Marron Farming Workshop, Field Day and Trade Show

March 13, 2004
Pemberton Freshwater Research Centre

Compiled by Greg Maguire

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Department of Fisheries

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Theme of workshop

“We have an excellent method for farming marron but we can improve on the genetics”

1.0 Improved Performance of Marron Using Genetic Strategies

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This presentation summarises the results of several genetic strategies investigated to improve the performance of marron.

(1) Comparison of different river strains, a neutrally selected domesticated "Pemberton" line and a new mass selected line developed from commercial stocks from a wide range of farms in Western Australia.

(2) Further development of the mass selected line.

(3) Development of pedigree lines based on some of the best stocks in (1).

This talk complements one by George Cassells, in this volume, who covers some of the husbandry components of FRDC Project 2000/215 Improved performance of marron using genetic and pond management strategies.

Below is a detailed discussion of the two major genetic improvement strategies being used within this project. It is adapted from an earlier article which appeared in the Marron Growers newsletter.

1.1 Genetic Improvement: *Mass Selection v Pedigree Breeding* PROS & CONS

Most farmers are aware of the current marron genetic improvement project where over the past 2 years we have evaluated a number of strains to identify the best marron for aquaculture, and more recently, commenced a selective breeding program to further improve growth. Our team is using two types of selection systems, mass selection and pedigree-based selection in the selective breeding component of the project.

Mass selection: A selective breeding program where selection is based on individual merit and by truncation. An individual whose phenotypic value (i.e. growth rate) is equal to or exceeds the cut off value (truncation point) is saved, while those with lower values are culled. Family relationships are ignored. Mass selection is also sometimes referred to as individual selection.

In comparison to a breeding program based on pedigree, a mass selection breeding program is far less complex. In its simplest form a mass selection breeding program for one trait (i.e. growth) selects the largest male and female marron from a pond or series of ponds for broodstock while the smaller, slower growing animals are culled or sold. The key advantages of this mating design are that; 1) farmers can implement mass selection on their own properties if they are prepared to invest the time and resources required to collect measurements, keep records and familiarise themselves with the basic quantitative genetics theory and equations required to select broodstock, 2) fewer ponds are required, 3) costs are lower, 4) the formulas, statistics and computer programs are simpler and easier to use than those for a pedigree breeding program, 5) there is no requirement to individually tag marron, 6) large numbers of juveniles can be produced with limited resources, and 7) more broodstock can be used.

However, there are a number of disadvantages of a mass selection breeding program. In particular; 1) gains are reduced over the long term, 2) there is little or no control over the effective breeding number because there is no control over mate selection, and 3) there is little control over inbreeding. In fact, a mass selection program can, if poorly designed, result in quite high levels of inbreeding because if a farmer merely selects broodstock from the largest marron produced on their own farm, or even worse from only one pond, they are likely to be from the same parents.

In our project the mass selected line was originally developed by obtaining the largest 2-year-old marron from a large number of farms throughout WA. These marron were bred at Pemberton and their juveniles reared on two farms in WA. Recently, we drained these ponds and again selected the largest 10 % of male and 40% of female 2-year-old marron for broodstock. These broodstock have been transferred to breeding ponds at Pemberton to produce the next generation of mass selected marron.

In the short term, this program is capable of producing a large number of faster growing juveniles, while utilising relatively few resources. However it does run the risk that in the longer-term higher levels of inbreeding will occur.

Pedigree-based breeding: A breeding program that uses not only the traits of individuals and families, but also a family tree on which to base selection and mating decisions. This requires mapping the genetic history of a particular individual or family to identify the best broodstock.

This is a much more sophisticated and complex breeding program, where broodstock are selected not only on their individual merit, but also on the performance (merit) of other members of their family. Simply put, while a marron may not be the largest in a pond, if we know it is closely related to other very large animals it is probable that it also carries similar genes and will pass these on to its progeny.

The key advantages of a pedigree mating design are that; 1) inbreeding and effective breeding number can be controlled, 2) selection for several traits is made simultaneously, and 3) larger genetic improvements can be made over the longer term.

The key costs of this mating design are that; 1) a large number of holding ponds or tanks are required to maintain separate family lines, 2) the formulas, statistics and computer programs are complex, 3) marron must be individually tagged, and 4) fewer marron are produced each generation due to the large amount of resources required.

Needless to say, unlike mass selection, it would be very difficult for individual farmers to attempt a pedigree-based breeding program on their own properties. In our project we are developing 110 family lines, this requires 110 separate holding tanks for juveniles in addition to broodstock breeding ponds.

Using the results from our recently completed strain evaluation experiment we have used both between-strain and within-strain selection to establish the base population for our pedigree-based breeding program. First, the best broodstock have been identified using between-strain selection to identify the families with the best genes for the traits we wish to improve. Secondly within-strain selection has been used to select the best individual marron from within each of the best strains.

In our project we have added another layer of complexity to the pedigree breeding program by developing a selection index to determine breeding values for individuals, based on the economic merit for each marron in our pedigree. This selection index is quite complex, but basically it enables us to identify and select broodstock based not only on weight (i.e. growth), but also a number of other factors that are of economic importance such as age at sexual maturity, colour, size of claws, size of carapace and size of abdomen. These individual marron have been selected and individually tagged, their progeny will also be tagged so that the family line of each individual can be determined and used to estimate breeding values (EBV's) for each individual marron to aid the selection of broodstock in the future.

Using EBV's for individual marron, the selection index and sophisticated computer software, means our research team will be identifying the best broodstock based not only on weight, but also several other commercially important traits. Incorporating the pedigree information will improve the accuracy of our EBV's and provide us with far greater control over inbreeding and potentially greater returns for farmers over the longer term.

1.2 Which is better?

Pedigree breeding has much better longer term potential, provided the industry can support a long term sophisticated breeding program. Whereas mass selection can be used to improve performance in the shorter term by producing a large number of marron that are better than existing industry stocks, but ultimately not as good as those produced by a pedigree breeding program. On this basis, both are worth pursuing to provide industry with better animals for farming in both the short and long term and this is the strategy we are adopting in the marron genetic improvement project.

1.3 Acknowledgements

I would like to thank my co-investigator Dr Phil Vercoe (Senior Lecturer Genetics) from The University of Western Australia, who along with Department of Fisheries Technical Officers, George Cassells, Sandy Seidel, Carey Nagel and Chris Bird have made a major contribution to this marron genetics research program. Dr Greg Maguire provided valuable comments on this article.

FRDC Project 2000/215

Improved Performance of Marron Using Genetic and Pond Management Strategies

Dr Phil Vercoe and Dr Craig Lawrence

Department of Fisheries
Government of Western Australia

Fish for the future

What's in this talk

Improved Performance of Marron Using Genetic Strategies

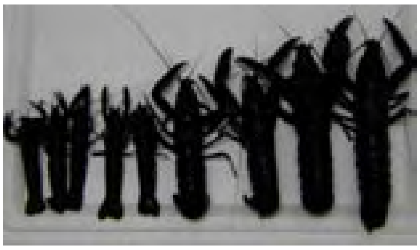
- Update on the breeding program and ATSE grant
- Progress we've made breeding for better marron and developing a selection index

Why Marron ?

- Large size
- High market value
- High global demand
- Little competition
- Disease status
- Simple lifecycle
- Relatively easy to farm
- Farming techniques well established

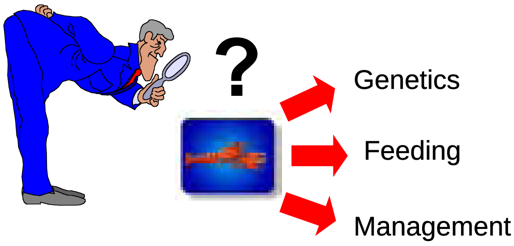
Objectives

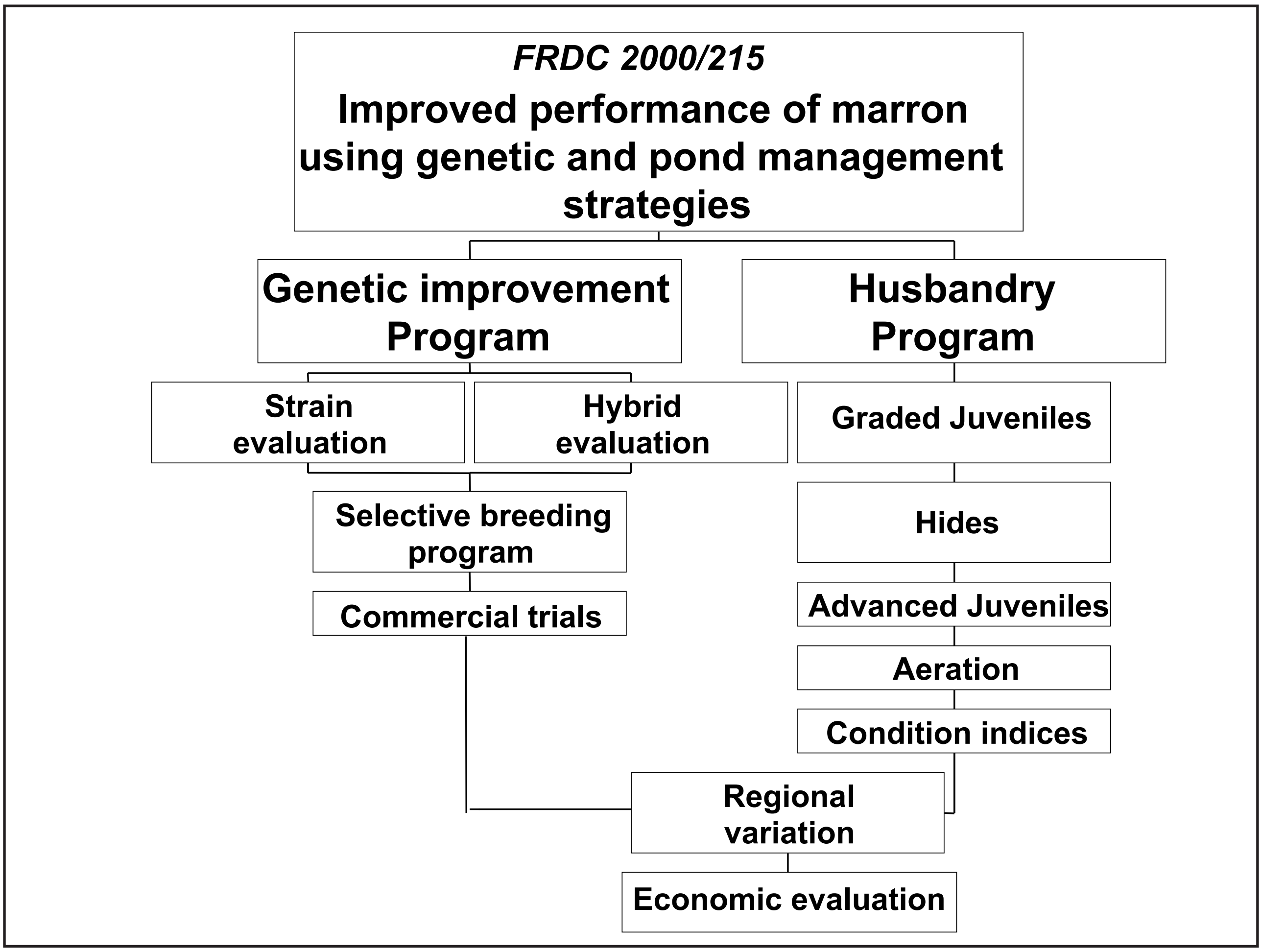
- Increase growth rates
- Decrease size variation



25 g → 250 g

The solution





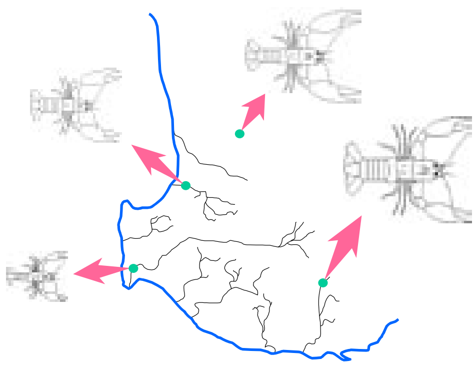
Strain evaluation experiments

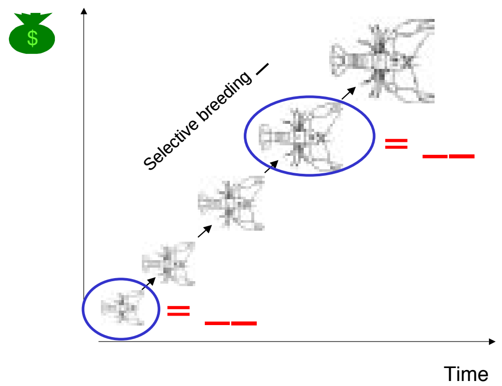
- **Shenton Park**
  - Exp 1) 10 strains (growth)
  - Exp 2) 8 strains VIE tagged (social interaction)
  - Exp 3) Performance of hybrids
- **Commercial farms**
  - Exp 4a) Comparing performance of mass selected and Pemberton lines with industry stocks
  - Exp 4b) Comparing performance of 2 lines (mass selected and Pemberton) in 2 different regions

Strain evaluation = identify the "best" marron for aquaculture

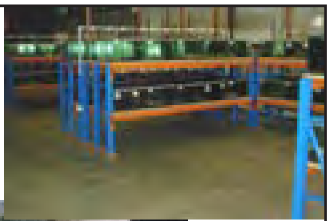
- 6 wild river strains
- 3 selected "domesticated" lines (Selected Stock, Pemberton, Blue marron)
- 1 industry "domesticated" line

Why evaluate strains ?

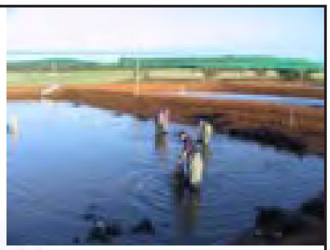




Shenton Park Aquaculture Laboratory



Commercial Farms



Results – reproductive success*

Strain	% Berried females
1	13
2	35
3	45
4	53
5	56
6	84
Pemberton Line	77
Selected Stock Line	64

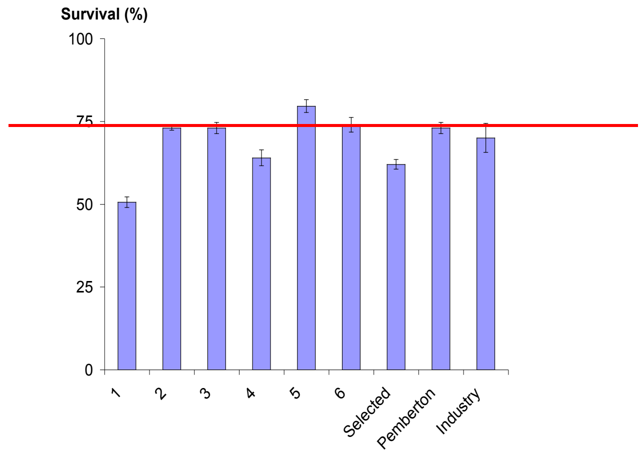
* Reproductive success of marron strains 2000/2001 breeding season

Weight of juveniles at stocking
(29/3/01)

Strain	Mean Weight (g)	se
1	0.93	0.13
2	1.26	0.15
3	1.07	0.11
4	3.10	0.29
5	2.13	0.18
6	1.35	0.16

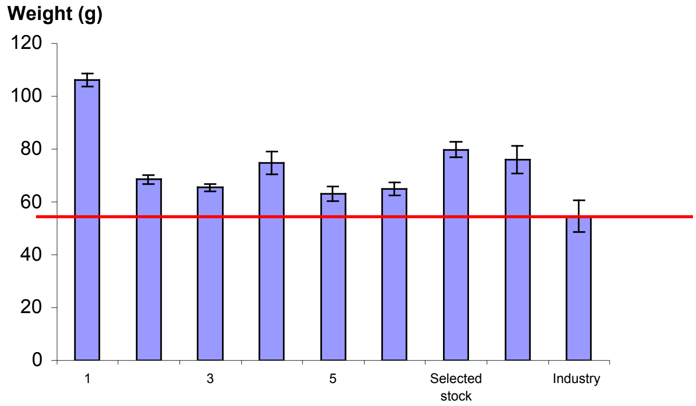
Results – survival

(Nov 2002)

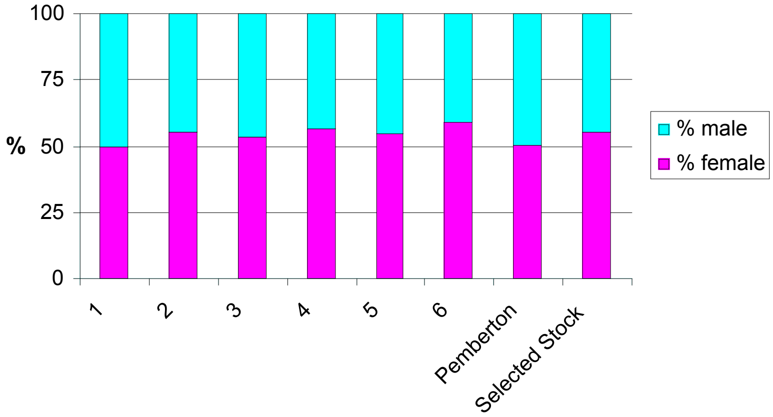


Results – growth

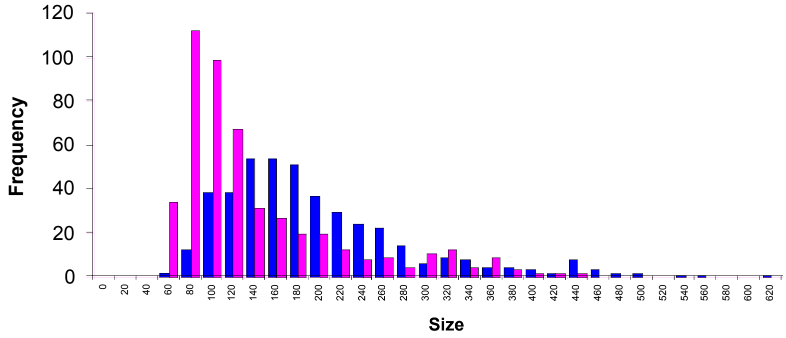
11/11/2002



Strain Sex Ratios



Size of females & males

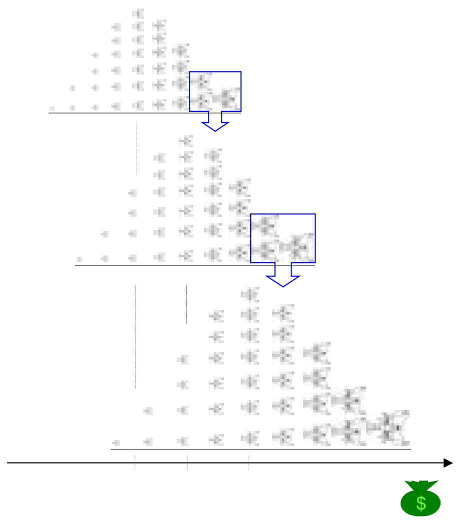


Selective Breeding

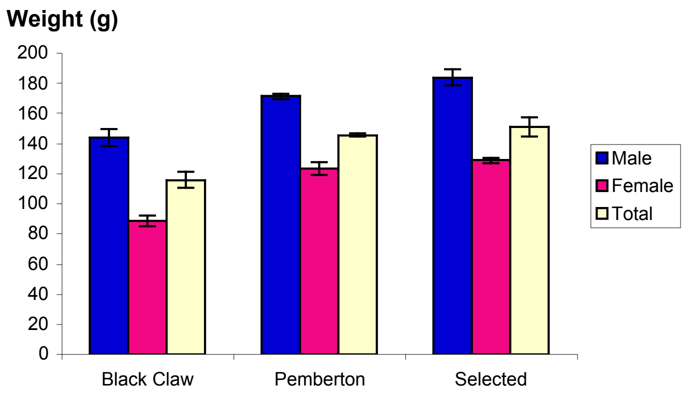
Selectively breeding marron

- Mass selection breeding program
- Pedigree breeding program

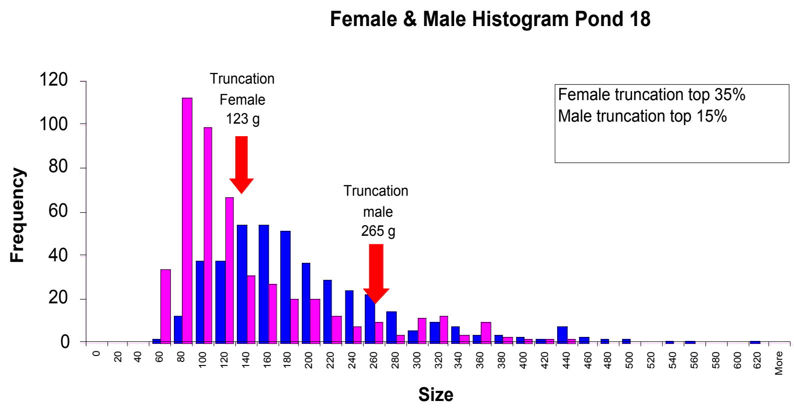
Mass selection breeding program



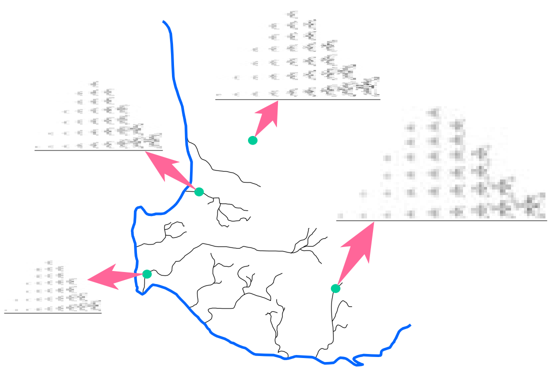
Mass selection – 1st generation



Mass selection



Pedigree breeding program



Selection index for breeding marron

The ATSE grant has been useful

We've developed:

1) Strong collaboration with top group
2) Selection index for breeding program

What we should talk about

- Remind you about ATSE
- What we did
- What we accomplished
- Explain "selection index"
- Where we are now

Australian Academy of Technological Sciences and Engineering

Program: Frontiers of science and technology workshops and missions

Objectives

- Access expertise and best software
- Strategic alliance
  - Danish Institute of Agricultural Science (DIAS)
- Formal recognition
  - International Network on Genetics in Aquaculture

International Network on Genetics in Aquaculture

- International collaboration - ongoing benefits
  - collaborative research
  - workshops
  - training in applied fish breeding and genetics

Breeding values

Genetic variation

Breeding Objective | Selection criteria | Breeding station

Selection schemes

Mating designs

ATSE – outcomes

- Potential of the software
- Access to software and expertise - ongoing
- Student exchange - ongoing
- Associate member of INGA
- International funds?
- Strategy for genetic improvement
- Designed a pedigree based program
- First selection index

Selection Index

A way of ranking individuals when you're assessing their performance on more than one trait.

Our selection index

- ATSE workshop - breeding objectives
- Good information (accurate)
- Settled on 4 main traits
- Selection Index for base population

Index for base population

- Included:
  - Body weight (size distribution)
  - Body shape (more tail, less claws)
  - Survival
  - Sexual maturity
- Accounted for other traits
- Identified top 5 lines

Simplified Index

I($) = growth + form

growth	form
Total weight	Tail volume (+ve)
Size category	Claw area (-ve)
Survival	Carapace area (-ve)
Early maturing	
FCE	

Base population

- Want variation
- Variety of genes for our traits
- Consider making most $$ car in world!
- Depends on?

Breeding objectives

Ferrari Rolls Royce Mini

Base population

- Base population made up of most profitable populations
- In our case - 5 best lines based on selection index

Wrap up

We are making progress and have used the ATSE grant to form strong international collaborations and develop a selection index for breeding program

Selection Index

Player Statistics for Norm Smith medal:

	Akers	Black	Buckley(s)
Kicks	18	16	17
Handballs	2	23	7
Possessions	20	39	24
Marks	3	2	1
Tackles	3	9	3
Goals	5	1	1
Behinds	2	0	1

Single trait

Player Statistics for Norm Smith medal:

	Akers	Black	Buckley(s)
Kicks	18	16	17
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Rank – many traits

Player Statistics for Norm Smith medal:

	Akers	Black	Buckley(s)
Possessions	20	39	24
Marks	3	2	1
Tackles	3	9	3
Goals	5	1	1
Behinds	2	0	1
	33	51	30

Selection Index

Player Statistics for Norm Smith medal:

Kicks	(4)
Handballs	(1)
Possessions	(-)
Marks	(2)
Tackles	(3)
Goals	(10)
Behinds	(5)

Selection Index

Player Statistics for Norm Smith medal:

		Akers
Kicks	(4)	x 18 = 72
Handballs	(1)	x 2 = 2
Possessions	(-)	
Marks	(2)	x 20 = 6
Tackles	(3)	x 2 = 9
Goal	(10)	x 5 = 50
Behinds	(5)	x 2 = 10

Selection Index

Player Statistics for Norm Smith medal:

		Akers	Black	Buckley(s)
Kicks	(4)	72	64	68
Handballs	(1)	2	23	7
Possessions	-			
Marks	(2)	6	4	2
Tackles	(3)	9	18	9
Goals	(10)	50	10	10
Behinds	(5)	10	0	5
		149	119	101

What does ranking depend on?

Breeding objectives	Weighting	Akers	Black	Buckley(s)
Kicks	(4)	72	64	68
Handballs	(1)	2	23	7
Possessions	-			
Marks	(2)	6	4	2
Tackles	(3)	9	18	9
Goals	(10)	50	10	10
Behinds	(5)	10	0	5
		149	119	101

Ranking

Rank	Scenario 1 (all traits equal)	Scenario 2 (weighted differently)
1	Black	Akers
2	Akers	Black
3	Buckley(s)	Buckley(s)

Establishing base population

- Males

Strain (rank)	Index	Number
1	112	11
2	84	7
3	72	6
4	69	6
		30

Selected individuals within strains - index

Establishing base population

- Females

- 5 best strains (#'s)
- Approximately equal numbers
- At least 1 of each strain/male

2.0 Thomson's Flat Pond Trial 1

Effects of stocking density for year 1 and grading strategy in year 2 on growth, survival and profitability for marron stocked into and harvested from model farming ponds in summer – a report after year 2

Greg B. Maguire, George Cassells, Tony Church, John Heine and Craig S. Lawrence
Department of Fisheries, Research Division, PO Box 20, North Beach, WA 6920, Australia

Caveat

This document describes research for the 2 year production. The ponds were harvested in early February 2004 and not all economic analyses have been completed. The methods, described in Maguire et al. (2002a, 2003a,b) and updated in this paper for this trial, worked well but may not be ideal for all commercial farms.

2.1 Summary – using a question & answer format

Why was the research conducted?

This is covered in more detail below but summer stocking and harvest (by pond drainage) cycles were assessed to give the industry an option for continuity of marketing without having to rely on labour intensive, inefficient harvesting methods such as hide harvesting or trapping. Harvesting summer juveniles from nursery ponds also offers the potential of improving survival of juveniles by moving them, from a very high density in commercial nursery ponds (possibly 400/m^2 in January), to much lower densities (5-13.5/m^2) in growout ponds.

At the end of year 1, grading by size or sex was assessed for year 2 to see if this improves production, particularly by reducing overall size variation. Extreme size variation within each marron pond is a major challenge with marron farming. For example, males from low density ponds at the end of year 1 ranged in size from less than 20 g to more than 200 g.

The trial only used recycled discharge from trout and marron ponds and tanks and was aimed at assessing water reuse (after passage through vegetated channels, a settlement pond and a reed pond) as a tool industry can use to overcome water shortages and ensure that any discharge to natural waterways has high water quality.

How do the ponds differ from commercial ponds?

The ponds used (average of 152 m^2 water surface area) were relatively small for grow-out ponds and relied on venturi aeration not paddlewheels. They also contained a concrete harvesting channel, so that they could also be used for fish if needed. This allowed for initial flushing of the marron in relatively clean running water before transfer to the processing shed. Each pond had an electric fence to contain stock. As recommended for commercial ponds, the pond complex was also enclosed by a perimeter fence to exclude predators such as water rats and overhead netting excluded birds. Because of the presence of redfin perch in Big Brook Dam upstream of the water intake, 1.4 mm mesh filtration was used as water entered the ponds.

In contrast to many commercial ponds, all stock harvested at the end of year 1were restocked if needed i.e. no larger marron were sold off and all "runts" were retained for restocking in year 2.

How did the farming methods differ from the original plan?

The major differences between year 1and 2 management as proposed by Maguire et al. (2002a) and what was actually done was that demand feeding was relied upon more than feeding tables, seepage rates with these new ponds were higher than expected (use of recycled water allowed this to be managed easily), and a second addition of silage was used after about 6 months in year 1 because of the water exchange induced clarity of the ponds.

Terms

The ponds were stocked in late January 2002 with summer juveniles presumed to be one month old i.e. one month after the juveniles left the female. Year 1 is until early February 2003 and Year 2 is until early February 2004. Winter juveniles were not used in this trial but are used typically by industry. These would be harvested from nursery ponds in May to August i.e. be at least 4-7 months old.

2.2 Key R&D questions and answers to date

The first farming trial in the Thomson's Flat ponds was conducted to answer a wide range of significant questions including:

1. *For 2 year production cycles, should year 1 be run at a high density (13.5 juveniles/m^2) instead of a low density (5.0/m^2), followed by a low density (3.1/m^2) in year 2*? At the end of Year 1, marron at the lower stocking density (5.0/m^2) were larger, survived better and were less variable in size. More of these low density marron were marketable (see next talk by Maguire et al. in this volume) although none were sold but rather were restocked for year 2 of the trial. Ponds stocked at the higher stocking density (13.5/m^2) yielded a greater total weight (biomass) of marron than the low density ponds but FCR results were similar. Overall, the results for both densities were outstanding particularly given that these were new ponds stocked with tiny juveniles in summer. The year 1 stock for the high density were carried through into two size grades (3 ponds for each size grade) and, for comparison, the same strategy was used for some of the marron from the low density ponds. At the same density in year 2, the marron from the high density year 1 ponds did not obviously "catch up" but the size disadvantage was relatively small after 2 years and the survival rates in year 2 were similar. Taking into account, the pond areas used in year 1 (obviously less for the high density juveniles) and the area used in year 2, production for the high density marron over the two years was 2.43 tonnes/ha/year while the equivalent for the low density marron was 1.61 tonnes/ha/year (see R&D Question 9 for the methods used to generate these values). The relative profitability of high density in year 1 treatment depends on the "economic penalty" for slower growth i.e. imputed sale prices for different size categories at end of year 2. We propose to use the following values but welcome comment on these: <40 g ($0/kg, i.e. unsaleable), 40-70 g ($8/kg, i.e. based on equivalent value of yabbies), 70-100 g ($17/kg), 100-150 g ($20/kg), 150-250 g ($23/kg), and >250 g ($26/kg). Clearly, a farmer would consider growing on the smaller size grades, after the year 2 harvest, as we chose to do.

2. *In year 2, after harvesting of all stock at the end of year 1, should marron be restocked without any grading, or as two size grades or as two sex groups?* The marron graded by size (averaged across both size groups) survived significantly better in year 2 (79%) than the ungraded marron (70%) ($P<0.05$) with the sex graded marron (averaged across both sex groups) showing an intermediate result. Lower survival can effectively reduce density, resulting in faster growth. Thus the growth results in year 2 were in the reverse order i.e. average weight gain was best for the ungraded

marron (mean weight gain of 78.5g) followed by the marron graded by sex (mean weight gain of 77.6 g averaged across both sex groups) and the marron graded by size (mean weight gain of 75.6g averaged across both size groups). However, the growth results, and biomass harvested results (see below) were not statistically significant ($P>0.05$).

3. *Can most of the small 0+ juveniles stocked (at about 0.3 g/marron) reach commercial size in two years?* Growth rates in year 1 were very good but the winter was much cooler in year 2 so that subsequent growth rates were a little disappointing. When all year 2 size and sex grading treatments were averaged for year 2, virtually all marron reached at least 40 g (in theory marketable, depending on demand, but the proportions of marron that were larger than 70 g were 82% and 76% for low and high density groups after year 2. The equivalent values for larger than 100 g were 65% and 58% . It should be noted that commercial farmers stocking in winter and harvesting in winter (in year 1 and year 2 of growout) are harvesting some stock at ages of 18 and 30 months (since the juveniles left maternal care) whereas in this trial the final harvest was at 25 months. It will be interesting to see what size the slower growers reach when these spare stock are harvested in May (28-29 months since the juveniles left maternal care).

4. *Can a stocking, drain harvest, restocking and final drain harvest cycle, with each of these steps carried out in summer, yield good survival at final harvest and during post harvest handling?* Overall, this was quite successful. **(A)** Survival during year 1 of the farming trial was very good considering that very small summer juveniles were stocked. The restocking after year 1 was conducted efficiently and initial harvesting and post-stocking mortality for the year 1 harvest was less than 3% despite the marron having been weighed twice and held at high densities in a cooled, recirculating holding system. Losses during harvest and restocking (see below) for year 2 were also low and this was probably aided by negligible occurrence of soft (just moulted) marron during the year 2 harvest). Survival during year 2 of the farming trial was a little disappointing and reflected prolonged, low level losses well after the initial post stocking phase and some mortality, particularly of large marron, during the summer as the final harvest was approaching. **(B)** The availability of recycled water from the settlement and reed ponds was a key advantage, particularly given the high but declining seepage rates from the new ponds. Seepage increased after all ponds were drained and hosed out during the year 1 harvest but again declined throughout the next year. A major water change was effected in all ponds in late Spring in Year 2 and ponds that had no seepage received a minimal flow to match ponds with low seepage rates. The potential concern was the degree to which shale accumulated in the central concrete channel and in year 2 this probably led to a build-up in organic matter in the ponds as it blocked the bottom outlet slots in the outer pipe surrounding the overflow standpipe within each pond. (The shale is consolidating but some ponds have excess shale and this will have to be removed.) These harvesting channels worked very well provided that clean running water was supplied at the right time as the pond depth declined towards the top of the harvesting channels. **(C)** The new system for holding and processing the marron after removal from the pond maintained very good dissolved oxygen levels and ensured that marron were kept submerged or wet from water sprays during processing. The cooler unit in the recirculating indoor holding system kept temperatures very favourable (usually less than 20^0C) while use of ice in the shaded outdoor initial holding tanks was very effective (for Year 1) but outdoor holding tanks were not needed in Year 2 as stock was transferred to broodstock sales (larger marron), restocked as broodstock to continue the Pemberton marron line (ungraded) or restocked into single sex ponds for planned sales as table marron in May 2004 (smaller marron).

5. *Can the 150 m^2 ponds be operated successfully using only reused water (after passing through vegetated channels and settlement and macrophyte (reed) ponds)?* Water quality readings were excellent throughout the trial (data not presented here). When draining and refilling multiple ponds per day, a high degree of recycling must occur but turbidity levels were very low (water was very clear) when used for refilling after passing through these treatment ponds. Organic build-up in the 50 mm pipelines carrying trout hatchery effluent to Thomson's Flat and in the pipe grid supplying water to each pond, after being pumped from the reed pond, was a problem but this was addressed by "pigging" the supply lines and by using a larger pump, to provide a rapid flush of the pipes to individual ponds. A smaller pump was adequate to replace seepage and provide water exchange to these 20 ponds and to three commercial scale marron ponds (800-1000 m^2) and 22 experimental pools.

2.2.1 Additional questions

6. *Do both sexes have similar survival rates?* After year 1 there was a slight bias towards females but the sex ratio was close to 1:1. However, in the all male ponds in year 2, survival was much lower (66%) than in the all female ponds (84%). When all eight mixed sex ponds resulting from the low density treatment in year 1 were considered, a similar pattern emerged with respective survival rates for year 2 being (72%) and (82%). This could be a size effect or a sex effect as males are larger than females, however, a sex effect is more likely as there was little consistent difference in survival rates between ponds stocked with small or large size grades (see Table 2).

7. *Did any of the treatments (pond management strategies used) affect size variation?* As indicated in Maguire et al. (2003a), growing marron at a high density in year 1 increases size variation. When these two density groups are carried through at the same density in year 2, the difference in size variation does not get worse but it still exists. Clearly, if you size grade compared to an ungraded group, the size variation at stocking and harvest will be lower in large size grade and small size grade compared to the ungraded marron. However, if we average across the two size grades and do the same for the all male and all female ponds, this may not still be the case (more analysis required).

8. *Was demand feeding successful?* Maguire et al. (2003b) showed that the Pemberton Freshwater Research Centre staff who feed to the ponds on an apparent demand basis i.e. they fed into the shallows and next day adjusted feed rates in individual ponds on the basis of whether feed was left over or completely consumed, managed to provide feed inputs that correlated well with the biomass of marron harvested at the end of year 1. This suggests that demand feeding in clearer ponds can be highly successful. This is reinforced by the excellent FCR values obtained in year 1 i.e. about 1.5 kg of feed per kg increase in marron biomass. They achieved this in both high and low density ponds and this is quite challenging to achieve such a consistent outcome.

9. *How much biomass was produced per m^2 per year?* The most appropriate way to address this is to determine how many m^2 of pond can be stocked by the marron harvested in 1 m^2 (at low or at high density) after year 1, determine the biomass harvested in this number of m^2 (=X) and then compute as follows:

   Biomass harvested/m^2/year = Biomass harvested in X m^2 in year 2/(X+1) m^2

   For example, if 1 m^2 of high density pond yields 9.3 marron/ m^2 at harvest, this is enough to stock at 3.1/ m^2 in year 2. If a pond in year 2 produces 290 g/ m^2

   Biomass harvested/m^2/year = 3 m^2 x 290 g/4 m^2 = 218 g/ m^2/year = 2.2 t/ha/year

   The results for this index are given in R&D Question 1 above.

10. *Which is the most profitable management strategy in this study?* Profitability is still being fully assessed for this 2 year trial. However, as seen in another paper in this volume (Maguire 2004), the major costs associated with marron farming are capital costs ($9.16 out of a total cost $15.24/kg, based on the assumptions given in that paper). The next major cost (labour at $2.90/kg) is not greatly affected by the treatments (different management strategies) assessed in this present paper. As such, for this study where all ponds were similar, relative profitability will be largely driven by income. Thus, using the higher stocking density in year 1 will clearly be more profitable unless an even more severe price penalty is applied to smaller marron. Regardless of whether grading improves profitability, a farmer could choose to size grade for marketing convenience as for an individual pond, as opposed to the whole farm, size variation at harvest will be reduced. Once the economic analyses are complete and we have harvested the remaining smaller marron in May 2004, we plan to submit, to the Marron Growers Bulletin, an article on the relative profitability of these different farming strategies.

11. *Did differences in water exchange rate among the ponds affect growth or survival rates?* This has only been assessed for results from year 1 so far. A statistical technique called covariance indicated that these differences in flow rate did not significantly affect performance of the marron ($P>0.05$).

12. *Did the electric fences around each pond restrict movements between ponds?* The marron were seen to challenge the fences if the power was turned off for extended periods. However, at harvest after 2 years, all male and all female ponds contained negligible juveniles whereas mixed sex ponds contained numerous juveniles. This, along with the sex ratio results, suggests that movement between ponds was negligible. It is important to ensure that the fences are operating at full voltage, that edge erosion does not undermine fences and that reed growth near the pond edge is controlled (eg by use of a whipper snipper). Allowing reeds to grow well also encourages marron to erode pond wall soil under the reed roots.

13. *Can 25 month old broodstock be harvested in summer for transfer to broodstock ponds on other farms?* An initial trial at the end of year 1 with surplus high density pond marron was very successful with minimal transfer losses. After the year 2 harvest transfer of broodstock to eight widely located farms was generally very successful with initial losses of less than 1% to 3-5% (data for three farms). Broodstock transfers would probably be easier in cooler months.

14. *What proportion of females berried in year 2?* Sampling on a 3 monthly basis indicated that 44% of females in mixed sex ponds, sampled by hide harvesting, were berried in November 2003 (age 21 months). This was not strongly influenced by whether the marron had been held at a high or low density in year 1.

15. *Do replicate ponds on Thomson's Flat, managed in the same way, provide consistent results i.e. are they useful as experimental tools?* This is an important issue and is covered in the second Maguire et al. (2003b). In both years, the replicate ponds gave quite consistent results.

16. *Was hide sampling a good guide to average size at harvest?* This proved to be the case with year 1 harvest results (Maguire et al., 2003b) but the data have yet to be analysed for year 2 results.

17. *Is this type of farming sustainable?* This issue has been addressed by some of the coauthors in a recent national seminar. Sustainability involves three considerations.

(A) Environmental factors

Briefly, this farming system/management strategy used:

- land that had already been cleared,
- relied on water reuse,
- returned surplus cleansed water to Lefroy Brook to maintain river flow, particularly in summer,
- used no chemicals (including chemical fertilisers),
- contained unplanned escapes of marron,
- did not involve farming of a non-native species,
- used broodstock that originally were drawn from the local catchment (Warren River stock), involved no genetic engineered stock,
- excluded predators rather than applying potentially harmful response strategies,
- returned native competitors (tadpoles) to natural waterways when trapped,
- killed off exotics occurring in the ponds during harvest eg *Gambusia* (mosquito fish),
- used low amounts of low protein (23%) pelleted feed, based on grains rather than limited fish meal supplies,
- provided additional wetlands that did not exclude birds eg ducks or wading birds in discharge channels and settlement and reed ponds,
- avoided occurrence of serious diseases (there are very few diseases in marron farming), and
- managed to avoid ectocommensals eg "temmies" (temnocephalids) or ciliates (*Epistylis*).

Potential negatives were the use of power for pumping and aeration but if funds were available, this could be offset by use of solar power on processing shed panels to contribute power back to the grid. The other major impact is evaporative losses although these are balanced by reduced transpiration by the dense grass growth that previously covered Thomson's Flat.

(B) Social factors

At a social level this type of marron farming/this facility:

- fosters local employment,
- access is provided for farmers (eg Open Days) and secondary/tertiary students,
- where possible, regional equipment suppliers were used, and
- access to the facility has also been offered to boost tourism.

(C) Profitability

Clearly, the other aspect of sustainability, profitability is still being fully assessed. However, as seen in another paper in this volume (Maguire 2004), marron farming can be quite profitable as a form of farm diversification (provided the assumptions made by the author are met). The capital costs assumed by Maguire (2004) are considered by some to be relatively high estimates, particularly for earthworks. If such costs can be reduced, this could help offset the cost of purchasing a property specifically to farm marron.

18. *What changes to the design/construction of these experimental ponds would be recommended based on the experience gained in this trial?* Ideally, the ponds would be larger eg 250 m^2, to reduce the pond wall slopes and allow better compaction of the slopes, however, this would have been more demanding in terms of space, operating cost, number of animals used for a trial, and processing costs for postharvest work including restocking. The harvest channels could have been shorter to avoid "butting up" to the end walls as that tendency again encourages sedimentation within the channel. Less shale could have been added to each pond and more coarse shale would have been ideal for maintaining the pond edge to prevent erosion near the electric fences. In another location with more clay and greater elevation with respect to river level, more freeboard could have been used to separate the water edge within the pond (and hence the prime zone for reed growth) from the internal electric fence. Ideally, it would be good to remove accumulation of sediment in the channel by sludge pump about every 6 months. Some redesign of the outer pipe around the standpipe may be necessary unless shale movement declines through removal or consolidation. Having made these points, it should be said that the ponds sustained in excess of 4 tonnes/ha in some ponds during year 1 and marron bred freely in mixed sex ponds in year 2. Apart from the challenge of physically removing sediment from the channels as the pond drained, they were excellent to harvest particularly given the capacity to run clean water through the channels during harvest. Ideally, 1-2 ponds would be left unstocked, after thorough rinsing and extended drying approached harvest time, so that all ponds could be dried for 1-2 days before refilling.

Table 1. The key results from year 1 of the trial are summarised below.

Performance index	Low Density Ponds	High Density Ponds
Mean wt. males harvested (g)	63.10	51.00
Mean wt. females harvested (g)	53.00	43.20
Mean % survival	78.40	70.40
Biomass harvested g per m^2	227.20	425.70
FCR	1.59	1.54
% animals > 70g	30.60	18.10
% animals > 100g	13.40	5.60
% soft marron	4.62	2.97
No. days of trial (to restocking)		30-31/1/02 until 17-26/2/03, about 1 year and 20 days.

Table 2. The key results from year 2 of the trial are summarised below.

Performance	LD History	HD History	All Males Treatment	All Females Treatment	Size Grade Smalls: LD	Size Grade Smalls: HD	Size Grade Large: LD	Size Grade Large: HD	Ungraded
Mean wt. Harvested (g)	135.4	120.6	---------	---------	89.3	84.1	179.2	157.1	137.4
Mean wt. Males harvested (g)	160.3	140.0	157.6	---------	114.9	107.8	199.5	172.3	173.3
Mean wt. Females harvested (g)	119.2	106.1	---------	114.2	73.5	71.1	157.3	141.2	115.3
Mean % survival	75.7	75.2	66.3	84.3	80.4	75.2	75.7	77.8	78.9
% survival males	70.2	69.8	66.3	---------	74.8	65.4	71.7	74.2	68.0
% survival females	82.6	81.5	---------	84.3	84.1	81.0	83.0	82.1	78.9
Biomass harvested (g/m2)	359.8	288.4	320.2	297.5	224.0	196.8	419.1	379.9	267.8
% animals >70g	82.0	75.6	98.2	69.7	60.3	52.3	100.0	98.8	92.4
% animals >100g	64.9	58.9	83.2	48.3	32.8	28.6	95.2	89.3	77.2
% animals >150g	38.0	21.6	48.9	27.7	7.9	7.9	67.8	51.3	45.3

2.3 Draft scientific description of the trial

2.3.1 Introduction

Marron (*Cherax tenuimanus*) are often farmed in Western Australia by stocking juveniles into semi-intensive ponds in winter about 6 months after maternal care ceases in summer, growing these for 12 months, selling sufficiently large marron at that time, and growing the remainder i.e. grow-on, for up to a further 12 months (Cassells et al., draft). Efficient harvesting in cooler months is achieved by draining the pond, removing all marron, washing out accumulated organic matter, drying, refilling and restocking (Maguire et al., 2002b). In warmer months, less efficient partial harvest methods are used i.e. using baited traps or "hide harvesting" i.e. displacing marron from hides (folded bundles of fine plastic mesh netting with a float and weight at opposite ends) into a framed net. Summer harvesting is important for providing continuity of marketing and, to improve the efficiency of this strategy, summer drain harvesting was evaluated in this trial.

A major impediment to summer harvesting by drainage is loss of water as few marron farmers reuse water drained from ponds. In this trial, all water used for filling or water exchange in the ponds was recycled trout or marron pond/tank discharge after it had passed through vegetated channels, a settlement pond and a reed pond (see pond drawings in volume containing Maguire et al., 2002a).

Ponds harvested in summer should be restocked then with either unmarketable stock (grow-on) or juveniles. Summer juveniles are very small and pose the dual challenge of handling without mortality and growing to market size within 2 years. One strategy proposed by a marron farmer has been to stock the juveniles at a high density in year 1, grade at the end of that year, and use a lower density in year 2. This trial assesses that strategy in comparison to using low densities in both years and also compares different grading strategies, i.e. no grading, grading by size or use of single sex ponds at the end of year 1.

Marron farming can be adversely affected by poor survival or growth or excessive size variation. Morrissy (1992) showed that higher stocking densities depressed survival and growth when very small juvenile marron (0.06 g/marron) were stocked into ponds and that mortality was worse in year 1. Morrissy et al. (1995a) used larger juveniles and found that effects on survival were not as severe but that growth rates declined with increasing density. Similarly, in a study of results from 60 harvests at the one commercial farm, Morrissy et al. (1995b) found survival to be very high in year 1 when larger 0+ juveniles (1-10 g/marron) were stocked but that growth rate was depressed at higher densities.

A variety of factors can be managed differently at higher densities including feed input, refuge provision, aeration input and water exchange. Several of these factors were influential predictors of performance of marron in a survey for 40 pond harvests across a range of commercial ponds in Western Australia (Maguire et al., 2002c). In the above excellent studies by Dr Noel Morrissy, density was increased without necessarily adjusting all of these management strategies, whereas in the present study, all were to be increased at the higher density especially as biomass rises during year 1. (In practice, seepage rates in year 1 were sufficiently high that a higher exchange rate regime was needed in Year 1.) It is also possible that handling strategies when stocking summer juveniles have improved since the study by Morrissy (1992) who used much smaller juveniles than those stocked in the present study.

The ponds used in the present study each incorporated a concrete drainage channel. This was done to make then multi-purpose ponds i.e. suitable for fish as well. However, these channels did assist with harvesting in summer without extended aerial exposure of marron prior to initial gill flushing i.e. loss of sediment within the gill chamber during initial emersion. It was hoped that innovative post harvest handling of marron during grading would also reduce stress by limiting the duration and severity of aerial exposure.

Morrissy et al. (1995a) reduced the density for year 2 and only retained smaller marron for grow-on into year 2. Qin et al. (2001) found that size grading was not helpful in improving overall growth rates and restraining size variation at final harvest of marron. However, their choice of diet and densities and the absence of refuges makes interpretation of their results difficult. Karplus et al. (1987) compared three size grades and an ungraded control group of cherabin (*Macrobrachium rosenbergii*), all at the same stocking density, and found no growth, survival or production rate or income advantage unless the costly strategy of discarding the smaller size grade was adopted. In contrast, Lawrence and Jones (2001) strongly emphasised the need for size grading when stocking advanced juvenile redclaw (*Cherax quadricarinatus*). In this volume, very recent results are presented from a project led by Dr Craig Lawrence which show that size grading of winter juveniles provides a large size group that is significantly larger at final harvest than a comparable ungraded group, however, the difference is not very large.

Male marron grew 13.7-16.6% faster in year 1 than females in mixed sex commercial ponds (Maguire et al., 2002b), but definitive published comparisons of the performance of mixed sex and single sex groups in separate ponds in year 2 have not been located. Growing single sex groups is advantageous for yabbies (Lawrence and Morrissy, 2000) and cherabin (Sagi et al., 1986).

While growth and survival patterns are important in pond trials, the choice of density and husbandry strategy should be based on economic return (Lawrence et al., 1998; Maguire and Leedow, 1983; Morrissy et al., 1995b). In this study, partial economic return models that incorporate stocking and major operational costs, but not capital or labour costs, and size dependent value of crop estimates will be used (Allan and Maguire, 1992; Maguire and Leedow, 1983) unless more comprehensive models can be adapted.

In summary, this study assessed the performance of marron stocked as small summer juveniles into experimental ponds (about 150 m^2) at two densities in year 1 and under a range of grading regimes, at a lower density, for the second year of the production cycle, using pond design and management and harvest and postharvest strategies that may reduce losses associated with depressed growth or survival rates.

2.3.2 Methods

Source of juveniles

Juveniles were harvested mostly by hide harvesting and finally by complete drainage of two outdoor 150 m^2 nursery ponds (see pond drawings as Figures 3 and 4 in Maguire et al., 2002a) at the "hatchery location" within the Pemberton Freshwater Research Centre, Western Australia (116º05'E, 34 º33'S). These ponds previously held 55 and 24 berried females respectively and were managed as recommended by Cassells et al. (draft). The marron broodstock were all from the "Pemberton line" which has been neutrally selected for growth rate over many generations and has performed well in the current FRDC genetics project.

Where possible, the few juveniles exhibiting signs of damage or stress were excluded and the experimental ponds used for grow-out received a consistent ratio of juveniles from each nursery pond. In contrast to earlier research by Maguire et al. (2002b), no size bias was used and almost all available juveniles from the two ponds were used. The juveniles were transferred into partly submerged, porous plastic colanders in flowthrough trout fry raceways prior to counting. Groups of juveniles were placed on sloping PVC sheets supplied with a gentle trickle of water (usually around 23ºC); individuals were counted by gently separating each juvenile with a feather and directing it down with water flow into another flow-through colander. Marron were transferred in water in plastic basins and buckets and released into the shallows of 18 experimental ponds.

All water used for broodstock and nursery pond phases and counting was obtained directly from a weir on Lefroy Brook rather than being recycled aquaculture discharge. This water typically has low salinity (about 150 mg/L; see Morrissy, 1992).

Pond design and management

The experimental ponds (see drawings in attached Powerpoint presentation) used for the grow-out trial (137.3 – 170.0 m^2 water surface area at normal operating depth; mean 152.3 m^2, n=18) are located at the Thomson's Flat area of SWFRAC and had not been previously used for farming. They were dried for 3 weeks, filled to 30% volume, supplied with 22.5 kg hay silage per pond (to foster production of pond biota), drained after a further 4 weeks, then refilled. Two weeks later the juveniles were added (30-31/1/2002) shortly after crushed limestone was added (225 kg/pond). After another 6 months, another 22.5 kg hay silage per pond was added because water clarity was very high. At the end of year 1, two ponds were added to trial. These had been used for another marron trial for several months and hence no silage was needed but as no limestone had been applied to these ponds, crushed limestone (225 kg/pond) was added shortly before these two ponds were stocked for year 2 of this trial. (Note that these limestone addition rates are in excess of those recommended by the authors.)

All water added to or to be added to these ponds was recycled aquaculture discharge from trout ponds, passed first through a large swirl separator or from marron ponds. All water was directed along vegetated channels into a settlement pond and then into a macrophyte (reed) pond. Pond intakes were fitted with 1.4 mm mesh filters to exclude redfin. In year 1, initial rates of water exchange were relatively high to combat initial seepage and evaporation from these new ponds (average of 0.17 L/min/surface area in 2002; range for 18 ponds 0.04-0.37 L/min/surface area). As a result no additional water exchange was required in Year 1 except when ponds were drained. Three of the 18 ponds (two low density and one high density pond) were drained during year 1 and refilled after minimal deliberate removal of accumulated sediment to allow a census of animals in these ponds. In year 2, seepage increased after ponds were harvested and cleaning by active hosing of pond walls prior to refilling within 24 hours of being drained. Seepage rates then declined again. In December 2003, all ponds were partially drained and refilled once to improve water quality and holes were added in the outer pipe, surrounding the internal standpipe, just above the top of the concrete drainage channel to prevent shale/sediment accumulation in the channels causing overflow of the outer pipe through the screened standpipe.

Aeration was via venturi units supplied by 0.78 kW motors (see attached Powerpoint presentation) and duration of daily aeration was doubled in late Spring in year 1 for the high density ponds. These ponds reverted to normal aeration duration for year 2 of the trial. Initially a trout starter feed had been used and this was replaced by a commercial, pelleted freshwater crayfish feed in early Spring 2002 (see Maguire et al. 2002b, for composition). Feed rates were on a biomass basis with the initial rate set at 10% of estimated biomass (see Morrissy, 1996). However, from late Autumn of 2002 onwards, all rates were set on a demand basis i.e. adjusted based on daily observations of uneaten feed. Feeding was initially once per day, 5 days per week, generally mid-afternoon but from Spring 2002 feed was provided 6 days per week. For year 2 the feeding frequency reverted to 5 days per week. Ponds were sampled by hide harvesting (30-100 marron per pond) after months 3, 6, 9 and 12 in both years. This allowed evaluation of any bias in hide harvesting by direct comparison to the census of the renaming marron harvested from each pond (Maguire et al., 2003b).

Refuge provision was on the basis of about 0.15 refuges/m^2 in low density ponds and 0.30 refuges/m^2 in high density ponds in year 1 and 0.15 refuges/m^2 in all ponds in year 2. Note that this is not directly proportional to stocking density but a refuge density of more than 0.30 refuges/m^2 may inhibit water circulation. Furthermore, this differs from the refuge provision trial described by George Cassells and colleagues in this volume. Their trial involves two refuge densities and a constant marron stocking density. In our trial, refuge density is merely increased as stocking density was increased. (Note that their work showed that use of 0.30 refuges/m^2 in commercial ponds was not harmful.)

Water quality monitoring involved continuous data logger monitoring of water temperature in two ponds, with maximum/minimum thermometers as a backup, and at weekly monitoring of each pond for dissolved oxygen, and pH. Total ammonia, total dissolved nitrogen and reactive phosphorus were measured just prior to harvest in year 2.

Exclusion of predators and prevention of migration of marron from the ponds were aided by security fencing and movement sensors, elevated bird exclusion netting, pond complex and individual pond perimeter electrified wire line and mesh fencing, and wire mesh fencing across channels (see O'Sullivan et al., 1994). Tadpoles were trapped from the ponds during the first two months of year 1 (Parker, 1998) but were not abundant in the phase of year 2.

Harvesting and postharvest handling

Ponds were harvested after 12 months and 24 months by drain harvesting, during early morning hours, to follow commercial practice rather than the more frequent harvesting, for estimating biomass, often used in research trials (see Morrissy, 1992). The standpipe in the concrete sump in each pond is removed after installing an outlet screen within the sump (see attached Powerpoint presentation). The sump in each pond is cleared of sediment and organic debris as the pond drains and a continuous flow of water is maintained through the sump so that as marron move into the sump or are transferred by hand, gill washing effectively occurs within the pond.

The marron are gently collected by hand from the sump and transferred in mesh baskets to be rinsed. Once marron were removed from the pond they were held in clean, diverted river water not recycled discharge. For the year 1 harvest they were transferred to shaded, outdoor circular, aerated holding tanks. Ice was added to the outdoor holding tanks as needed. Later, individual trays were held out of water in a fine spray, the marron sexed and weighed before being stockpiled in submerged porous mesh baskets with a constant water flow until transfer to indoor, aerated, holding tanks serviced by a refrigeration unit. Water recirculated through these tanks and the submerged porous mesh baskets. For the year 2 harvest, marron were directly moved to the indoor, aerated, holding tanks after initial rinsing. Each day some water was exchanged and every 1-3 days, as needed, the holding system was drained, superficially cleaned and refilled.

During construction the ponds were stabilised with about a 75 mm layer of shale although there was considerable variability among ponds for this attribute. Prior to refilling after harvest, organic buildup on the pond walls was "washed down" into the sump, and out to the settlement pond via the pond outlet and discharge channels. Ponds were allowed to "dry" for a minimum of 4 hours before being refilled overnight with water from the reed pond.

After year 1, marron were sexed and weighed twice, firstly to determine size distribution and then to allow allotment of marron to the appropriate size of sex graded treatments (Figure 1). After two years, marron were either sold as broodstock (approximately upper 25% of males and upper 75% of females, retained as broodstock to continue the Pemberton line (ungraded to maintain neutral selection for size) or restocked in single sex ponds for proposed sale to a processor in May 2004.

Experimental treatments

The design for the trial is shown diagrammatically in Figure 1. The precise stocking density in year 2 depended on overall survival rate in the low density ponds, taking into account the marron needed to stock two ponds with ungraded marron in year 2, i.e. two additional ponds were used for year 2. That density was 3.1 per m^2, comprising a 30:1 ratio of hard and soft (postmoult) marron. The ungraded group was derived by mixing the two size grades from low density ponds after harvesting at the end of year 1. This reduced the chance of bias through less handling of the ungraded group (see Karplus et al., 1987). Low density ponds were processed as a block of 4 (there were 3 blocks of 4 ponds) and restocked. The two additional ponds were restocked from marron drawn from all of these 3 blocks of ponds. High density ponds were processed and restocked in blocks of 2 (3 blocks of 2).

The initial size distribution of marron, sampled during harvesting from the two nursery ponds, is given in the attached Powerpoint presentation. Average initial sizes of juveniles from the two ponds were 0.28 ± 0.12 (SD, n=100 marron) and 0.27 ± 0.08 (SD, n=100 marron). The year 2 stocking sizes are indicated in the attached Powerpoint presentation and differed depending on grading strategy for year 2.

Statistical analyses

Most data are analysed by Analysis of Variance with prior testing for normality and homogeneity of variance and block effects. Where appropriate, covariates such as pond size, survival rate or density at harvest, feed input (within a treatment), initial size for year 2 stocking, presence of 0+ juveniles (from any reproduction within the ponds in year 2), and water exchange rate will be used for final scientific publications.

2.3.3 Results

These are shown in the following powerpoint presentation.

2.3.4 Acknowledgments

The authors wish to thank D. Barnesby, T. Cabassi, P. Cavalli, C. Church, M. Dearden, D. Evans, B. Hendricks, G. Liddy, S. Clarke, N. Goldberg, L. McQuillan, N. Rutherford, and S. Yung and the 2000 Certificate III in aquaculture class of the Manjimup Campus, South West College of TAFE for their technical assistance. Financial assistance in establishing the 20 experimental ponds was provided by the Department of Fisheries, Commonwealth Regional assistance Program (RAP) and the South West Development Commission with excellent facilitation by J. Collingridge (Western Australian Department of Training and Employment). All assistance is very gratefully acknowledged.

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Figure 1. Design for the 2 year pond management trial with small juvenile marron at Thomson's Flat in 150 m^2 ponds. (Note that individual marron from 12 ponds in year 1 are redistributed to 14 ponds in year 2.)

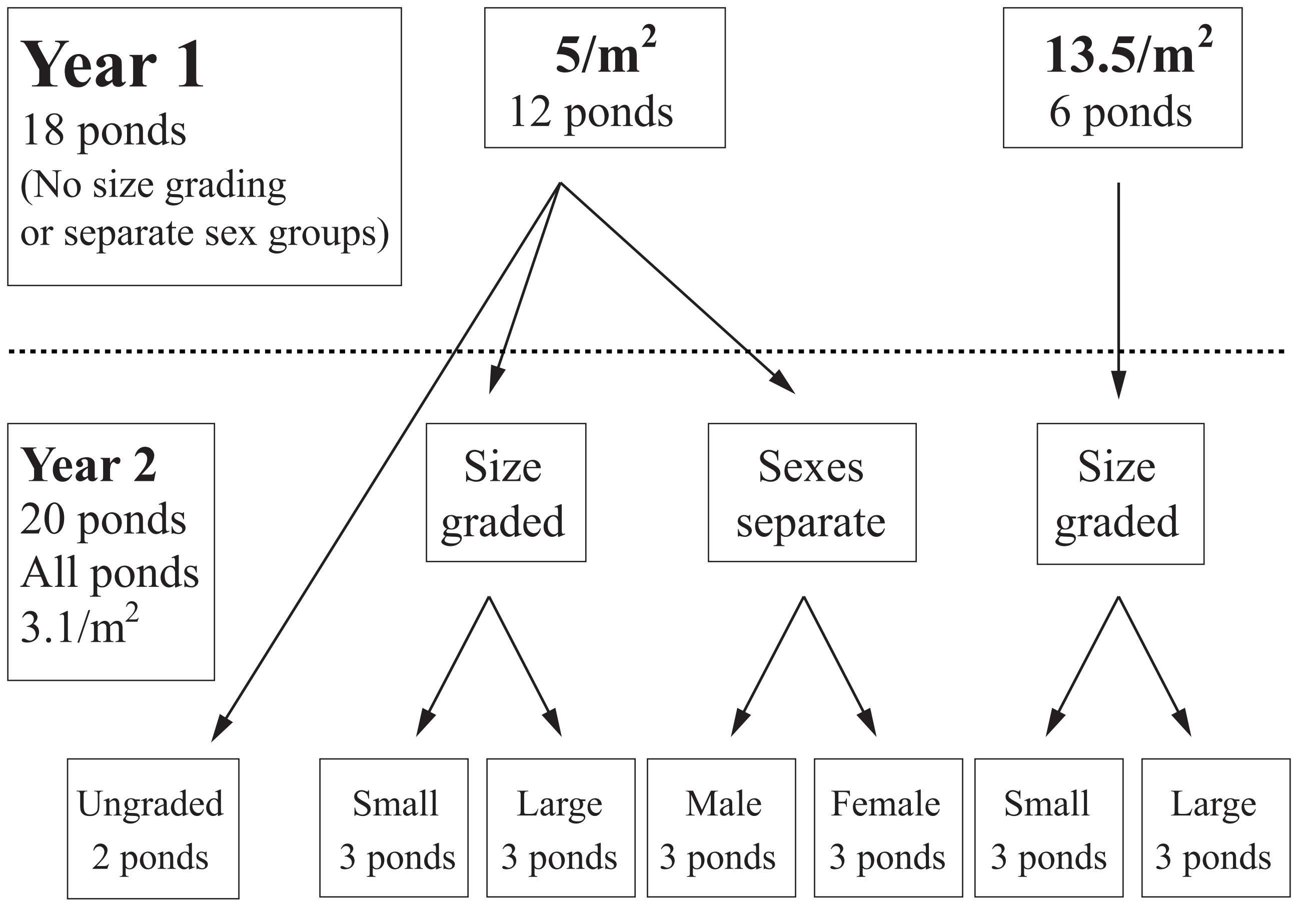
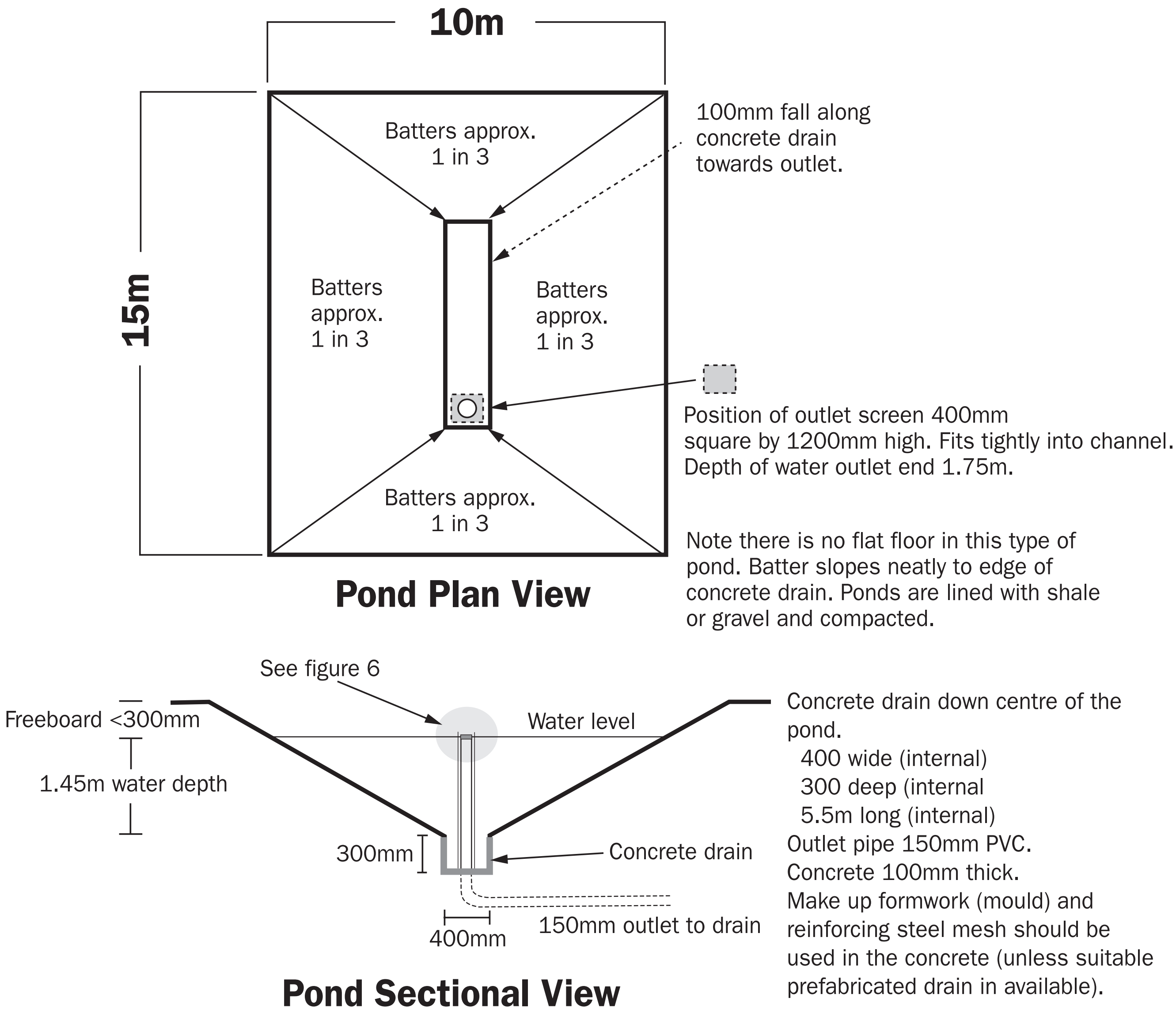


Figure 2. Experimental multi-purpose pond design (10m x 15m at water surface level) not to scale.



Not recommended as commercial growout ponds

Effects of stocking density (year 1) and grading strategy (year 2) on performance of marron in ponds stocked in summer – a report after year 2

Greg B. Maguire, George Cassells, Tony Church, John Heine and Craig S. Lawrence

Department of Fisheries
Government of Western Australia

Fish for the future

Fish for the future

Fish for the future

Typical marron farming cycle

- Juveniles leave females in early January (summer).
- At about 6 months old, these are harvested and stocked into grow-out ponds (winter; cool/larger).
- At 18 months old, these are drain harvested (winter); some are sold as table marron.
- The rest are restocked & grown to say 30 months old (winter) and then sold as table marron.

Fish for the future

Why change this?

- If every farmer does this, most stock are produced in cooler months.
- Need continuity of marketing for a major industry.
- Hide harvesting or trapping are OK for a cottage industry
- Alternative: stock and harvest in warmer months as well (we grew all stock for 2 years)

Fish for the future

Potential Problems/Solutions

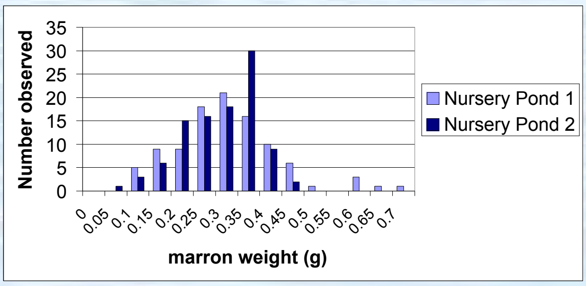
- Heat stress during stocking/harvest – **harvest when there are few moults & keep marron wet**
- High mortality of tiny juveniles at high density – **collect efficiently and use intensive management**
- Marron ponds yield huge variation in size within each pond – **try size/sex grading at year 1 (or is it just genetic?)**

Fish for the future

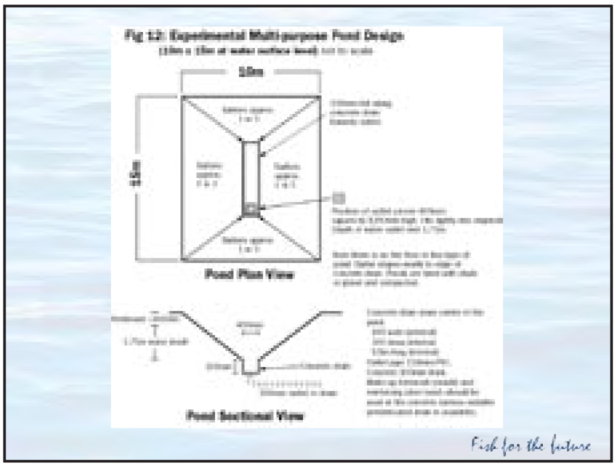
Can a 2 year stocking, drain harvest, restocking and final drain harvest cycle all be carried out in summer?

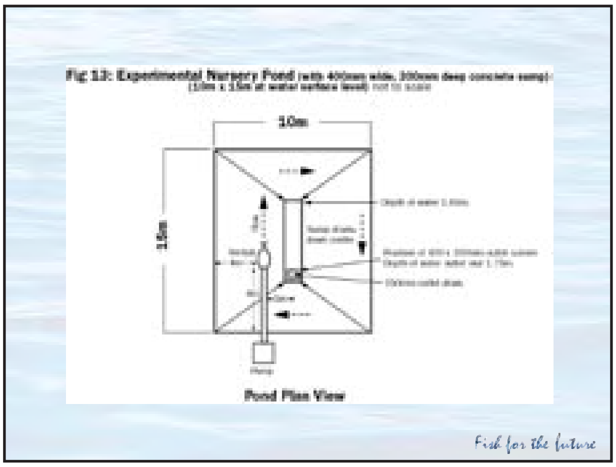
Need good survival at final harvest and during post harvest handling – **we kept harvesting plus initial restocking mortality below 3% at end of Year 1**

Fish for the future



Fish for the future

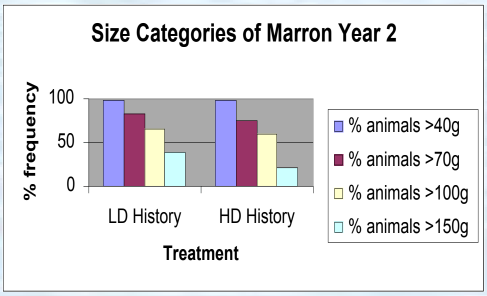




Can most of the small 0+ juveniles stocked (at about 0.3 g/marron) reach commercial size in two years?

Depends on market size sought

Fish for the future



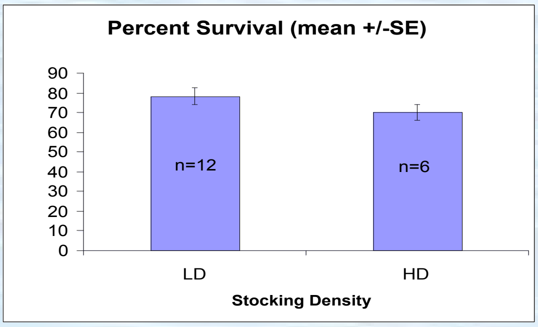
Proposed value of different size grades

- **<40 g ($0/kg, i.e. unsaleable)**
- **40-70 g ($8/kg, i.e. based on equivalent value of yabbies)**
- **70-100 g ($17/kg)**
- **100-150 g ($20/kg)**
- **150-250 g ($23/kg)**
- **>250 g ($26/kg) – Comments in Q&A today**

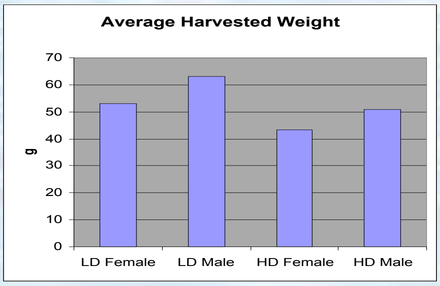
For 2 year production cycles, should year 1 be run at a high density (HD = 13.5 juveniles/m^2) instead of a low density (LD = 5.0/m^2), followed by a low density (about 3.1/m^2) in year 2?

We used more feed, hides and aeration for high density ponds in Year 1

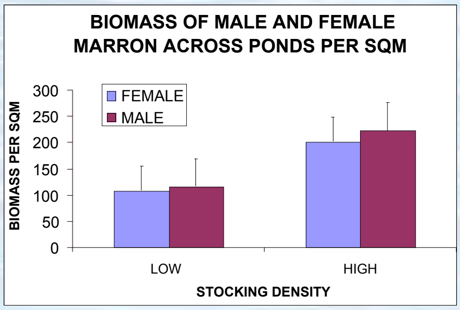
Survival after 12 months



Average weight (g) after 12 months (SE = 0.9- 1.1; n = 6-12 ponds)



Harvest weight (biomass as g/square metre) after 12 months



Can farmers do better?

Should do better

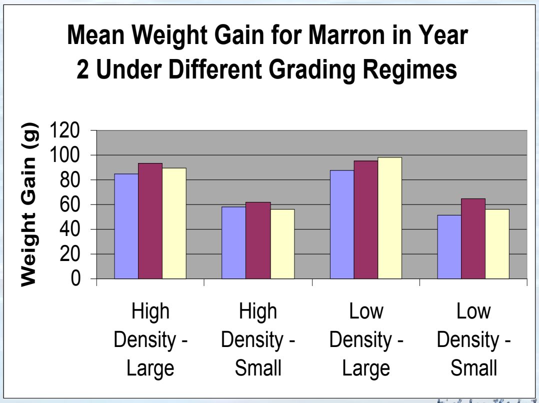
- We stored and restocked 3% of animals as soft marron into each pond for year 2
- A farmer should just move soft marron from harvested pond into a spares pond i.e. no holding in trays in the shed (thus reducing initial restocking mortality)
- Overall growth and survival rates are much better than for most farms especially given use of summer juveniles and new ponds here

Why did it all work so well?

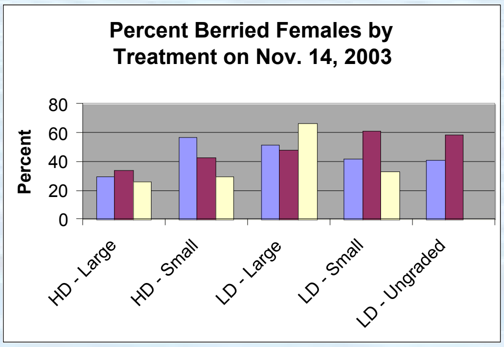
- Predator protection (birds/water rats/fish)
- Efficient demand feeding / commercial marron feed
- Aeration
- Water exchange as needed
- Silage in new ponds
- Daily observation of well designed ponds
- Careful live handling when stocking or harvesting (keep marron wet/in clean water)
- Good genetic line

Fish for the future

How did the two density groups perform when moved to a low density in year 2? –
In year 2 they grew at very similar rates on a g increase /marron basis
(individual replicate ponds shown)

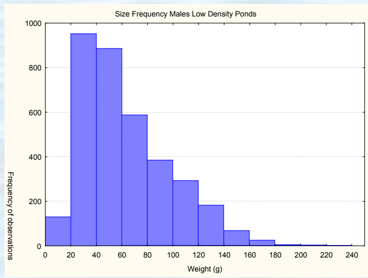


Was the percentage of females that berried in year 2 affected by the pond management strategy? –
There is a trend for females held in year 1 at a high density to be have a lower berry up rate in November year 2
(individual replicate ponds shown)

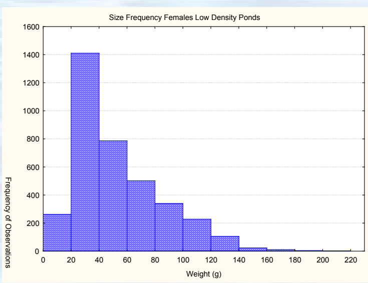


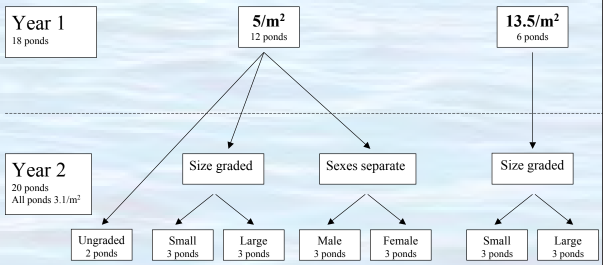
For year 2, after harvesting of all stock at the end of year 1, should marron be restocked without any grading, or as two size grades or as two sex groups?

Size variation of males from low density ponds after Year 1

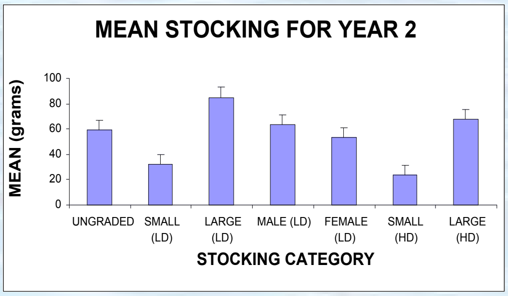


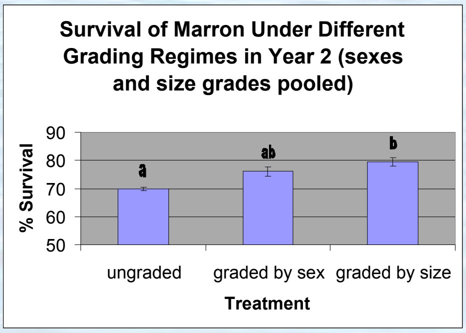
Size frequency of females harvested from Low Density ponds after 1 year

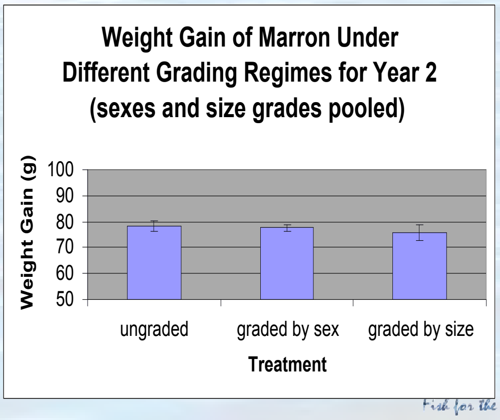


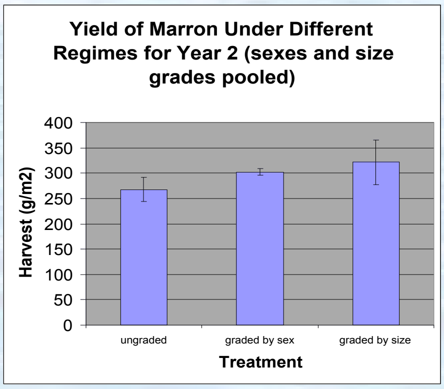


Average size when restocked



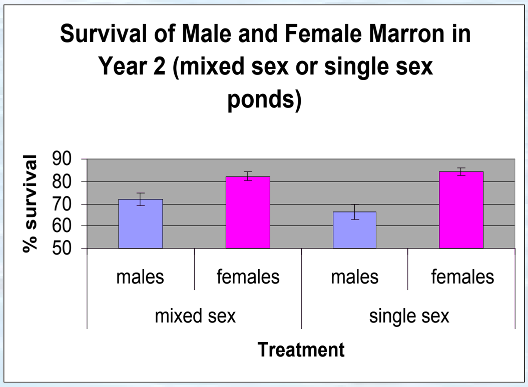






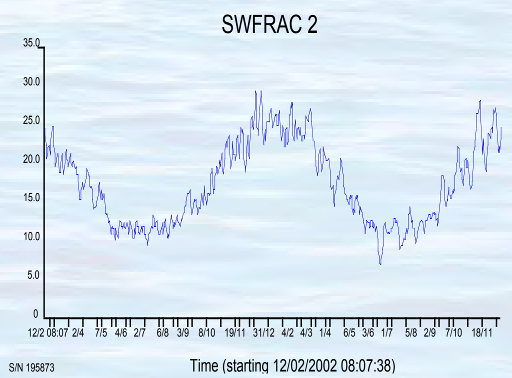
Do both sexes have similar survival rates?

No



Did Year 2 go well?

- **Lower water temperatures in Year 2**
- **Perhaps 25 months from leaving female is not long enough to get all to >70 g (with winter stocking final harvest may be 30 months from leaving female)**
- **Water quality good (oxygen high, ammonia and soluble nutrients low but organic load in ponds)**
- **Only a few hours drying of ponds after harvest**



How much biomass was produced per year?

- Have to take into account space used in year 2 and space used in year 1 producing enough 1+ marron to stock that space
- **2.43 tonnes/ha/year for high density in year 1 then grown in size grades in year 2**
- **1.61 tonnes/ha/year for low density year 1 then grown in size grades in year 2**
- **Virtually no soft marron in year 2 harvest – good for handling**

What proportion of females berried in year 2?

- **44% of females in mixed sex ponds, sampled by hide harvesting, were berried in November 2003 (age 21 months)**

Summary

- Economic analyses yet to be done (prices?)
- Summer stocking/harvesting cycle looks promising but year 2 survival a little low
- Use of high density in year 1 looks very promising but number in 40-70g of concern
- No strong advantage of grading by size or sex for year 2 except for survival

Summary

- Need to investigate lower survival of males
- Sustainability - **Carried out 2 year trial using only recycled trout/marron pond discharge after passing through settlement and reed ponds**
- **FCR very good for Year 1 with grains-based pellets (1.5:1)**
- **Can prevent escape of stock and exclude predators**
- Don't give up on marron farming – moving away from a cottage industry/genetic improvement!

Any Questions?

3.0 Improved performance of marron using pond management strategies

The effect of size grading of juveniles and increased hides upon marron (Cherax tenuimanus) production in commercial ponds

George Cassells, Craig Lawrence, Sandy Seidel and Chris Bird
Department of Fisheries – Research Division, PO Box 20, North Beach 6920 Western Australia

This talk complements one by Dr Phil Vercoe, in this volume, who covers some of the genetic components of FRDC Project 2000/215 Improved performance of marron using genetic and pond management strategies.

Growth and size variation is a major concern to marron farmers as a significant proportion of the crop can be below market size at harvest. This study investigated two strategies to address size variation in marron ponds; size grading of juveniles prior to stocking to remove smaller individuals, and increasing the amount of shelter to decrease competition. The best way to achieve this was by conducting large-scale experiments using commercial size ponds on marron farms.

On a commercial farm, six ponds were stocked with either graded (largest 50% of cohort) or ungraded juveniles. At two years of age the mean weight of marron from graded ponds (171 ± 1.43 g) was significantly larger than those stocked with ungraded juveniles (152 ± 2.05 g) ($P = 0.006$). The proportion of below market size marron (< 70 g) in graded ponds (4.63 ± 0.65 %) was less than in ungraded ponds (11.01 ± 1.97 %). Production in the ponds ranged from 1.5 – 2.8 t/ha (mean = 2.2 t/ha). This study complements very recent results, presented in this volume, from a project led by Dr Greg Maguire, which show that size grading of summer juveniles (upper and lower 50% of stock) did not produce very different results than a comparable ungraded group.

In the hide experiment six ponds on a commercial farm were stocked with juvenile marron. Three ponds contained hides at the standard density (0.15 hides/m^2), while three ponds contained twice the number of hides (0.30 hides/m^2). There was no significant difference between the mean weight of marron in 0.15 hides/m^2 ponds (116 ± 5.29 g) and 0.30 hides/m^2 ponds (124 ± 4.31 g) ($P = 0.29$). Production in the six ponds ranged from 2.5 – 3.3 t/ha (mean = 2.9 t/ha). In another paper in this volume (Maguire 2004), it is apparent that the cost of providing hides for marron ponds is quite significant.

KEYWORDS – marron, *Cherax tenuimanus*, hides, size grading.

The effect of size grading of juveniles and increased hides upon marron (*Cherax tenuimanus*) production in commercial ponds

Dr Craig Lawrence, George Cassells, Sandy Seidel and Chris Bird

Department of Fisheries WA, Research Division, PO Box 20, North Beach 6920

Examples of very well constructed marron farms and harvesting strategies on Kangaroo Is (South Australia) and at Denmark, WA (used in other trials within the FRDC marron project- 2000/215)

Well designed family farm (Wilson's) at Mt Barker, WA (used for the increased hides trial)

Trailer for initial cleaning and gill flushing of marron prior to transport to on-farm processing shed

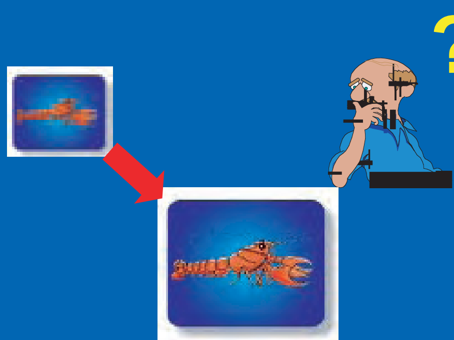
Very clean marron from holding trailer

Shows cleaning of pond after harvest to remove organic matter (initial hosing of sediment can be used prior to use of sprinklers if pond is heavily fouled)

Why Marron ?

- Large size
- High market value
- High global demand
- Little competition
- Disease status
- Simple lifecycle
- Relatively easy to farm
- Farming techniques well established

The Problem



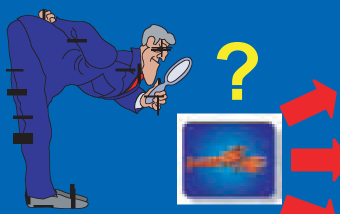
Objectives

- Increase growth rates
- Decrease size variation

25 g → 250 g

Size Variation

The Solution



Genetics

Feeding

Management

Management practices that might influence size variation

- Size grading of juveniles prior to stocking growout ponds

- Using more hides in growout ponds

Graded Juveniles

Does grading juveniles before stocking =

- **Bigger marron ?**
- **Decreased size variation ?**

Graded Juveniles

- **Commercial farm**

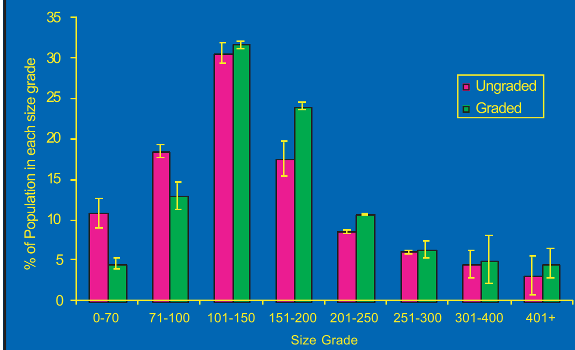
  10 710 juvenile marron stocked

  - 3 ponds stocked with ungraded juveniles
  - 3 ponds stocked with graded juveniles (largest 50%)

Mean weight, survival, yield and proportion of marron larger than 70 g from six commercial ponds at Pemberton stocked with either ungraded or graded juveniles.

	Ungraded	se	Graded	se	P
Mean Weight (g)	**152**	2.05	**171**	1.43	0.007
Survival (%)	**77**	4.33	**74**	1.64	0.65
Yield (t/ha)	**2.23**	0.39	**2.16**	0.00	0.89
Marron >70g (%)	**89**	1.97	**95**	0.65	0.07

Graded Juveniles

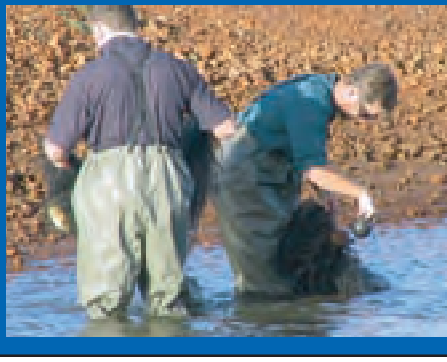


Hides

Do more hides =

- **Improved growth ?**
- **Increased survival ?**
- **Decreased size variation ?**

Increased hides



Increased hides

Increased hides

- Commercial farm
  - 15 724 juvenile marron stocked
    - 3 ponds 150 hides/1000m^2 pond
    - 3 ponds 300 hides/1000m^2 pond

Mean weight, survival, yield and proportion of marron larger than 70 g from six commercial ponds at Mt Barker with either hides at 0.15/m^2 or double hides at 0.30/m^2.

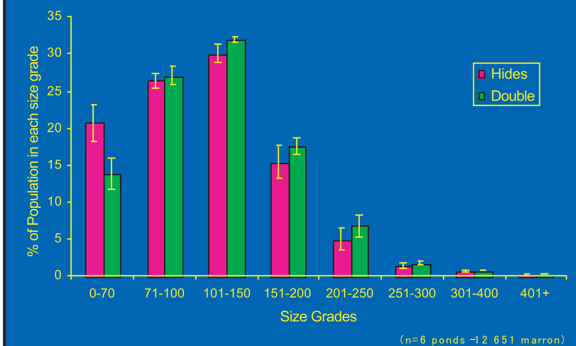
	Hides 0.15/m^2	se	Double hides 0.30/m^2	se	P
Mean Weight (g)	**116**	5.29	**124**	4.31	0.29
Survival (%)	**84**	3.41	**78**	4.14	0.33
Yield (t/ha)	**2.88**	0.21	**2.91**	0.24	0.94
Marron >70g (%)	**79**	2.41	**86**	2.08	0.097

Marron Size Variation

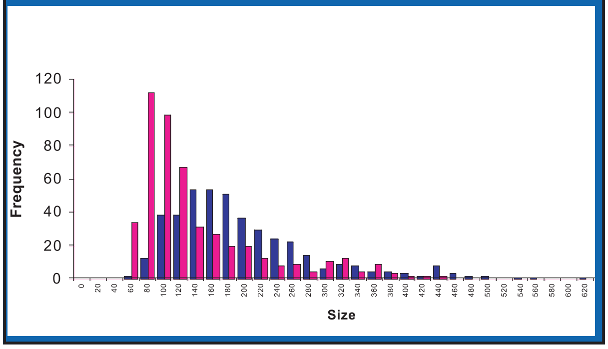
Hides = 28g – 485g

Double Hides = 36g – 503g

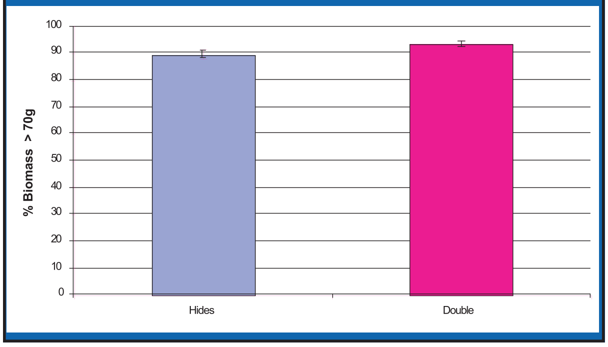
Marron Size Variation



Size of Females & Males



Hides Biomass > 70 g



Economics of Increased Hides

	Hides 0.15/m²	se	Double hides 0.30/m²	se	P
Return ($A/ha)	**61152**	6164	**63877**	6286	0.77
Cost of additional hides ($5/hide)	**0**		**7500**		
Net return/crop	**61152**		**56377**		
Payback period			**3 crops**		

Acknowledgments

- This research was funded by FRDC Project 2000/215.
- The assistance of participating farmers (Wilson and Omodei families) is gratefully acknowledged.

4.0 A preliminary analysis of profitability of marron farming within an existing farming property

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Department of Fisheries, Research Division, PO Box 20, North Beach, WA 6920

Caveat

These estimates have been developed for a convenient marron farming site. All potential marron farming locations will have their own site-specific costs. Potential farmers cannot simply apply these costs to their own situation. The presentation is given on a commercial MarronProfit Excel package which allows farmers to enter their own design strategies and costs. The capital costs that we have used strongly reflect the considerable experience that George Cassells has accumulated in reviewing the problems with under performing farms. As such this paper strongly asserts some of the Department's key extension messages to marron farmers.

4.1 Background

At last year's workshop Cassells, Maguire and Lawrence (2003) presented a paper on the capital costs for a marron farm. This was presented using Excel software "MarronProfit" developed on a contract basis by Bill Johnston of Queensland Dept of Primary Industries and Dan Machin of the Department of Fisheries, WA. This Pearling and Aquaculture Program initiative led to farmers being able to purchase the package. The above authors (Cassells et al.) provided the estimates of physical resources needed and the capital costs and these have been updated for today's presentation. Cassells and Maguire developed a set of operating costs and farm outputs that were inserted into MarronProfit by Dan Machin and these are presented as well today. (Craig Lawrence has been developing separate profitability estimates based on the high rate of genetic improvement that could be expected to result from the FRDC project work described by Vercoe and Lawrence in this volume.) Dr Lawrence's estimates are not included in today's paper but it is hoped that an integrated publication will be prepared in the future.

All models depend heavily on the assumptions made. These have been provided in considerable detail although subsequent publications may be more detailed. In general, the model is based on farmers constructing much of the infrastructure themselves but not major items such as earthworks, although some farmers can make substantial savings by doing their own earthworks provided the quality of construction is high. Examples of "own labour" include making refuges, establishing electric fencing and erecting bird netting, with some initial specialist help on this last item.

MarronProfit

Physical Description

Growout Parameters

Juvenile Stocking

Brood / Nursery Feeds

Process and Pack

Market and Freight

Labour

Additional Operating

Capital Expenditure

Revenue

A Decision Tool created by

Bill Johnston

Dan Machin

Production Summary

Summary Statistics

Graphs

Glossary

Queensland Government
Department of Primary Industries

Department of Fisheries
Government of Western Australia

Fish for the future

June 2003

4.2 Physical property description

The relative number of broodstock, nursery and growout ponds is in accord with that proposed by Cassells et al. (in prep). It allows for spare broodstock and yearling ponds to be available for holding modest numbers of marron not yet ready for sale on a size or moult cycle (soft marron) basis or market demand basis.

Physical Property Description

General Description

Total farm area	11.5	hectares
Area for growout ponds	6.02	hectares
Area for juvenile and broodstock ponds	0.62	hectares
Area for settlement/reed ponds	0.43	hectares
Area available for infrastructure	4.44	hectares

Growout Pond Dimensions and Requirements (at water level)

Freeboard	0.5	metres
Internal pond wall slope ratio	3	to 1

	Settlement	Reed / Bio	Growout	Broodstock	Juvenile	
Number of ponds	1	1	50	7	7	
Length of ponds	35.00	50.00	40.00	25.00	12.50	metres at water level
Width of ponds	35.00	50.00	25.00	20.00	12.50	metres at water level
Depth of ponds	3.00	1.50	1.50	1.60	0.80	metres
Pond surface area	0.12	0.25	0.10	0.05	0.02	hectares at water level
Pond volume	3.68	3.75	1.50	0.80	0.13	megalitres
Ponded area	1,225	2,500	50,000	3,500	1,094	square metres at water level
Area required for ponds	1,444	2,809	60,200	4,508	1,682	square metres

4.3 Growout parameters

The production cycle is largely based on winter stocking with a 2 year cycle in the growout ponds (after the nursery pond phase) involving half of stock being marketable after one year and the rest during the second year. Note that no marron are sold below 70 g from the growout ponds. A production goal of 2.2 tonnes/ha/year has been set. It is assumed that the farm produces its own juveniles and spares are sold for the very low figure of 10 cents each. However, we consider that this reflects actual cost of production, plus a profit margin, for juveniles from 2+ females (i.e. in their third year since leaving the own "mothers"). Culls refer to small marron considered too small or of insufficient quality to carry through to year 2 in the growout ponds (these are a minor consideration).

Growout Parameters

Total Production

Length of production	12.0	months
Pond dry-out period	0.0	months
Lead time to first stocking	18.0	months
Breeding and husbandry improvement	2.5%	

Saleable Product ONLY! (Do not include culls)	kg	numbers
Less than 40 grams	0	0
40 to 70 grams	0	0
71 to 100 grams	5,214	61,341
101 to 150 grams	4,168	33,344
151 to 200 grams	524	2,994
201 to 250 grams	678	3,013
251 to 300 grams	416	1,513
301 to 400 grams	0	0
400 grams plus	0	0
Total base production	11,000	102,206

Production rate	2,200	kg per hectare
Average weight of marron	107.63	grams
Weight of cull per annum	50	kg

Additional Sales

Juvenile

Number of unsaleable juvenile marron to be sold	35,000
Expected price for sale of juvenile marron	$0.10
Revenue from juvenile sales	$3,500

Culls

Kilograms of culls	50
Expected price	$0.00
Revenue from cull sales	$0

4.4 Juvenile stocking or production

This model assumes that you produce all of your own juveniles even though a price of 35 cents each for juvenile purchases is shown (along with a total cost of zero as none are purchased.) The on-farm juvenile rearing involves both stock from broodstock ponds and juveniles from the nursery ponds. Our interpretation is that the estimated cost per juvenile of 3.67 cents each excludes labour (and profit). The broodstock and juvenile feeds section assumes that broodstock are fed with marron pellets and juveniles with a higher protein (and costlier) small trout pellet. (We do consider that further research is needed to see if a more sophisticated diet should be used for broodstock.)

Juvenile Stocking or Production

Please choose either to purchase juveniles for stocking, or on-farm production using juvenile production ponds. — On-farm juvenile production — **This only includes nursery ponds**

Stock Requirement

Number of juveniles required per crop	136,500	

Juvenile purchase

Juvenile price	$0.35	per juvenile
Total cost of juveniles	$0	

On-farm Juvenile Rearing

Pond surface area	0.02	hectares
Number of ponds allocated	7	
Length of juvenile phase	6	months
Advanced juveniles per broodstock female	105	
Females required	1,300	
Broodstock ratio for spawning (females : males)	1	
Males required	1,300	
Mean weight of juveniles at harvest	2	grams
Mean weight of broodstock	200	grams
Estimated cost per juvenile produced	$0.0367	

The stocking of marron in broodstock ponds is industry best practice at 1:1, but in juvenile production the female to male ratio is 3:1. For the purpose of feed calculation use the 1:1 ratio.

Broodstock and Juvenile Feeds

	FCR	% of diet	$ per kg	Feed (kg)
Marron pellet	1.40	33%	$0.70	854
Juvenile feed A	1.40	67%	$1.75	256
Juvenile feed B	0.00	0%	$0.00	0
Juvenile feed C	0.00	0%	$0.00	0

Input data for combined broodstock and nursery ponds

Total cost of nursery feed	$1,046

4.5 Farm production summary

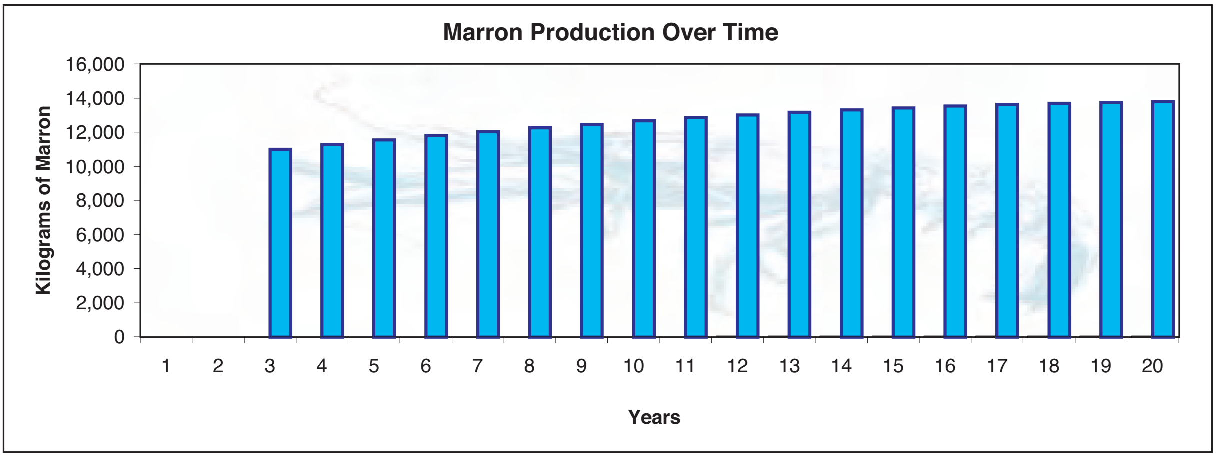
Over a 20 year cycle production per year progressively increases. This is based on a small progressive improvement (2.5% gain in production per year) being achieved in the gene pool by on-farm mass selection (complemented by periodic exchange of broodstock by cooperating farmers).

Please note that if farmers get to adopt the genetically improved stock arising from the FRDC project and its subsequent commercialisation (see paper by Vercoe and Lawrence in this volume), much better genetic gains should be achieved. This would involve the additional cost of purchasing genetically improved stock e.g. as juveniles for subsequent growth through to broodstock. Depending on the cost of this stock, we anticipate that this strategy will be more profitable than shown in our model.

Farm Production Summary

Average Production 10,471 kg

Years	Tonnes per Hectare	Annual Production
1	0	0
2	0	0
3	2,200	11,000
4	2,255	11,275
5	2,308	11,538
6	2,358	11,788
7	2,405	12,025
8	2,450	12,249
9	2,492	12,459
10	2,531	12,656
11	2,568	12,838
12	2,601	13,006
13	2,632	13,159
14	2,659	13,296
15	2,684	13,418
16	2,705	13,523
17	2,722	13,612
18	2,737	13,684
19	2,748	13,739
20	2,755	13,776



4.6 Growout feeds

This analysis assumes that only marron pellets are used in growout ponds and that a Food Conversion Ratio (FCR) of 1.8:1 (i.e. a total of 1.8 kg of dry feed being used to produce 1 kg of wet marron) is used). This is challenging and requires good survival, particularly in year 2. It is likely that as genetic improvement occurs, FCR will improve although this has not been built into this model.

Growout Feeds

	FCR	% of Diet	Feed Cost ($/kg)
Marron pellet	1.80	100%	$0.70
Growout feed B	0.00	0%	$0.00
Growout feed C	0.00	0%	$0.00
Growout feed D	0.00	0%	$0.00

Average annual cost of growout feed	$13,194	Excludes broodstock and nursery feeds!

4.7 Processing and packaging

These are relatively minor costs.

Processing and Packaging

Packaging breakdown

	% of Product
2 kg box	1%
5 kg box	1%
10 kg box	98%

Packaging

Item	Kg of marron per box	Cost per item	Items per box	No of uses	Total cost
Styrofoam box - 2 kg	1.8	$1.75	na	10	$0.18
Styrofoam box - 5 kg	4.6	$2.60	na	10	$0.26
Styrofoam box - 10 kg	9.0	$3.50	na	10	$0.35
Foam liner	na	$0.10	2	10	$0.02
Ice pack	na	$2.00	1	10	$0.20
Label or logo					$0.05

Summary

	Number required - P1	$ per kg	Cost per box
2 kg box	58	$0.25	$0.45
5 kg box	23	$0.12	$0.53
10 kg box	1,140	$0.07	$0.62

4.8 Market and freight costs

It is assumed that the farmer delivers product to the outlet or transport depot and as such these costs are absorbed elsewhere in the model. While the authors are strong supporters of marketing cooperatives, we deemed it to be inappropriate to impose this condition in the model and as such the promotional levy is zero. This is not a comment on whether we see such levies as appropriate.

Market and Freight Costs

Freight cost - styrofoam pack	**$0.00**	**per kilogram**
Freight cost - styrofoam pack - return from market	**$0.00**	**per kilogram**
Market floor commission	**0.00%**	
Agents commission	**0.00%**	
Promotional levy	**$0.00**	**per kilogram**

Year	Freight	Levy/Comm	Totals
1	$0	$0	$0
2	$0	$0	$0
3	$0	$0	$0
4	$0	$0	$0
5	$0	$0	$0
6	$0	$0	$0
7	$0	$0	$0
8	$0	$0	$0
9	$0	$0	$0
10	$0	$0	$0
11	$0	$0	$0
12	$0	$0	$0
13	$0	$0	$0
14	$0	$0	$0
15	$0	$0	$0
16	$0	$0	$0
17	$0	$0	$0
18	$0	$0	$0
19	$0	$0	$0
20	$0	$0	$0

4.9 Labour requirements

This seems lean but it involves the farmer paying himself/herself a part time wage as manager in addition to receiving a profit from the farm. Some casual assistance is provided for harvesting. It should be remembered that this is based on farm diversification rather than a stand alone, fulltime marron farm. MarronProfit is designed for farmers to put in their own estimates so this is definitely a section that farmers need to customise. Some farmers may choose to operate the farm as a couple and rely on the profits rather than "drawing a wage" as well.

Labour Requirements

On-costs	**% of weekly wage**		
Workers compensation	1.50%		
Superannuation contribution	8.00%		
Leave loading	17.50%	**percent of 4 weeks wages**	
Training	0.00%		
Casual employees			
Hours of casual employment	400		
Pay per hour	$14.00		
Annual expense	$5,600		
Salaried Employees	**Skilled Staff**	**Labourer**	**Manager**
Number of employees	0	0	
Weekly salary	$0	$0	$375
Annual expense	$0	$0	$24,765

4.10 Additional operating expenses

These are comprehensive but are, individually, more minor costs e.g. electricity (for the shed, aerators and for water reuse by pumping from the reed pond) contributes 56 cents/kg to the cost of production.

Additional Operating Expenses

Fuel and oil	$1,200	Water supply or pumping licences	$0
Repairs and maintenance	$1,500	Aquaculture licences and permits	$275
Electricity	$5,842	Salt (medicinal)	$0
Accounting and legal	$1,000	Chemicals (cleaning)	$50
Administrative expenses	$4,500	Chemicals (medicinal)	$0
Phone (domestic and mobile)	$500	Miscellaneous items	
Travel (related to business)	$1,000	Security	$500
Vehicle registrations	$200	Memberships	$100
Vehicle insurance	$275		$0
Other insurances	$2,500		$0
Council rates	$0		$0

4.11 Assumptions for capital costs

Please note that some revision has occurred for the year of purchase, Life (years) and Salvage value compared to Cassells et al. (2003).

4.11.1 Cost of servicing capital investment

No estimate is provided here.

4.11.2 Land and buildings

It is assumed that the farmer owns an existing farm and does not need to purchase property. The land already has a large general-purpose shed, a small workshop, and an office and has electricity connection with a capacity sufficient to allow development of the marron farm.

4.11.3 Purging and processing facility

These are relatively minor costs and allow for marron to be held live within the shed so that they are purged prior to being driven to point of sale. The cool room allows for live storage of product overnight after packing into foam boxes. The amount for tanks has been reduced but blower and aeration costs have been increased.

4.11.4 Vehicles and machinery

It is assumed that the farm has a utility but that 50% of the cost can be attributed to the marron farm. The cost has been increased to $15,000. A 4WD motorbike and trailer are purchased for the marron farm. There is an existing tractor with a blade, bucket and mower/slasher (not attributed to marron farm).

4.11.5 Ponds

Growout pond construction is the major cost for the whole farm although plumbing and electricity infrastructure costs are also significant. Some farmers have not built specialised broodstock and nursery ponds but these are in fact only about 5% of total capital costs. The alternative of just using growout ponds for these purposes may lead to lower production of juveniles and inefficient use of growout pond facilities. The other alternative is to just buy juveniles but this can be very expensive and not allow the farmer much control over quality of stock. The major change has been to impute no salvage value for the ponds in case the farmer moves out of marron farming.

Farmers often ignore the next 5 items in this category but they can be crucial to obtaining high survival and/or growth rates. Venturi aerators are needed for nursery ponds and the estimate is generous as it includes spares for miscellaneous purposes e.g. within holding tanks. Paddlewheel aerators, in combination with electricity connection costs (above), are significant but greatly reduce the risk of a crop failure. Using a very low stocking density or low feed inputs to avoid the need for aeration is a poor choice because the key cost of marron farming is the high capital cost and good survival and growth rates at a reasonable density are crucial for profitability.

Similarly, the cost of refuges is high but farm survey work (Maguire et al., 2002) clearly shows that provision of refuges can reduce size variation and increase profitability. Similarly, some farms have suffered heavy losses from water rats yet the materials-only cost of electric fences to exclude

Capital Cost of Marron Farm

Project Length (Years) 20

Capital Item	No. of items	Cost of items ($)	Total cost ($)	Year of purchase	Life (years)	Salvage value (%)
Land and Buildings						
Land	-	$0	$0	0	20	120%
Storage sheds	0	$0	$0	0	20	40%
Workshop	0	$0	$0	0	20	40%
Office	0	$0	$0	0	20	40%
Electricity connection to property/ponds	-	$0	$0	0	20	100%
Purging and Processing Facility						
Tanks	4	$500	$2,000	2	10	10%
Blower and aeration equipment	1	$1,000	$1,000	2	10	10%
Chiller or freezer	1	$750	$750	2	15	20%
Cold room (post processing)	1	$6,000	$6,000	2	18	20%
Scales	1	$500	$500	2	5	0%
Sort table	2	$350	$700	2	18	0%
False tank bottoms	4	$250	$1,000	2	5	0%
Pumps	2	$250	$500	2	5	0%
Vehicles and Machinery						
Utes	1	$15,000	$15,000	0	10	20%
Motorbikes / four wheelers	1	$7,000	$7,000	0	10	20%
Tractor / bobcat	0	$0	$0	0	15	10%
Bucket and blade	0	$0	$0	0	15	10%
Trailer	1	$600	$600	0	10	0%
Mower / slasher	0	$0	$0	0	10	0%
Ponds						
Growout pond construction	50	$3,883	$194,150	1	19	0%
Growout pond piping and infrastructure	50	$385	$19,250	1	19	0%
Growout pond electricity connection	50	$1,320	$66,000	1	19	0%
Juvenile and broodstock pond construction	14	$1,600	$22,400	0	20	0%
J and B pond piping and infrastructure	14	$215	$3,010	0	20	0%
J and B pond electricity connection	14	$100	$1,400	0	20	0%
Venturi aerators	12	$100	$1,200	0	5	0%
Paddle wheel aerators	57	$750	$42,750	1	5	0%
Crayfish shelters	8375	$6.00	$50,250	1	5	0%
Rat exclusion - electric fence	-	$4,000	$4,000	1	19	0%
Bird netting	-	$40,000	$40,000	1	10	50%
Water Supply						
Supply dam construction	-	$0	$0	0	20	100%
Bore/well/soak construction	-	$0	$0	0	20	100%
Water Treatment						
Settlement pond construction	1	$4,000	$4,000	1	19	0%
Reed/bioremediation pond construction	1	$4,000	$4,000	1	19	0%
Startup Stock						
Juveniles	-	$0	$0	0	20	0%
Breeding stock	-	$9,429	$9,429	0	20	100%
Other	-	$0	$0	0	0	0%
Other Infrastructure and Equipment						
Additional pumps	1	$3,500	$3,500	0	5	5%
Feeding equipment	-	$100	$100	0	5	0%
Water monitoring equipment (and other testing)	1	$1,550	$1,550	0	10	0%
Harvesting equipment (bins, flow traps)	-	$500	$500	0	10	0%
Workshop tools and equipment	-	$0	$0	0	10	0%
Water storages	0	$0	$0	0	20	0%
Venturi pumps	9	$225	$2,025	0	5	0%
Feasibility study	-	$5,000	$5,000	0	20	0%
Aerator controllers	16	$100	$1,600	0	20	0%
Total capital outlay			$511,164			

water rats is less than 1% of capital costs. This estimate includes internal electric fences to retain broodstock and deter larger marron from entering nursery ponds. However, internal electric fences are not proposed for growout ponds. (These are used on Thomson's Flat to ensure that marron do not move between research ponds.)

Marron typically moult in the shallows and are highly vulnerable to predation by birds. By our estimate, bird netting represents only about 8% of capital costs. Our estimate is not based on quotations from within WA but rather from the total cost incurred by a reputable aquaculturist in NSW, based on the farmer(s) erecting the bird netting, with some initial specialist help. It is also worth noting that while netting may have to be maintained/replaced within a 20-year period, the posts, stays and aerial support wires should have a long life.

4.11.6 Water supply and water treatment

It is assumed the farm already has an established water supply e.g. bore or dam. However, the cost of reticulating the water to the ponds is included in the Ponds section above. We strongly advise farmers to install a settlement and reed pond so that discharge (and often seepage and overflow) can be treated and be available for reuse. This can also have environmental advantages if the farm discharges to a natural waterway. Too often, we have found that marron farmers have insufficient water to service all of their ponds. Reuse of water, provided it does not become too saline, can help greatly. The cost of installing these treatment ponds is low even when combined with the cost of the pumping system from the reed pond sump back to the ponds. If the reticulation system from the dam or bore to the ponds is designed and installed well, little extra plumbing is needed as the supply line from the reed pond pump can tap into this reticulation grid.

4.11.7 Start-up stock

We strongly recommend that farmers construct broodstock and nursery ponds first so that they can stock the subsequent growout ponds with the farmer's own juveniles. It is crucial that good quality potential broodstock be acquired and again this is a minor part of the total cost.

4.11.8 Other infrastructure and equipment

These are relatively minor except for pump costs. Each aerator controller allows groups of three or more ponds to automatically receive aeration at predetermined times. This allows for good pond management and staggering of the timing of start-up electrical loads. On Dan Machin's recommendation, a new item of $5000 for a feasibility study, in part to assess the suitability of the site, has been included.

4.11.9 Overall capital costs

The total cost has increased slightly to about $511,000 compared to the estimate of about $502,000 made by Cassells et al. (2003).

4.12 Revenue

This is driven by production and assumes that prices keep pace with inflation. As such, revenue in 20 years time is expressed in "today's dollars", i.e. in real terms. Prices are always arguable but were based on the best on offer from a mix of buyers at the time the data were collected. If a farmer can obtain better prices, over 20 years, it will greatly improve profitability. At present, prices for luxury seafoods are under pressure but this need not be a long-term trend.

Revenue

Prices

	Average Price	Weight (kg)	Weight Class Revenue
Less than 40 grams	$15.00	0	$0
40 to 70 grams	$17.00	0	$0
71 to 100 grams	$19.00	5,214	$99,066
101 to 150 grams	$20.00	4,168	$83,360
151 to 200 grams	$27.00	524	$14,148
201 to 250 grams	$27.00	678	$18,306
251 to 300 grams	$31.00	416	$12,896
301 to 400 grams	$33.00	0	$0
400 grams plus	$33.00	0	$0
Total		11,000	$227,776

Revenue

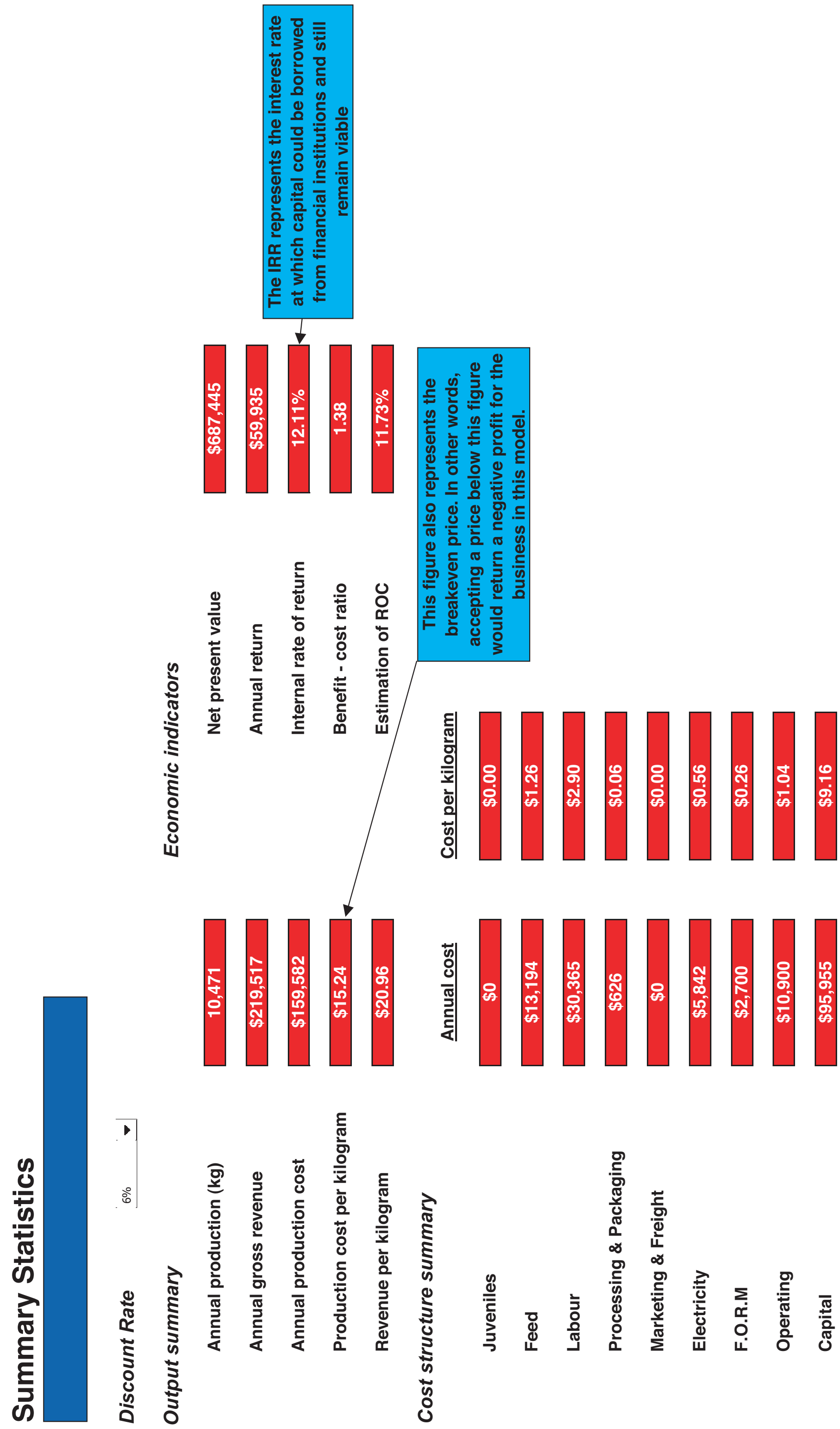
Years	Juvenile Sales	Production Revenue	Total Revenue
1	$0	$0	$0
2	$0	$0	$0
3	$0	$227,776	$227,776
4	$3,500	$233,470	$236,970
5	$3,500	$238,910	$242,410
6	$3,500	$244,090	$247,590
7	$3,500	$249,002	$252,502
8	$3,500	$253,640	$257,140
9	$3,500	$257,997	$261,497
10	$3,500	$262,067	$265,567
11	$3,500	$265,841	$269,341
12	$3,500	$269,314	$272,814
13	$3,500	$272,476	$275,976
14	$3,500	$275,320	$278,820
15	$3,500	$277,839	$281,339
16	$3,500	$280,025	$283,525
17	$3,500	$281,868	$285,368
18	$3,500	$283,360	$286,860
19	$3,500	$284,493	$287,993
20	$3,500	$285,258	$288,758

4.13 Summary statistics

The discount rate of 6% is important as profitability takes into account the opportunity to get a safe 6% return elsewhere e.g. as a fixed term deposit, adjusted for inflation. A glossary is provided, later in the document (downloaded from MarronProfit) to explain these terms.

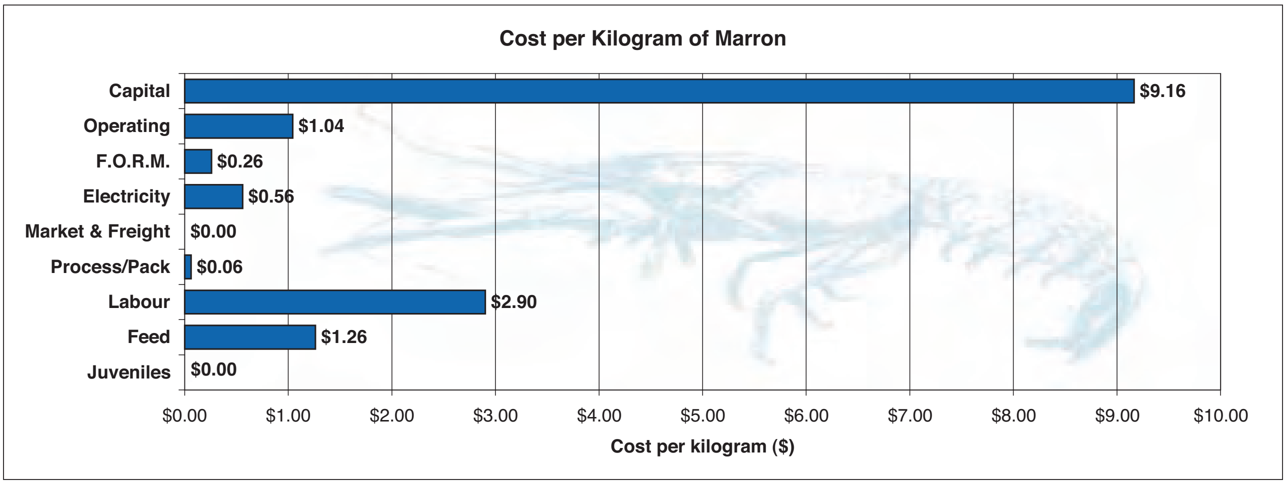
The return on capital ROC (11.73% return on capital) is quite attractive for farm diversification but of course the assumptions have to be met. There is a $5.74/kg margin for revenue (income) over costs.

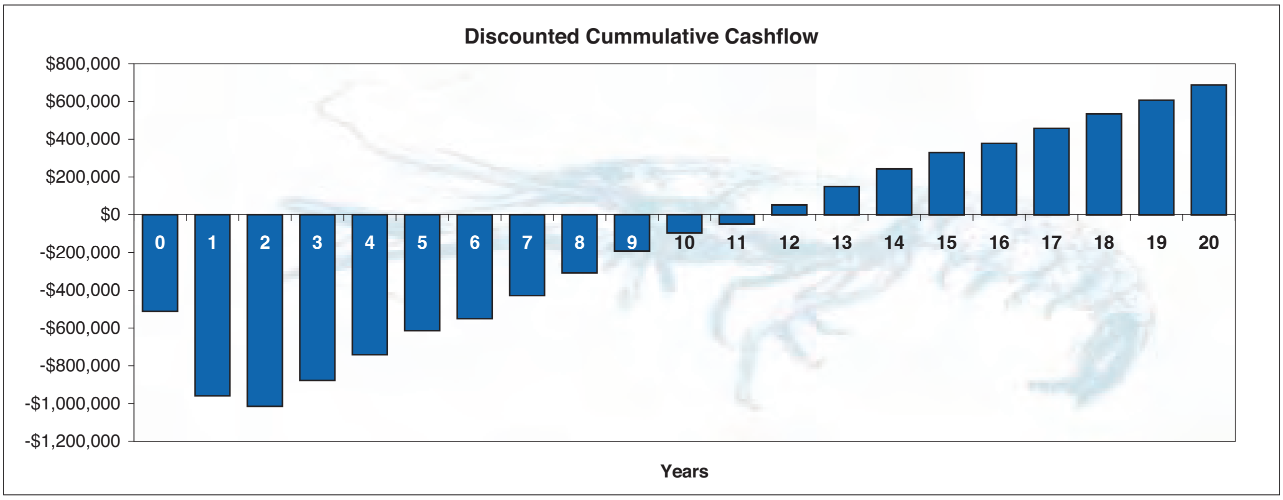
The cost structure summary confirms that marron farming is a capital-intensive business but that its operating costs are low relative to price.

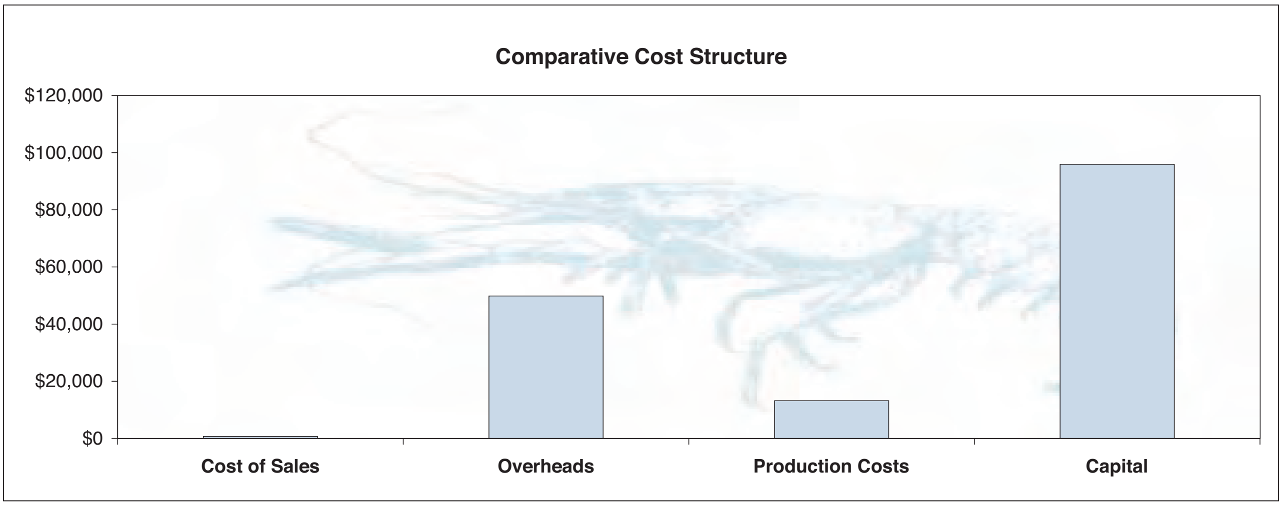


4.14 Graphs

This restates some of the patterns from the summary statistics but the discounted cumulative cashflow is notable.







4.15 Glossary of terms

Administration/office expenses: associated with administration (tax accountants, business advice) and office operation (paper, staples, pens, computer disks etc.).

Agent's commission: commission charged by agents or contractors as a percentage of gross prices received.

Annual return: the net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over the life of the project. If the NPV is positive the project is likely to be profitable. When the NPV is converted to a yearly figure it becomes annualised. In this report the annualised return is called the annual return. It is a measure of equivalent annual returns generated over the life of the project expressed in today's dollars.

Annual wage: basic weekly wage for the period of stated employment.

Aquaculture licences and permits: annual fees paid to governing bodies for licenses to conduct aquaculture farming (DNR, DPI, EPA etc.).

Base production: the production of marron at the inception of the farm without the influence of selective breeding improvements.

Benefit - cost ratio: indicates the return for every dollar spent. If the ratio is 1.1, then for every dollar you invest you get $1.10 return. Therefore, the benefit - cost ratio must be greater than 1.0 for the project to be successful.

Biomass of farm: kilograms of fish/crustacean/shellfish (at their harvest weight) the farm will hold, given the stocking density and water volume.

Bulk bin freight cost: freighting one fully loaded bulk bin to market.

Chemicals (cleaning): purchase of chemicals used in cleaning such as disinfectants, hand wash, soap etc.

Chemicals (medicinal): purchase of chemicals used in the treatment of fish for health reasons.

Cost of items (capital): individual cost of the item(s) to be purchased, not the aggregate. The figure will be multiplied by the number of items indicated in the cell to the left.

Council rates: rates payable by the owner of the property to the local council.

Death rate: death of fish/crustacean/shellfish from initial stocking to harvest.

Discounted cumulative cash flow: this graph tracks the cash flow of the farm over the life of the project (20 years). Discounted cash flow analysis is used to determine the annual cost of production and the likely profitability of redclaw farming on the farm. In any investment analysis it is necessary to estimate likely future project cash inflows and outflows. A key feature of investment analysis is the process of discounting future cash flows to present values. Discounting procedures are used to evaluate the profitability of a project whose life is more than one period. People generally prefer to receive a given amount of money now rather than to receive the same amount in the future, because money has an 'opportunity cost'. For example, if asked an amount of money they would just prefer to receive in 12 months' time in preference to $100 now, most people would nominate a figure around the $110 mark. In other words, to them money has an opportunity cost of around 10 per cent.

Domestic electricity: electricity bills related to owner/operator, or staff, accommodation.

Drawings: money drawn from the business to pay domestic bills such as home electricity, home phone, gas, car repairs, anything related to the domestic situation outside the business.

Farm electricity: electricity bills directly related to the operation of the farm only.

Feed conversion ratio: kilograms of feed required producing one kilogram of fish/crustacean.

Fingerlings/juveniles or spat required per crop: fingerlings/juveniles or spat that need to be bought, or produced, to achieve the target farm biomass.

Freight cost: cost of freighting one kilogram or unit of packed fish/crustacean/shellfish to market.

Fuel and Oil: purchase of fuel and oil (both diesel and unleaded) for machinery on the farm.

Internal rate of return (IRR): the discount rate at which the project has an NPV of zero is called the internal rate of return. The IRR represents the maximum rate of interest that could be paid on all capital invested in the project. If all funds were borrowed, and interest charged at the IRR, the borrower would break even, that is, recover the capital invested in the project.

Leave loading: additional amount of money paid on top of wages over the annual leave period. Commonly expressed as a percentage. For example:
= ($500 x 4) x 15%
= $2,000 x 15%
= $300

Legal expenses: any costs associated with the use of legal services relating to the business e.g.. contracts, operational disputes, property purchases, co-owner agreements and so forth.

Life in years (capital): the expected life span of the capital item before it has to be completely replaced, rather than repaired. A maximum of 20 years can be entered in any one cell, even if the capital item will last for greater than 20 years (ponds, land, electricity connection and so on).

Market floor commission: commission charged by the market as a percentage of gross prices received.

Number of items (capital): indicates the total number of items to be purchased.

Other insurances: any insurance, not related to vehicles. This may include income protection, buildings, stock etc.

Phone: cost associated with the use of phones (including mobiles) that is related to the operation of the business.

Freeboard: The distance between the water level and the top of the tank or pond (or the overflow level)

Pond Dimensions: Are at water level only. The need for freeboard increases the land requirement of the ponds. The estimates of "*area available for other infrastructure*" have been adjusted to take this fact into account. Assuming a 50cm freeboard on 1:3 slope, this will add 3m to the at water level pond dimensions, for example 12.5m x 12.5m, at water level nursery pond, will have a actual land requirement of 15.5m x 15.5 m = 240.25m^2

Promotional levy: levy sanctioned by industry and paid on a per kilogram basis.

Pumping licences: fees paid on an annual basis for the right to pump water (bores, rivers, creeks, and dams).

Repairs and Maintenance: any cost associated with the repair and maintenance of machinery and infrastructure. This figure does not include the full replacement of capital items.

Return on Capital (ROC): is a direct comparison of the amount earnt each year (equivalent annual return) as compared to the capital investment. It is simply calaculated by dividing EAR by the total capital invested.

Salt: annual cost of purchasing salt for purging and medicinal treatment.

Salvage value: if an item is to be completely replaced it may be traded in or sold for a certain value. This is called its salvage value and it will be used as part payment on a new item. For example, you bought a utility 10 years ago for $20,000 and it is ready to be replaced. The new utility costs $25,000. If we can sell or trade the old utility for $5,000 it has a salvage value of 25%. Therefore, to buy the new utility we need only pay $20,000 ($25,000 less $5,000 for the old utility).

Stocking density: number or kilograms of fish/crustacean/shellfish per square metre of water volume.

Superannuation contribution: amount of the basic weekly wage paid into a superannuation fund expressed as a percentage.

Total production cost: the sum of all cost components related to the production of the fish/crustacean/shellfish that have been converted to a per product basis.

Training: percent of the basic wage that is allocated to the continued training of staff.

Travel: any travel expenses incurred as a result of conducting business and/or gathering information (industry meetings, conferences, market visits).

Vehicle insurance: cost of insuring all vehicles directly related to the operation of the farm.

Vehicle registrations: cost of registering all vehicles directly related to the operation of the farm.

Water charges: cost payable to an authority (DNR, local water boards, and councils) for the use of water. This does not include the capital cost of purchasing a water allocation.

Weekly wage: basic wage per week for one employee.

Workers compensation: compensation payment as a percentage of the basic weekly wage.

Year of purchase (capital): the year in which the item is purchased. Year zero defines the point at which the project begins. For instance, capital items such as land and ponds are required before production can begin and therefore are purchased in year zero. Many of the items will be deemed necessary before production can start and should be purchased in year zero. Year one defines the actual start of the first production season.

4.16 References

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Maguire G. B., Cassells, G., Brand-Gardner, S. and Lawrence, C. S., 2002. Survey of commercial marron farming in Western Australia. Freshwater Crayfish, 13: 611 (Abstract only).

5.0 Key features of the Thomson's Flat tour

Pemberton Freshwater Research Centre

Tony Church, Senior Technical Officer
PFRC, Department of Fisheries, Pemberton, WA, Australia

The Dr Noel Morrissy Pond Complex at Thomson's Flat Annexe is available for inspection today. It is now established as an extension centre where pond designs and associated equipment can be demonstrated. The Pemberton Freshwater Research Centre (PFRC) staff have done an excellent job in firstly getting this facility established and then operating it very efficiently.

The theme of the day is "we have an excellent method for farming marron but we can improve on the genetics" so a key component is the life support system for the marron in the ponds (aeration, predator protection and capacity for water exchange through reuse of discharge water). The life support system associated with harvesting includes the concrete sumps in ponds so that the marron barely leave water during the harvest and are effectively "gill-washed" before transport to the processing shed. In the postharvest shed the key resources are the indoor tanks that form part of a recirculated, well-aerated, cooled flowthrough system that keeps marron either submerged or at least wet during processing. There is a good deal of associated equipment at Thomson's Flat and this is listed in the attached Powerpoint summary.

One of the important resources, used in the genetics component of the FRDC project led by Dr Craig Lawrence, is the set of 22 pools on Thomson's Flat which have been used to assess the fertility of crosses between different river strains and commercial lines of marron. On Thomson's Flat, we are also maintaining the neutrally selected Pemberton line of marron, which some of you have purchased as broodstock, and which may prove useful as a control line for monitoring the rate of improvement in FRDC marron lines. (At the main hatchery site for the Pemberton Freshwater Research Centre a mass selection line is being bred for this project. The hatchery site is not available for inspection today as major reconstruction is being undertaken after serious storm damage.)

Thomson's Flat is also being used to mass produce a mixed size group, bred from marron rescued from Waroona Dam, so that this marron fishery can be re-established as the dam refills. Pond facilities on Thomson's Flat and at the hatchery site have also been used to mass rear the threatened hairy marron from the Margaret River (research conducted by Dr Brett Molony and Chris Bird). Another relevant segment of our work is the monitoring of the rate of recovery of farmed marron suffering from tail blister (research conducted by Dr Brian Jones, Dr Greg Maguire and Kylie Freeman).

The recently expanded Pemberton Aquaculture Producers' marron processing, marketing and tourism facility is also open for inspection. For the first time in this series of Marron Open Days, we are hosting a small Trade Show and some of these exhibitors have been the source of some of the services and equipment used in establishing and operating the Thomson's Flat Annexe. We are grateful for the support of those companies and organisations involved in the Trade Show.

5.1 Acknowledgment

In addition to the PFRC staff, special note should be made of the contribution of Ivan Lightbody (the Research Division's workshop specialist) who transformed the design ideas from George Cassells and Greg Maguire into an excellent postharvest system that can be dismantled and transported to other research locations as needed.

Key features of Thomson's Flat tour

(Pemberton Freshwater Research Centre PFRC)

Tony Church
Senior Technical Officer,
PFRC

Department of Fisheries
Government of Western Australia

Fish for the future

Locations

- Thomson's Flat pond complex
- Pemberton Aquaculture Producers (Farm Fresh Marron)
- PFRC "hatchery" area (closed to the public for repair of storm damage)

Pemberton staff

- **Tony Church (Manager)**
- **Terry Cabassi (Technical Officer)**
- **Chris Church (Marron/general Technical Officer)**
- **Dave Evans and Neil Rutherford (Fish Nutrition Technical Officers)**

Thomson's Flat pond complex

- 150 m^2 model ponds
- Commercial scale ponds with harvest sump
- Predator protection (bird netting)
- Individual pond fences (research/genetic management tool)
- Settlement and reed ponds/re-use pump
- Marron hybrid pools

Thomson's Flat pond complex

- Pond water supply filters (no red-fin perch)
- Tadpole traps
- Timer controls
- Pond wall roadways
- Mini tractor
- Pond sumps (moulds or prefab sections)
- Postharvest processing/holding facilities
- Blower/generator

Major infrastucture changes

- Increased water supply from hatchery to Thomson's Flat (TF)
- Dual pumps for high or low pumping rates on TF

Pemberton Aquaculture Producers (Forrest Fresh Marron FFM)

- Efficient processors and marketers are critical for the industry
- Now have a tourism component
- Will be part of a new joint tour for tourists (PFRC hatchery, Thomson's Flat and FFM)