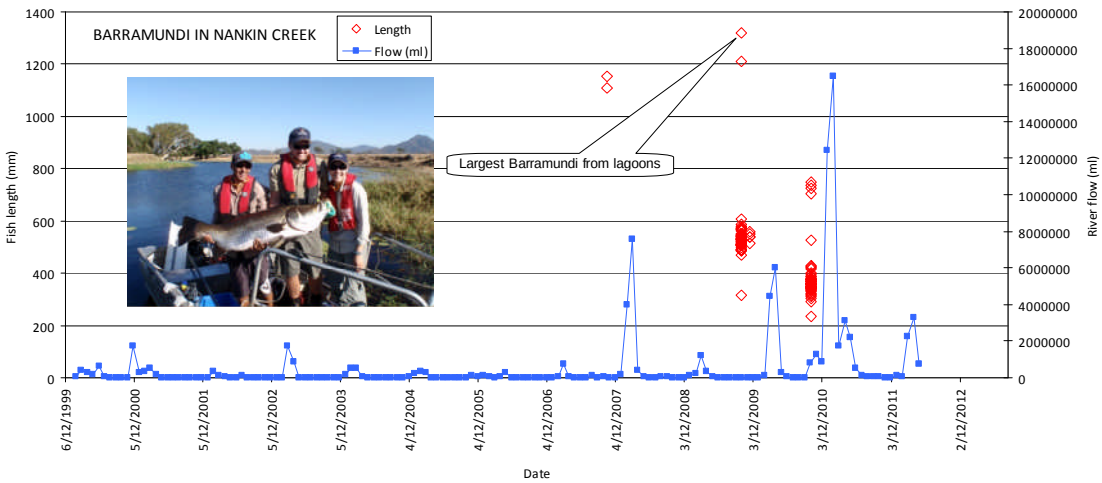

Figure 22: River flows and Barramundi in Nankin Creek from 2000-12

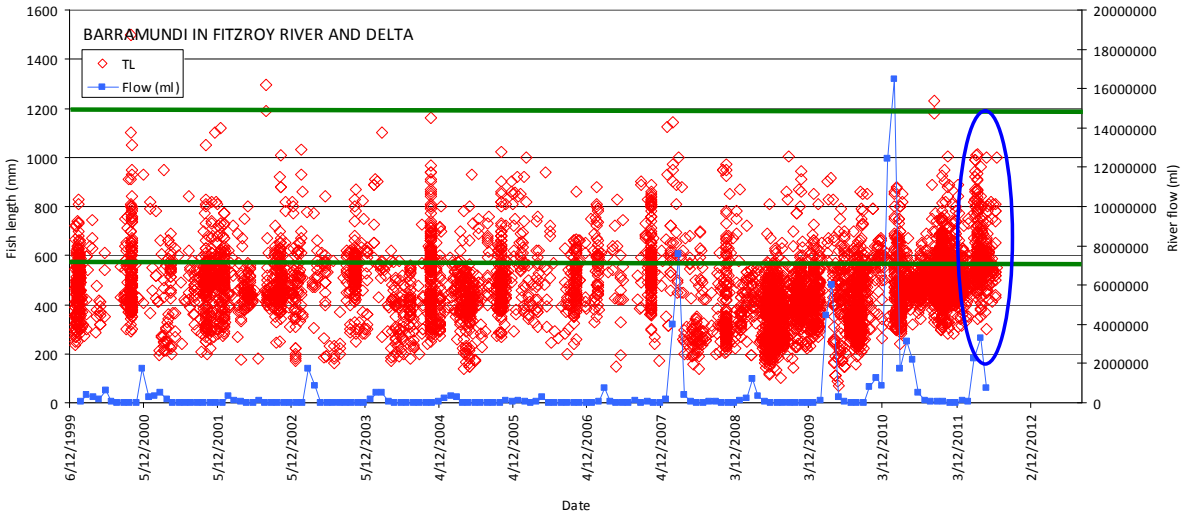

Figure 23: River flows and Barramundi in Fitzroy River from 2000-2012

Fitzroy River

The Fitzroy River estuary below the Barrage has continuous data on its use since 1985. In 2012 the Barramundi population is high, the result of strong recruitment in 2008, 2009 and 2010. *Figure 23* shows the fish recorded in the river from 2000-2012.

Barramundi are seldom recorded from above the Barrage even though there is a fishway. It is only following major flood events that fish are found above the Barrage. Following the flood in 1991 there were 7 tagged fish recaptured above the Barrage as far upstream as the junction of the Dawson and Mackenzie River 200km upstream. From 1991 to 2011 there were no further tagged fish recaptured above the Barrage.

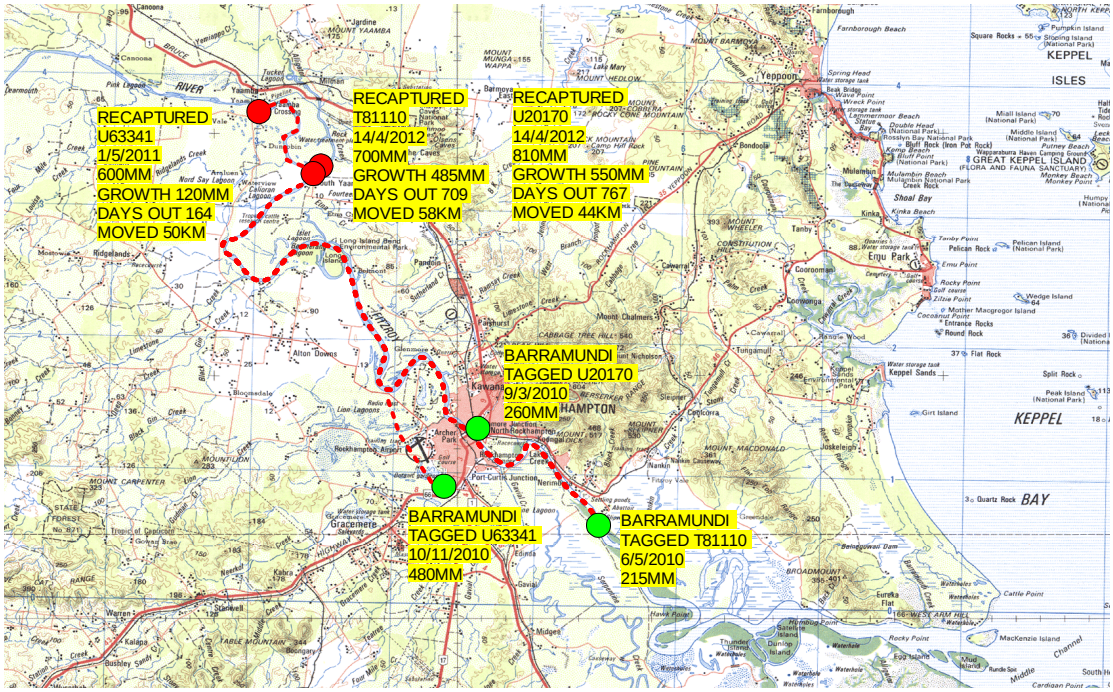

Figure 24: Barramundi recaptured above Barrage since 2011 flood

Following the 2011 flood there have been 3 recaptures of fish tagged in the estuary (*figure 24*) and numerous reports of Barramundi being caught above the Barrage. No data collection has been undertaken so that no estimate of stock above the Barrage is possible however based on the reports it is expected that there are moderate numbers of fish there.

17. RAINFALL AND RIVER FLOW

Figure 25 shows flows in the Fitzroy River and rainfall in Rockhampton from 2000-2012. During that time there was an extended drought period from 2003-2007. This was followed by a wet period from 2008-2012. Rainfall, river flows and timing of flows are key drivers of Barramundi recruitment (see section 11) and ultimately fish stocks.

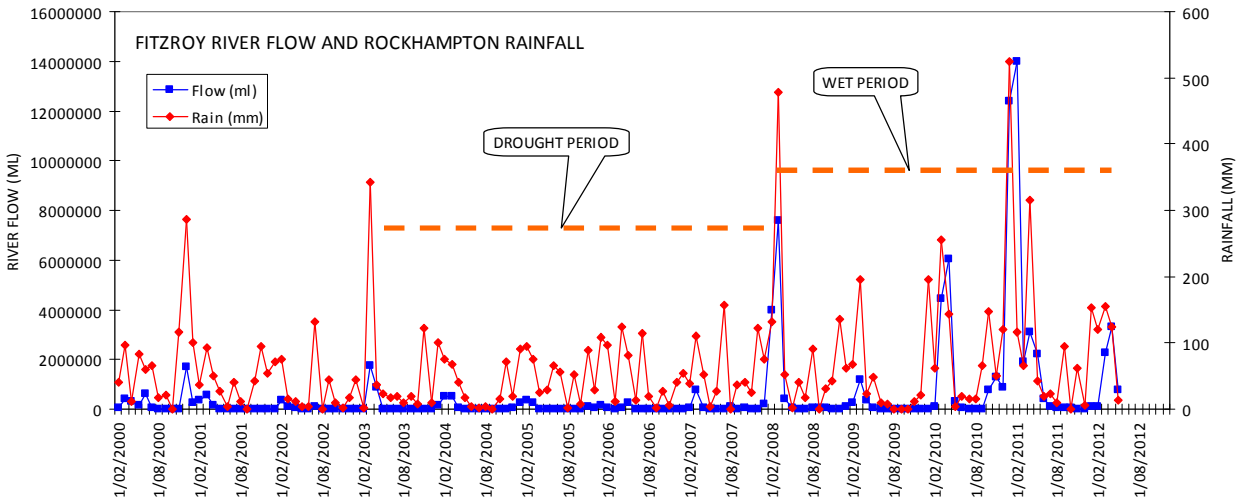

Figure 25: Fitzroy River flow and Rockhampton rainfall from 2000-12

All the climate models used by the Bureau of Meteorology to predict weather patterns are now pointing to an El Nino forming before the end of spring 2012, however there remains a moderate to high level of uncertainty in the individual models.[14] That prediction would suggest that there is a reduced probability of suitable conditions for good recruitment in 2013.

18. DISCUSSION

The development of the Crystal Bowl is in its early stages and there are a number of uncertainties in relation to the predictions. However even at the current level of development recreational and commercial fishers can use the information with some level of confidence. The uptake of this will be greater if the predictions sit comfortably with their own observations.

The greatest uncertainty lies in being able to assess overall stock levels. Using 2011 as a benchmark year and comparing stock levels with that year provides a basis of assessing stocks. Stocks that year were estimated to be the highest for 25 years based on 3 good recruitment years in 2008, 2009 and 2010. There have not been 3 such years in the past 25 years.

Assessing fish mortality is the other greatest uncertainty as there are numerous methods that can be used to assess both fishing and natural mortality. At this stage the assessment of the most appropriate method has not been completed however it is considered that there are sufficient data available to make these estimates. In the interim the estimates are mostly based on general estimates used in stock assessment.

[14] http://www.bom.gov.au/climate/ahead/ENSO-summary.shtml

19. FURTHER DEVELOPMENTS

Further development of the Crystal Bowl will depend on:

- How stakeholders view the credibility of the predictions
- Whether stakeholders value the predictions provided
- Funding

If these dependencies are resolved then the focus of future development will be:

- Improve the accuracy of the predictions of future Barramundi stocks especially in relation to estimating fishing and natural mortality
- Extend the predictive capability to other regions and species
- Continue improvement of information collection and delivery through such things as the use of Smart Phone apps

20. CONCLUSION

The first steps have been taken to move down the pathway of developing the capacity to predict fish stocks at a regional level. It is hope that the approach that has been developed here will encourage others to improve on what has been done. At this stage in the development it will be important to keep costs low, data collection as simple as possible and the predictions credible and reliable rather than strive too hard to improve the accuracy of the forecasts. If this process is accepted then accuracy will come as a natural evolution as it has done in weather forecasting.