Marron Farming Workshop and Field Day

April 5, 2003
Pemberton Freshwater Research Centre

Compiled by Greg Maguire

Government of Western Australia
Department of Fisheries

Fish for the future

Department of Fisheries
3rd floor The Atrium
168-170 St George's Terrace
PERTH WA 6000
Telephone (08) 9482 7333
Facsimile (08) 9482 7389
Website: http://www.fish.wa.gov.au

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1.0 Progress in the FRDC Marron Aquaculture Project

Using genetic and husbandry strategies to improve production

Dr Craig Lawrence
Department of Fisheries, Research Division, PO Box 20, North Beach, WA 6920, Australia

The FRDC Marron Project 2000/215 “Improved performance of marron using genetic and pond management strategies” has made significant progress since funding was approved. In this project the performance of six wild river strains, hybrids of strains, a domesticated strain, a mass selected strain and industry stock is being compared to identify the best marron for aquaculture. In addition, a number of pond management strategies are being evaluated to determine if they can improve marron growth and decrease size variation.

The strain evaluation experiments have been completed and data on growth rates, survival, sex ratio and morphology (i.e. claw size, abdomen size and carapace size) have been analysed. The hybrids have been transferred to tanks at Pemberton to assess fertility of hybrid marron strains.

A selection index was developed in consultation with colleagues from both the University of Western Australia and one of the top five centres in the world for animal breeding and genetics, the Danish Institute of Agricultural Science, to identify the best marron strains for inclusion in our selective breeding program. These strains have been tagged and combined to establish a base population for the second stage of this project, selective breeding to produce an improved strain of marron for aquaculture. These marron will form the basis of a pedigree selective breeding program that includes advanced computer software, mating designs and quantitative genetics tools to improve a number of characteristics including growth, claw size, meat yield and size at sexual maturity, while at the same time controlling inbreeding.

A major component of the FRDC marron research project is conducted on commercial marron farms. The commercial farm experiments that were established on four properties in Pinjarra, Pemberton, Mount Barker and Denmark in 2001 are nearing completion. Two of the properties are being used for husbandry experiments to quantify the effects of grading juveniles prior to stocking and the effect of increasing the density of hides upon both growth and size variation. The other two farms are hosting genetics experiments to compare the growth of a mass selected line of marron originally created by Department of Fisheries staff in 2001 at Pemberton, with a domesticated line and industry stocks. At the conclusion of the genetics experiments on commercial farms in 2003, the best marron from the mass selected ponds will form the basis for a selective breeding program using mass selection. This strategy will in the short term provide farmers with marron that are superior to current industry stocks, however in the longer term even better marron will be produced from the pedigree breeding program.

FRDC Project 2000/215

Improved Performance of Marron Using Genetic and Pond Management Strategies

Dr Craig Lawrence

Senior Research Scientist (Aquaculture)

Department of Fisheries, Research Division,

North Beach, WA 6920

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

Department of Fisheries
Government of Western Australia

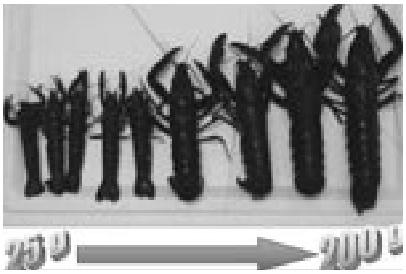
Fish for the future

Better Marron = Bigger Profits:

A progress report on the marron genetic improvement & pond management program

Objectives

- Increase growth rates
- Decrease size variation



Research Partners & Collaborators

- Department of Fisheries Western Australia
- FRDC
- ADF
- University of Western Australia
- University of Adelaide
- SARDI
- Marron grower associations in Western Australia and South Australia

Key Achievements FRDC Marron Research Project - 24 months

- Shenton Park Laboratory established
- Marron strains collected
- Juveniles produced - strains & hybrids
- Husbandry & genetics experiments stocked
- Best strains identified
- 80 000 marron stocked in experiments on commercial farms and at Shenton Park Laboratory

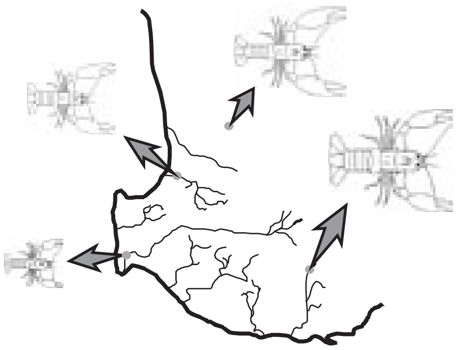
FRDC 2000/215
Improved performance of marron using genetic and pond management strategies

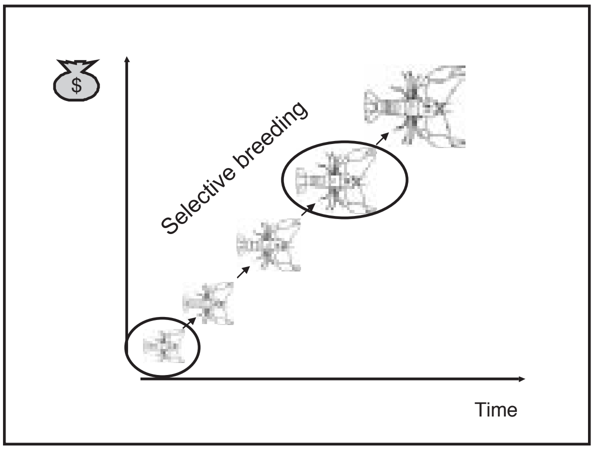
- **Genetic improvement Program**
  - Strain evaluation
  - Hybrid evaluation
  - Selective breeding program
  - Commercial trials
- **Husbandry Program**
  - Graded Juveniles
  - Hides
  - Advanced Juveniles
  - Aeration
  - Condition indices
- Regional variation
- Economic evaluation

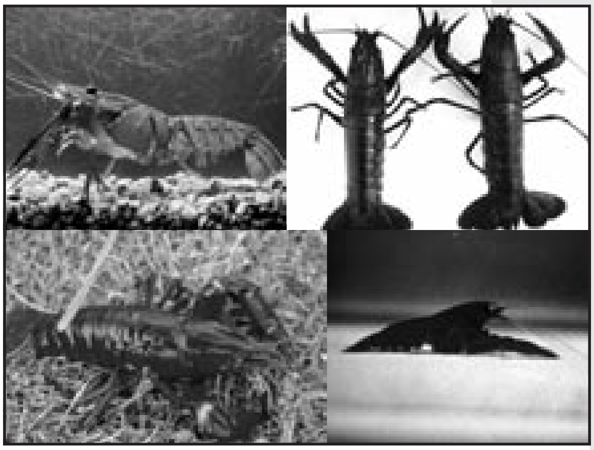
Strain Evaluation

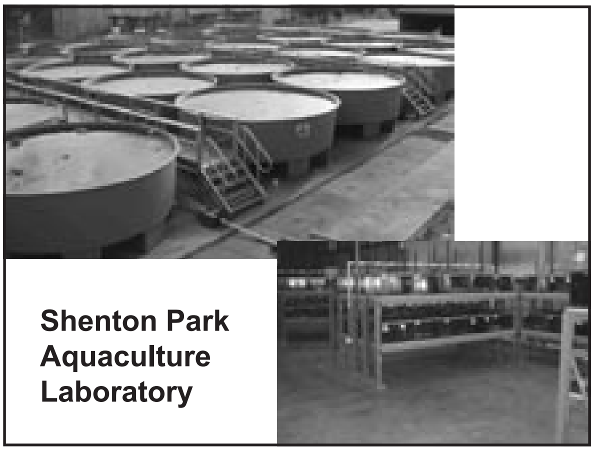
- 6 wild river strains
- 3 selected "domesticated" lines
  (Selected Stock, Pemberton, Blue marron)
- 1 industry "domesticated" line

Why evaluate strains ?









Strain Evaluation Experiments

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

Strain Evaluation Experiments

- Shenton Park Ponds
  - 10 strains (growth)
  - Stocked in triplicate
  - Commenced March 2001
  - Concluded March 2003

Results Reproductive success*

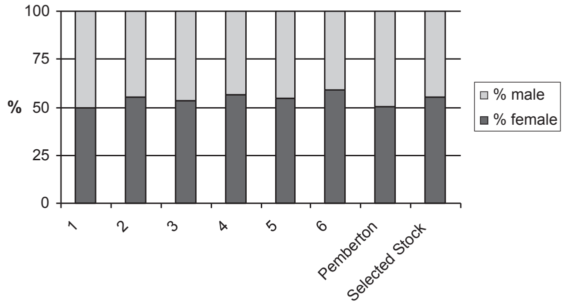
Strain	% Berried females
1	13
2	35
3	45
4	53
	56
6	84
Pemberton Line	77
Selected Stock Line	64

* Reproductive success of marron strains 2000/2001 breeding season

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

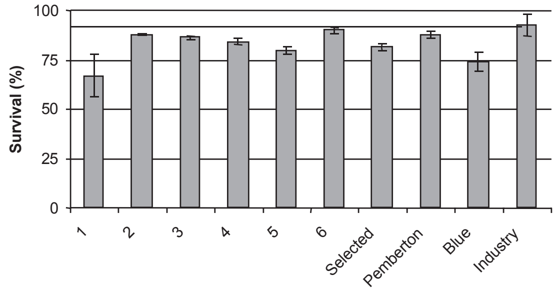
Strain	Mean Weight (g)	se
1	0.93	0.13
2	1.26	0.15
3	1.07	0.11
4	3.10	0.29
5	2.13	0.18
6	1.35	0.16

Strain Sex Ratios



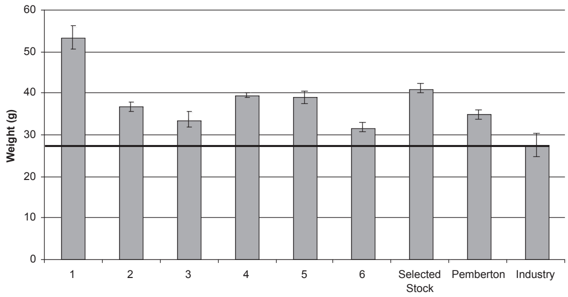
Results Survival

(Drain 1 –3 July 2001-March 2002)



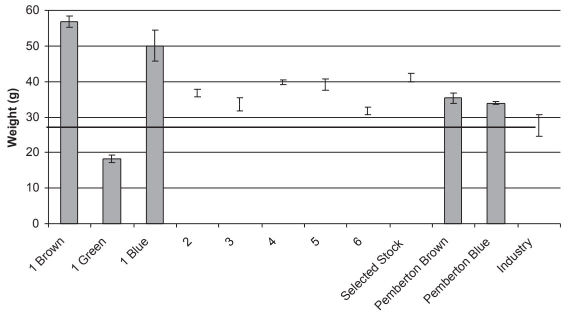
Results Growth

13/03/2002



Results Growth

13/03/2002



Status / Recommendations

- Strain evaluation experiment completed
- Identified best performing strains
- Stock from Shenton Park will form basis of pedigree selection program in 2003

Strain Evaluation

Next 12 months

- Establish selective breeding program for best strain(s) in June 2003
- Produce 18 000 progeny from improved strain for stocking commercial farm experiment in Feb 2004

Australian Academy of Technological Sciences and Engineering Grant

Development of an international centre for aquaculture genetics

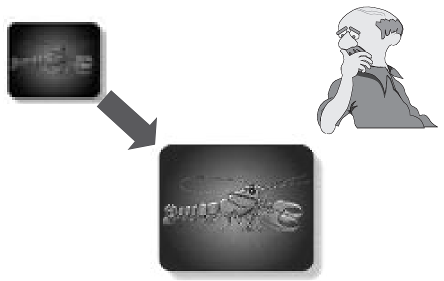
and

enhancement of a selective breeding program for the commercial production of freshwater crayfish in Australia

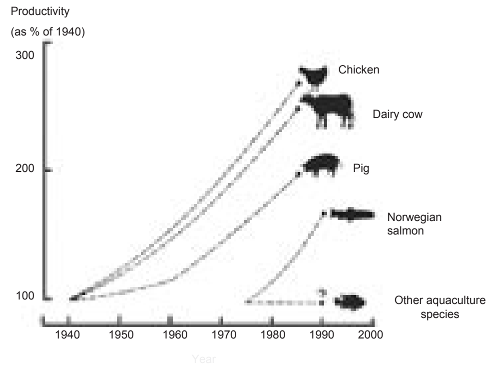
Collaborators

- **Australia**
  - Dr P. Vercoe (The University of Western Australia)
  - Dr C. Lawrence (Department of Fisheries WA)
  - Dr I. Williams (The University of Western Australia)
- **Denmark**
  - Dr M. Henryon (ABG, DIAS)
  - Dr P. Berg (ABG, DIAS)
- **Malaysia**
  - Dr M. Gupta (INGA)

Quantitative genetics selective breeding



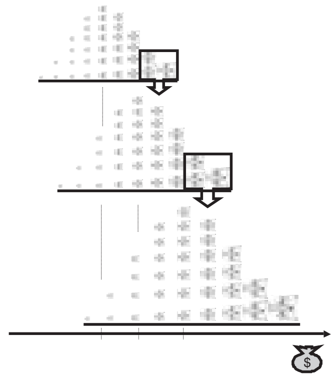
Agriculture vs aquaculture



Selective Breeding Program

- Mass selection breeding program
- Pedigree breeding program

Mass selection breeding program



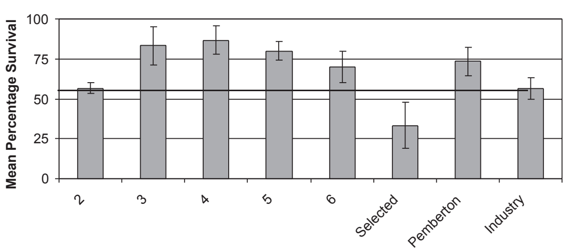
Pedigree breeding program

Strain Evaluation Experiments (social interaction)

- Shenton Park Ponds
  - 8 strains VIE tagged (insufficient river strain 1 progeny produced)
  - Stocked in triplicate
  - Commenced March 2001
  - Concluded March 2003

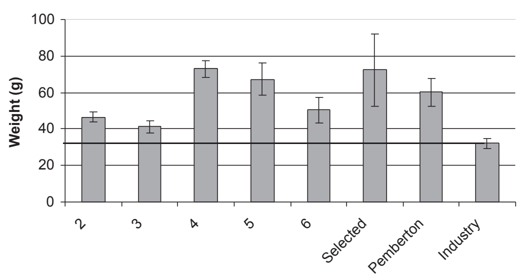
Results Survival

4th Drain Social Interaction - Mean Survival



Results Growth

4th Drain Social Interaction 29/7/02 – Mean Weight



Status / Recommendations

- Experiment completed
- Tags became difficult to read

Strain Evaluation Experiments

- Commercial farms
  - Denmark & Pinjarra
  - a) Comparing performance of mass selected and Pemberton lines with industry stocks
  - b) Comparing performance of 2 lines (mass selected and Pemberton) in 2 different regions

Survival

Pinjarra	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Pond 6	Mean (se)
Treatment	Selected	Selected	Pemberton	Pemberton	Industry	Industry	
Survival (%)	40	27	12	0.2	0	37	19 (7.3)

Survival

Denmark	Pond 7	Pond 14	Pond 15	Pond 17	Pond 18	Pond 19	Mean (se)
Treatment	Industry	Industry	Pemberton	Pemberton	Selected	Selected	
Survival (%)	90	87	73	67	70	67	76 (4.2)

Strain evaluation experiment

Next 12 months

- Winter 2003 = Final drain and data collection from commercial ponds
- Identify best performing marron
- Select best performing marron from Denmark & Pinjarra for broodstock in 2003 mass selection breeding program

Status / Recommendations

- Reduced survival at Pinjarra
- Good results from Denmark
- Stock will contribute to mass selection breeding program in 2003

Hybrid Evaluation

- **Shenton Park Aquariums**
  - Six river strains in a 6x6 reciprocal mating design
  - Potential 30 hybrid mating combinations
  - 26 hybrid lines produced (21 in 2001, 5 in 2002)
  - Comparing 27 hybrid lines with river strains in aquaria and tanks

Hybrids produced from marron strains

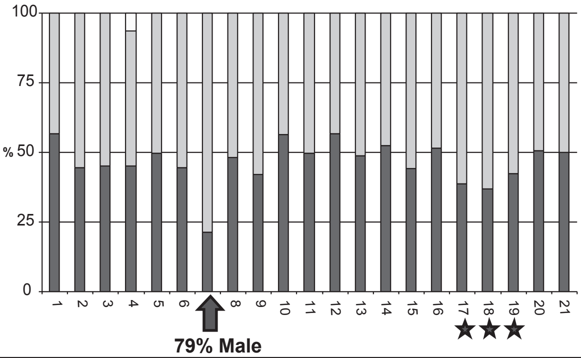
		Male					
		1	2	3	4	5	6
	1	X	X	X			X
	2	X	X	X		X	X
Female	3	X	X	X		X	X
	4	X	X	X	X	X	X
	5	X	X	X	X	X	X
	6	X	X	X	X	X	X

(**X** = juveniles produced 2000/2001 breeding season
X = juveniles produced 2001/2002 breeding season)

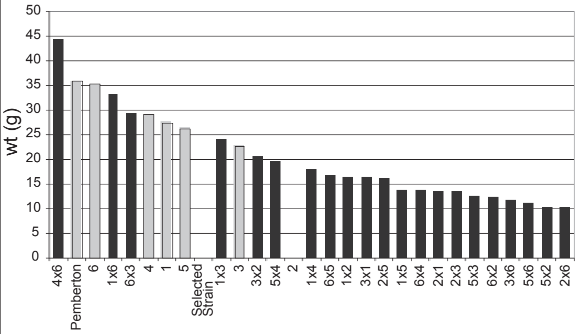
Hybrid Evaluation

- Skewed sex ratios but no monosex
- One hybrid produced 79% male progeny
- Hybrids most likely to be sterile are those between the most diverse populations (IP, industry benefits, importing countries)

Hybrid Sex Ratios



Mean weight of hybrids and river strains in aquaria 11/3/02 (pooled data for 3 aquaria/line).



Status / Recommendations Hybrid evaluation experiment

- Completed aquarium trials to evaluate growth
- Good growth and survival necessitated program change to complete evaluation of fertility in larger tanks at Pemberton
- Transferred best hybrids to Pemberton

Next 12 months

- Rear hybrids to sexual maturity to evaluate fertility

Graded Juveniles

- **Commercial farm**

  10 710 juvenile marron stocked
  - 3 ponds stocked with ungraded juveniles
  - 3 ponds stocked with graded juveniles (largest 50%)

Graded Juveniles Survival

Pemberton	Pond 1	Pond 2	Pond 3	Pond 9	Pond 10	Pond 11	Mean (se)
Treatment	Graded	Graded	Control	Control	Graded	Control	
Survival (%)	35	12	41	67	56	66	46 (8.7)

Status / Recommendations Graded juveniles experiment

- Due to reduced survival in 3 ponds restocked experiment (combined graded marron from pond 2 and pond 1 to even out densities)

Next 12 months

- Winter 2003 = Final drain and data collection from commercial ponds

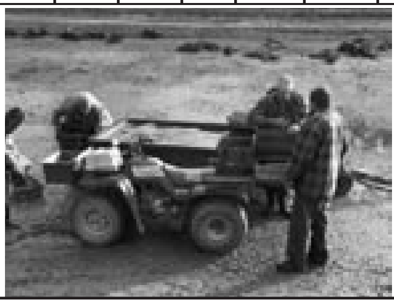
Hides

- Commercial farm

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

Hides Survival

Mt Barker	Pond 27	Pond 25	Pond 26	Pond 7	Pond 13	Pond 14	Mean (se)
Treatment	Double	Hides	Double	Hides	Hides	Double	
Survival (%)	90	91	88	96	95	94	92 (1.3)



Status / Recommendations Hides experiment

- Excellent survival

Next 12 months

- Winter 2003 = Final drain and data collection from commercial ponds

Condition Index

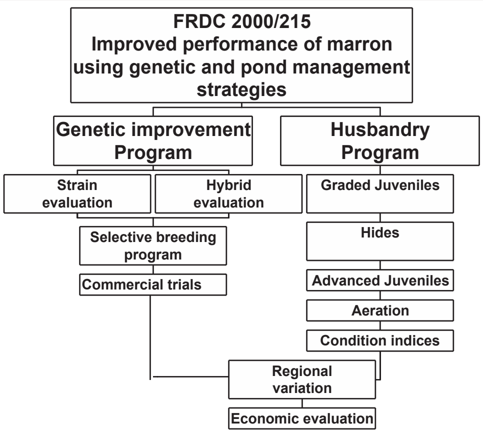
- Develop CI for farmers
- Investigated options – Hepatopanceas indices,morphology, glucose, clotting, blood protein, BIA, TOBEC.
- Focused upon morphology
- Collected data from 4 commercial farms

Status / Recommendations Condition Index experiment

- Revised CI working well
- Data awaiting analysis

Next 12 months

- Collect and validate farm data
- Seek student for this area of research



Experiments to commence in 2003

- Advanced juveniles (2003–2005)
- Aeration (2003-2005)
- Evaluation of best strain on commercial farms (2004–2005)
- Selective breeding of best strain or hybrid (2003, 2004 & 2005)

Advanced juveniles (2003–2005)

- Purchase juveniles from northern farm and stock on southern farm
- Compare growth of early released northern juveniles with later released southern juveniles
- 1 farm (WA) - 3 ponds northern stock vs 3 ponds southern stock

Aeration (2003-2005)

- Compare different aeration times on a commercial farm (short, average and long)
- 1 farm (SA) – 3 ponds long aeration, 3 ponds short aeration, 3 ponds average aeration

Evaluation of best strain on commercial farms (2004–2005)

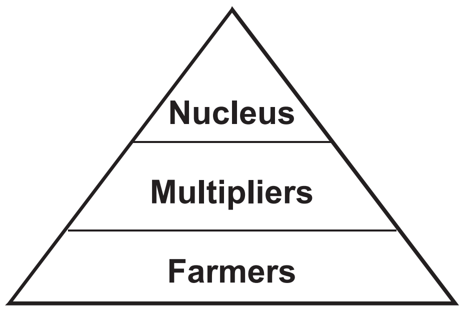
- Evaluation of improved marron strain on 2 commercial farms
- Compare performance of improved strain with industry stocks
- 3 ponds improved strain vs 3 ponds industry line/farm
- Location (WA & SA)

Selective breeding to improve best marron strain (2003-2005)

- Select best broodstock from best strains identified in previous strain evaluation experiment.
- Produce marron from 1) Pedigree breeding program and 2) Mass selection breeding program (June 2003 & 2004)
- IP agreement and commercialisation strategy to be finalised
- Transfer improved marron juveniles to industry for commercialisation (2004 & 2005)

Plan ⇒	**Tools** ⇒	**Implementation**
Breeding Objective	Breeding values Genetic variation Selection criteria Selection schemes Mating designs	Breeding station Commercialisation

Commercialisation of improved marron strain



Thank You

2.0 Thompson'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 1

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

Caveat

This document describes research for which the second year of the 2 year production cycle has only recently commenced. As such there are no firm economic conclusions yet from the research. The methods, described in Maguire et al. (2002a) and updated in this paper for this trial, worked very well but may not be ideal for all commercial ponds. Similarly, the ponds used (average of 152 m^2 water surface area) are relatively small for grow-out ponds. The major differences between year 1 management as proposed by Maguire et al. (2002a) and what was actually done, were, 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 handled), and a second addition of silage was used after about 6 months because of the water exchange induced clarity of the ponds.

2.1 Key questions and answers to date

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

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? After 12.5 months 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.

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 restocking was conducted efficiently and initial post-stocking mortality was low despite the marron having been weighed twice and held at high densities in a cooled, recirculating holding system.

Can most of the small 0+ juveniles stocked (at about 0.3 g/marron) reach commercial size in two years? This cannot be answered yet but the growth rates in year 1 were so good that this is likely to be the case. Size variation is always a problem and some individuals may not reach marketable size (70 or 100 g depending on the preference of individual farmers).

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? Results to date are very encouraging but year 2 survival rates will be a key issue. 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. The harvesting channels in the ponds 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. 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 in the recirculating indoor holding system kept temperatures very favourable (usually less than 20°C) while use of ice in the shaded, outdoor, initial holding tanks was very effective.

Can the 150 m^2 ponds be operated successfully using only reused water (after passing through settlement and macrophyte ponds)? Water quality readings were excellent throughout the trial (data not presented here as detailed analysis is ongoing).

Do replicate ponds on Thompson'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. paper in this volume.

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

Performance	Low Density Ponds	High Density Ponds
Mean wt. males harvested	63.10	51.00
Mean wt. females harvested	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.

2.2 Background

Marron 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., in prep.). Efficient harvesting in cooler months is achieved by draining the pond, removing all marron, washing out accumulated organic matter, 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 is being evaluated.

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 for filling or water exchange in ponds has or will be recycled through settlement and reed ponds (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 is 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 0+ juveniles (1-10 g/marron) were stocked but that growth rate was depressed at higher densities.

A variety of factors could 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 studies, density was increased without adjusting all of these management strategies, whereas in the present study, all will be increased at the higher density especially as biomass rises during 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 incorporate a concrete drainage sump to 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 is hoped that innovative post harvest handling of marron during grading will 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 make 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*).

Male marron grew 13.7-16.6% faster in year 1 than females in the same 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 (see Lawrence et al. presentation in the volume containing Maguire et al., 2002a). 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 assesses 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 Methods

2.3.1 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 Research and Research Centre, Western Australia (116°05’ E, 34°33’ S). These ponds previously held 55 and 24 berried females respectively and were managed as recommended by Cassells et al. (in prep.). The marron broodstock were all from the “Pemberton line” which has been neutrally selected for growth rate over many generations (see summary by Lawrence in this volume).

Where possible, 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 23°C); 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).

2.3.2 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 Thompson’s Flat area of PFRC 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 about 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 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 the current trial.

All water added to or to be added to these ponds is recycled aquaculture discharge from trout ponds, passed first through a large swirl separator or from marron ponds, then passed through settlement and macrophyte (reed) ponds and then through 1.4 mm mesh filters to exclude redfin. Initial rates of water exchange have been relatively high to combat initial seepage and evaporation from these new ponds. As a result no additional water exchange was required except when ponds were drained. Three of the 18 ponds (two low density and one high density pond) were drained and refilled during year 1 to allow a census of animals in these ponds.

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 has 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. Sampling was conducted by hide harvesting (30-50 marron per pond) from all ponds after months 3, 6, 9 and 12 in both years.

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 Lawrence 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 is increased.

Water quality monitoring is dependent on available labour but involves continuous data logger recording of water temperature in two ponds, and weekly monitoring of each pond for dissolved oxygen, and pH. Salinity, total ammonia, total dissolved nitrogen and reactive phosphorus, and suspended solids are measured occasionally.

Exclusion of predators and prevention of migration of marron from the ponds were aided by security fencing, 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 early phase of year 2.

2.3.3 Harvesting and postharvest handling

Ponds will be 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, rinsed and positioned in shaded, outdoor circular, aerated holding tanks. 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. Ice was added to the outdoor holding tanks as needed.

During construction the ponds were stabilised with about a 75 mm layer of shale. 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" 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, saleable marron will be transferred to a processor and where possible, data obtained on initial survival after transfer to customers.

2.3.4 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.

2.3.5 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.

2.4 Acknowledgments

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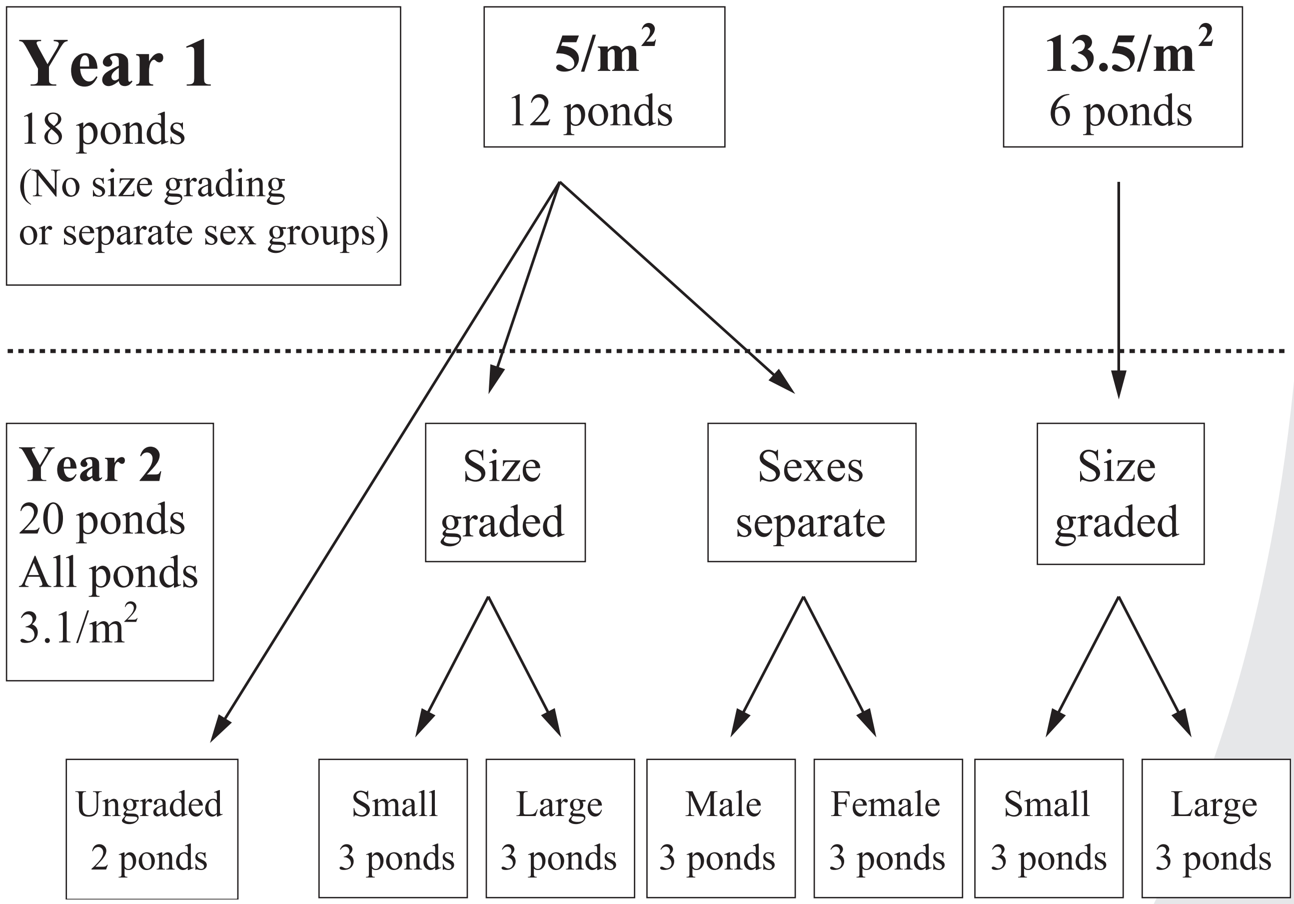


Figure 1. Design for the 2 year pond management trial with small juvenile marron at Thompson's Flat in 150 m^2 ponds. (Note that individual marron from 12 ponds in year 1 are redistributed to 14 ponds in year 2.)

Thomson's Flat Pond Trial 1 -
a report after year 1

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

Department of Fisheries
Government of Western Australia

Fish for the future

Typical marron farming cycle

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

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

Can a 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.

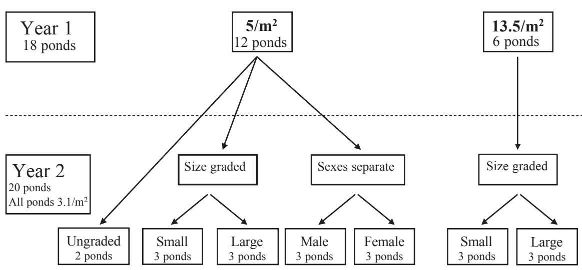
Can most of the small 0+ juveniles stocked (at about 0.3 g/marron) reach commercial size in two years?

Morrissy (1992) had poor survival and growth of very small summer juveniles (0.06 g/marron) at high densities

Larger juveniles? Better handling? More intensive management? in our trial

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?

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?



We attempt to offset adverse effects of higher stocking densities by using more intensive farm management

Management variables

- Number of hides
- Aeration duration (venturis)
- Amount of water exchange
- Higher feed rate
- Extend use of high protein nursery feed (total of 7 months)
- Efficient live harvesting

Can the 150 m^2 ponds be operated successfully using only reused water?

(Use settlement and macrophyte ponds)

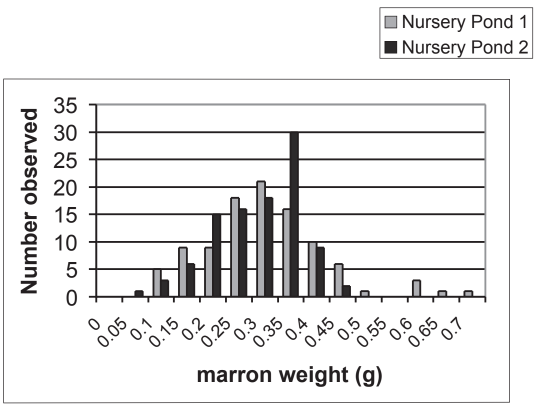
Performance measures

- size at harvest (year 1 and 2)
- survival
- feed usage
- FCR
- size variation
- size distribution
- water quality

- Costs
  - stock
  - feed
  - power
- Income
  - $/kg depends on size
  - Tonnage
  - Quality

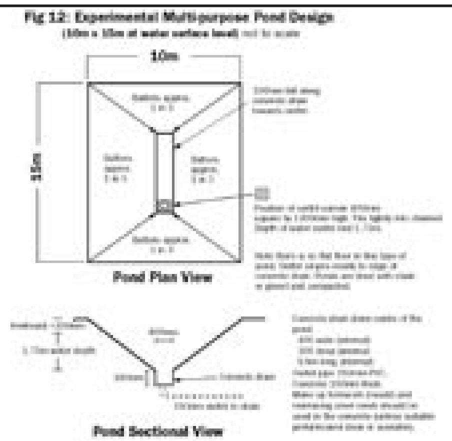
Today we report on:

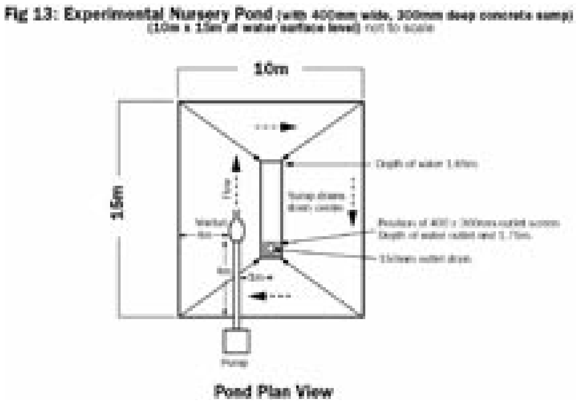
- Performance from stocking size (next slide) to harvest over 12 months and initial restocking for year 2 of trial
- Not covering economic performance yet (need data for the whole 2 years)



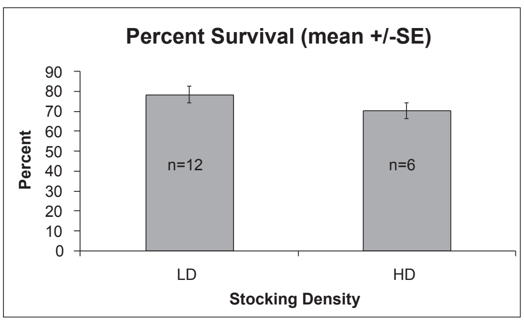
Design/Harvesting of ponds

1. Design of pond
2. Aeration
3. Full pond
4. Partially drained pond
5. Collecting marron from flowthrough channel
6. Washing down pond after harvest
7. Live processing area

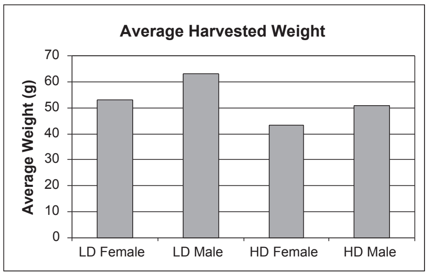




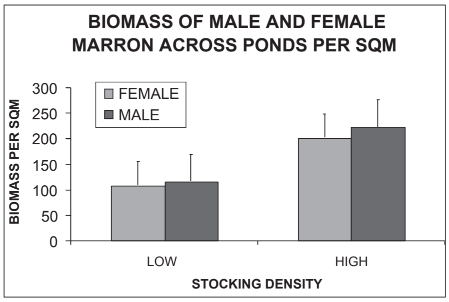
Survival after 12 months



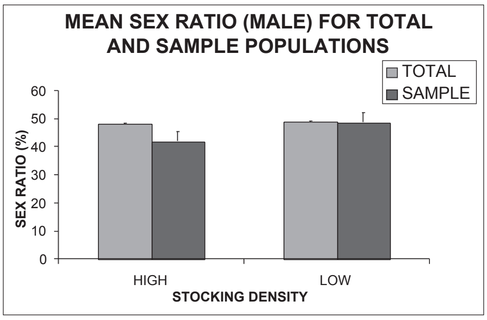
Average weight (g) after 12 months



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



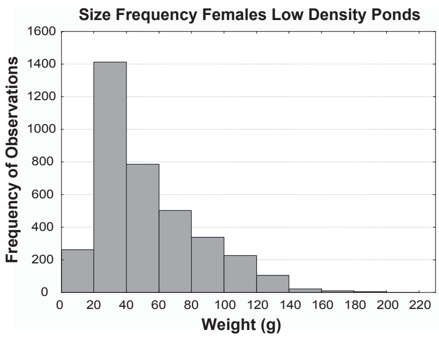
Sex ratio after 12 months



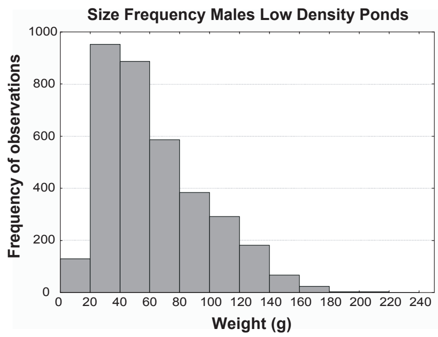
Size variation

- This is covered in the next 4 slides
- Why?
- Size variation is the key technical problem in marron farming

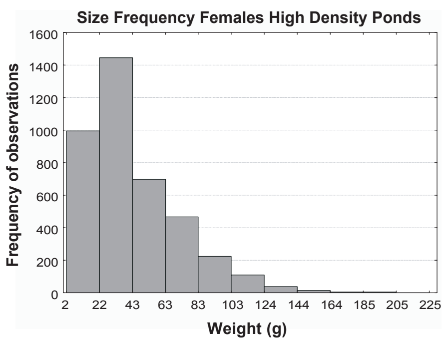
Size frequency of females harvested from Low Density ponds after 1 year



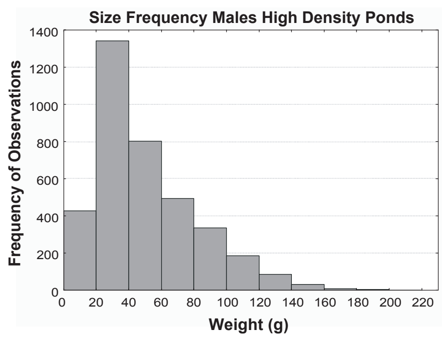
Size frequency of males harvested from Low Density ponds after 1 year



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



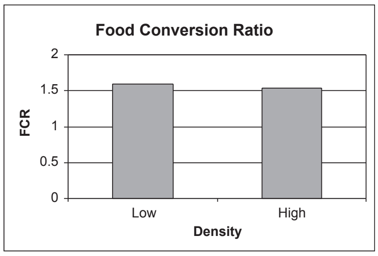
Size frequency of males harvested from High Density ponds after 1 year



Size variation within a pond after 12 months

- Marron were more variable in size in high density ponds as well as being smaller

FCR (feed input/biomass gain)



Summary

- Marron survived well (better at low density)
- Marron grew very well (better at low density)
- Size was more variable at high density
- Males grew faster than females
- The total harvest was greater at high density
- A greater proportion were marketable at the low density
- Food conversion ratio of approx. 1.5:1 was outstanding

Dissolved Oxygen and Temperature for harvesting

- During Pond Drain-down

Dissolved Oxygen

- DO ranged from 1.6 to 5.0 ppm in harvesting channel.
- DO rose rapidly with flushing water running (timing of inflow of clean water into the harvest channel is the key).

Temperatures

Temperatures ranged from 21 to 27.2°C in harvesting channel.

- In Holding Tanks
  - Temperature was controlled by using a chiller inside for longer term storage, and adding ice to shaded outside holding tanks (for initial holding prior to sorting and weighing)
  - DO was controlled with flowing water/aeration indoors and aeration outdoors

Mortalities

Number mortalities due to harvesting,

- handling, storage:

248/15,781 x 100 = 1.6%

Number of mortalities from all ponds for 2 week period after restocking:

113/9413 x 100 = 1.2%

Can farmers do better?

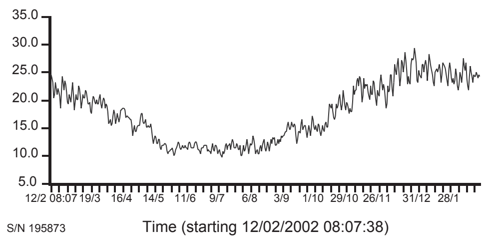
Should do better

- 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

Annual Range of Water Temperature in Pond 1



Temperature issues

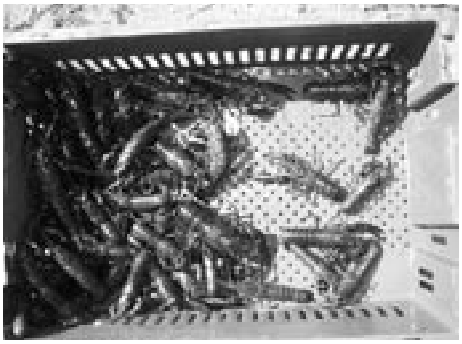
- Thomson's Flat is not shaded
- Warmer winter temperatures allowed some winter growth
- Summer was very hot but survival was still excellent (marron are robust)

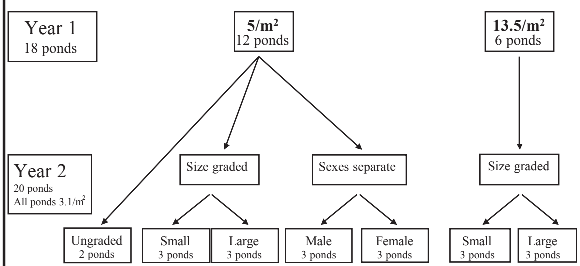
Large size grade

- Top 50% on a weight basis
- Ignored sex of animal for this size grade

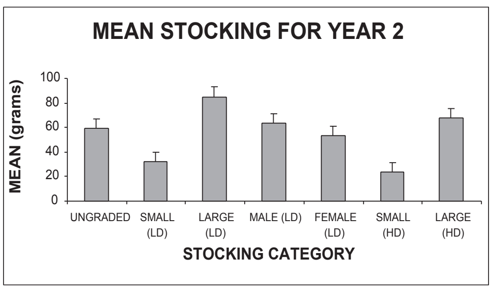
Small size grade

- Lower 50% on a weight basis
- Ignored sex of animal for this size grade
- NOTE: ungraded marron received same amount of handling as size or sex graded marron





Average size when restocked



More data

- See "How predictable is marron farming?" talk for more data from this trial for:
- % soft
- % marketable
- Variation among replicate ponds

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- T. Cabassi
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- **WA Dept of Training & Employment/TAFE students**

3.0 Is marron farming predictable?

Greg B. Maguire, Lea McQuillan and John Heine
Department of Fisheries, Research Division, PO Box 20, North Beach, WA 6920, Australia

Caveat

Some of the results presented here are obtained from relatively small ponds (average of 152 m^2 water surface area) and may not apply to all commercial ponds or other strains of marron.

3.1 Introduction

Results from 12 ponds stocked at a low density (5.0/m^2) with summer juveniles and managed for 12.5 months before the year 1 harvest are presented which complement those in the preceding paper by Greg Maguire, George Cassells, Tony Church and Craig Lawrence in this volume. The data on whether hide sampling predicts harvest size well will form part of a larger scientific paper by Lawrence et al. covering equivalent results from several locations and pond designs.

3.2 Overview

In 1991, the Australian Bureau of Agricultural and Resource Economics published an analysis of the profitability of key aquaculture industries and this indicated that for a well designed, equipped and managed farm, profitability was more predictable than for several other industries, eg. yabby, marine prawn and barramundi farming (Treadwell et al., 1991). Unfortunately, surveys of marron pond harvests indicate that production has been highly variable across and within farms (Maguire et al., 2002a). Moreover, the slow growth in annual marron production for WA confirms that many farms are not operating on a consistently productive basis. However, in commercial growout ponds at well managed farms, results can be very consistent, for example, three commercial ponds within a trial managed by farmers at Mt Barker yielded very consistent results for survival and growth rates (Maguire et al., 2002b).

Growout ponds are only a component of marron farming and it is equally critical that production of juveniles for stocking the growout ponds also be reliable. This has not always been the case but George Cassells' experience is that while some novel lines of marron, eg. the Margaret River hairy marron, can be difficult to breed, most commercial stocks should produce reliable supplies of juveniles. As noted in the paper by Cassells et al. (in this volume), use of broodstock and nursery ponds is highly desirable. However, George Cassells sees the key problems as handling of breeding stock at the wrong time or inappropriate use of aerators (see calendar developed by Cassells and Maguire, 2002 with appropriate adjustment for warmer locations).

Profitability and juvenile production aside, the question of "Is marron farming predictable?" can have several important meanings.

1. Do ponds managed the same way give consistent results within the same year?
2. Can harvest size (average individual marron weight) be easily predicted by hide sampling?
3. Can biomass be easily predicted from feed demand?
4. Do farming conditions vary much from year to year?

3.2.1 Do ponds managed the same way give consistent results within the same year?

Examination of the results from the 12 low density ponds harvested after 12 months (preceding paper by Greg Maguire, George Cassells, Tony Church and Craig Lawrence in this volume) suggests that results can be both quite impressive and consistent and it is hoped that these can be achieved on a commercial scale (see Powerpoint display attached to this talk). It is notable that survival rates did vary among theses ponds. Given that tiny summer juveniles were stocked, some variation can be expected and can be offset by using higher stocking densities.

3.2.2 Can harvest size (average individual marron weight) be easily predicted by hide sampling?

This and the next question are highly relevant to the outcomes of a survey of marron processors undertaken as part of an excellent extension initiative, by the Department of Fisheries Pearling & Aquaculture Program, called the Marron Roadshow. In the survey processors wanted good advance notice of the quantity and size of stock that would be available from individual farms.

Hide sampling, at least for the 150 m^2 ponds on Thompson's Flat proved to be without significant bias when conducted by sampling a minimum of 50 marron per pond from each of the 12 low density ponds just prior to harvest. However, the analysis of how much the average weight for each sex changes as more and more of the harvest is weighed shows that marron are very difficult to sample with any degree of accuracy and in that sense hide harvesting is an inadequate way of predicting the average size of marron in a pond. The problem is not the hide harvesting but the sheer variability of the marron. Initial size grading before stocking may help but when about the top 50% of winter juveniles were used for the Mt Barker trial (noted above in paragraph 3), size variation among individual marron was still very high after 12 months (Maguire et al., 2002b).

3.2.3 Can biomass be easily predicted from feed demand?

In relatively clear ponds, supplied with feed only in the shallows, it is possible to monitor uneaten food especially if light coloured marron pellets are used (darker trout pellets are more of a challenge). In theory, this monitoring allows estimation of feed demand so that marron can be fed very efficiently.

When average daily feed input per square metre for the 10 weeks prior to the harvest for each of the 12 low density ponds discussed above was plotted against the biomass of marron harvested from each pond (on a per square metre basis), there was a clear statistical relationship ($P = 0.02$, Fig. 1). This strongly supported the view that the staff feeding the marron at Thompson's Flat could indeed feed effectively to demand. This probably contributed strongly to the excellent food conversion ratio results (about 1.5 kg of feed added over the whole year per kg of marron harvested – that is after correction for the minor biomass of marron stocked as summer juveniles).

Unfortunately, there was still a lot of scatter among these points and this indicates that predicting biomass (or potential harvest) from the apparent feed demand will not be very accurate and probably not meet the needs of processors.

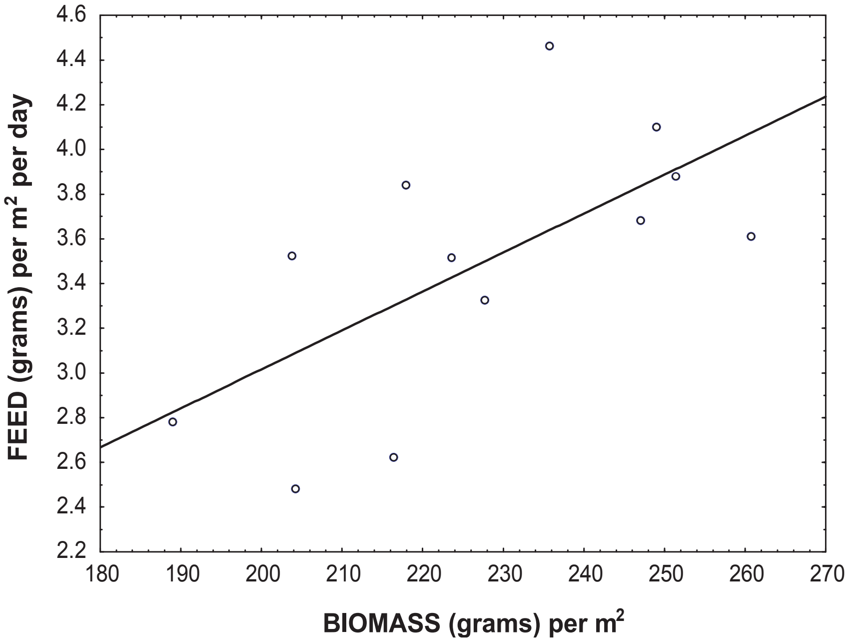


Figure 1. Relationship between average feed supplied to each of the 12 low density ponds, over the ten weeks prior to harvest, and biomass harvested from each pond (see preceding paper by Greg Maguire, George Cassells, Tony Church and Craig Lawrence in this volume).

3.2.4 Do farming conditions vary much from year to year?

Obviously they do and the summer of 2002-03 was one of the hottest on record. Regardless, survival rates were excellent and it suggests that being well equipped, with aeration and capacity to do water exchange (particularly in the cool of the morning), can allow a farmer to deal with hot periods (unless the farm is located in areas that are just too hot for marron farming). Despite the hot summer, the post stocking mortality after summer harvesting of marron in these ponds was quite low and again suggests that if well set up, a farmer can drain harvest on most days.

Overall, the conclusions are that marron farming should provide consistent results but that predicting total harvests or average size from demand-driven feed rates and/or hide sampling will not be very reliable even if unbiased.

3.3 References

Cassells, G., and Maguire, G., 2002. Marron farming calendar. Marron Growers Bulletin, **24**(2): 28

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

Maguire, G.B. Cassells, G. and Brand-Gardner, S., 2002b. Are growth rate and size variation affected by formulated feed type in semi-intensive ponds for marron *Cherax tenuimanus*? Freshwater Crayfish, **13**: 136-145.

Treadwell, R., McKelvie, L. and Maguire, G.B., 1991. Profitability of Selected Aquacultural Species. Australian Bureau of Agricultural and Resource Economics Discussion Paper 91.11, ABARE, Canberra, 85

Is marron farming predictable?

Greg Maguire, Lea McQuillan
and John Heine

Research Division

Department of Fisheries
Government of Western Australia

Fish for the future

Specific issues addressed

- Is the industry operating in a reliable manner?

1. Do ponds managed the same way give consistent results?
2. Can harvest size (average individual marron weight) be easily predicted by hide sampling?
3. Can harvest biomass (kg/pond) be easily predicted from feed demand?
4. Do farming conditions vary much from year to year?

Profitability

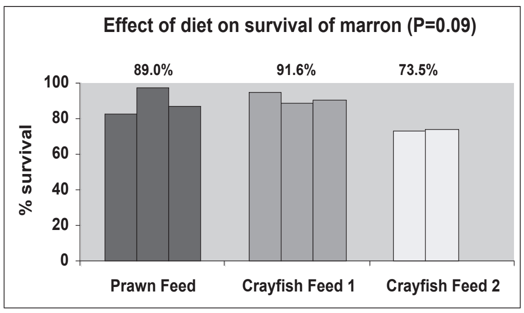
- ABARE in 1991 modelled profitability of marron farming as more predictable than for several other industries, eg. yabby, marine prawn and barramundi farming
- Few disease problems and the SW of WA has a favourable climate for marron farming so it should be predictable

Industry performance

- A surveys of marron pond harvests indicated that production has been highly variable across and within farms (see poster in foyer)
- Low total annual production for WA confirms that many farms are not operating on a consistently productive basis

Any good news?

- Results from ponds at a Mt Barker farm shows that production can be both impressive & consistent (Wilson family farm)
- Data are for winter juveniles grown for one year in "replicate" ponds on different diets

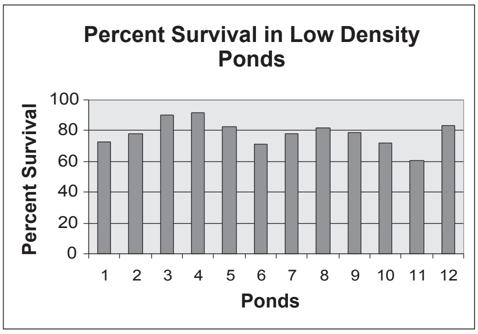


In breeding predictable?

- For normal commercial lines, it should be but some farmers have problems
- Follow the calendar in Marron Growers Bulletin, 24(2): 28 in 2002 but adjust for warmer sites

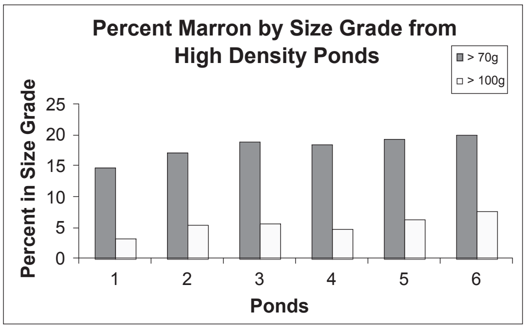
Do ponds managed the same way give consistent results?

- Results from the trial in the preceding talk indicate that results can be relatively consistent across 12 low density ponds stocked at 5/m^2 with summer juveniles or 6 high density ponds at 13.5/m^2
- Survival is a little variable - could be initial mortality with tiny juveniles



Growth data

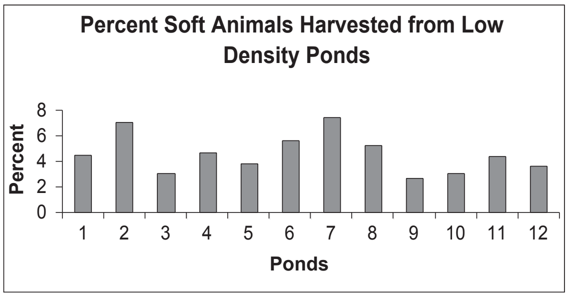
- This looks at growth on a marketability basis and proportions are relatively consistent across 6 ponds.
- Note averages of equivalent values for the low density ponds were 30.6% >100 g and 13.4% > 70 g.



Percentage of soft marron

- This is reasonably variable
- Average of equivalent values for high density ponds was 2.97%
- In terms of variation through time, it is possible that farmers will have to be observant about incidence of moults in particular ponds before choosing which pond to harvest in different parts of the summer

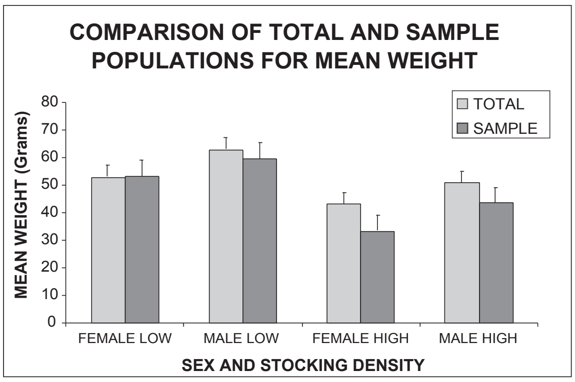
Note that the scale used is 0-8%

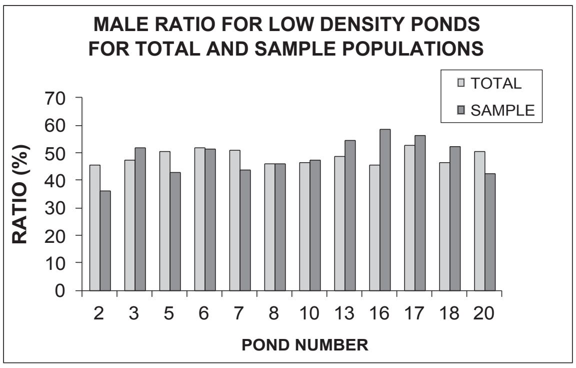


Is hide harvesting a good predictor?

- Note that this is part of a larger study by Lawrence et al. for different ponds and sites
- For the Thomson Flat ponds, hide sampling seems to be unbiased (next slide)
- Second slide shows data for hide sampling & total harvest for sex ratio expressed as:

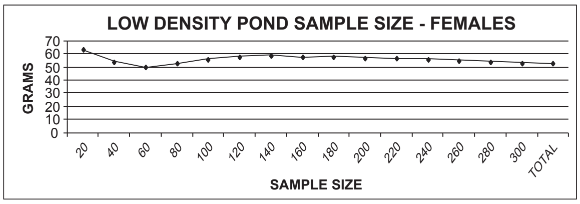
  Number of males as % of total sample or harvest

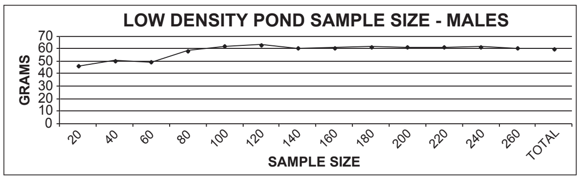




Unbiased sampling can still be inefficient

- In the next slide we see the effect on average weight of males and females as more and more animals from the pond are weighed, until all marron from one low density pond have been weighed
- The conclusion is that you need to sample a large proportion of the pond's population to get a reliable estimate



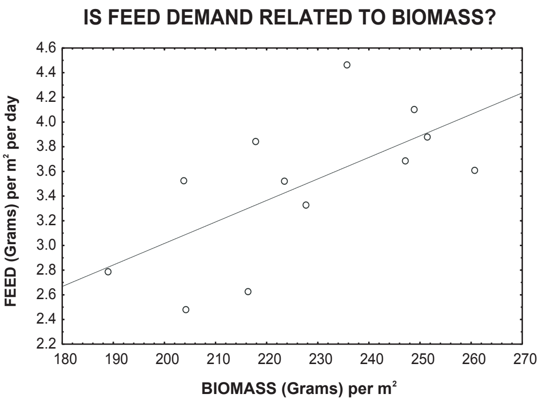


Can biomass be easily predicted from feed demand?

- Can monitor uneaten food especially if light coloured marron pellets are used in the shallows.
- In theory, this monitoring allows estimation of feed demand and efficient choice of daily feed rates.
- Does the theory hold up?

How is the question addressed?

- Average daily feed input, per square metre, for the 10 weeks prior to the harvest for each of the 12 low density ponds was plotted against the biomass of marron, per square metre, harvested from each pond



Good and bad news!

- There was a clear statistical relationship ($P = 0.02$)
- Staff feeding the marron in the low density ponds could indeed feed effectively to demand
- Unfortunately, there was still a lot of scatter among these points
- Predicting biomass (or potential harvest) from the apparent feed demand will not be very accurate

Do farming conditions vary much from year to year?

- Clearly they do. Variation in water temperature and rainfall are the key variables
- Water reuse can help with both:

  - Cool water can be flushed through the ponds in the morning & reduce BOD

  - Reuse of water helps greatly in low rainfall years when supply is limited.

Overall

- Marron farming should provide consistent results
- Predicting total harvest or average size for processors is difficult
- **Greatest help is good management to maximise growth & survival rates in the pond and in the shed**
- Hopefully Craig Lawrence's FRDC project will reduce size variation within ponds.

4.0 The cost of building a marron farm within an existing farming property

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

Caveat

These estimates have been developed for a convenient marron farming site. All potential marron farming locations and form designs 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. No profitability estimates will be presented in this talk. The capital costs that we have used strongly reflect the considerable experience that George Cassells has accumulated in reviewing the problems with underperforming farms. As such this paper strongly asserts some of the Department's key extension messages to marron farmers.

4.1 Background

MarronProfit is under development on a contract basis by Bill Johnston of Queensland Dept of Primary Industries for the Department of Fisheries. This is an excellent Pearling and Aquaculture Program initiative that is being coordinated by Dan Machin and Mandy Dearden and should lead to a farmer being able to purchase the package and enter cost and production values that are appropriate for that farmer's site and approach to marron farming. The above authors (Cassells et al.) have provided the estimates of physical resources needed and capital costs for a convenient site and their farming strategy.

All individual assessments of farm costs 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.

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.

4.3 Assumptions

4.3.1 Cost of servicing capital investment

No estimate is provided here.

4.3.2 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, an office and has electricity connection with a capacity sufficient to allow development of the marron farm.

4.3.3 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.

4.3.4 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. A 4WD motor bike 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).

4.3.5 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 next 5 items in this category are often ignored by farmers 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 eg 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 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 Thompson'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.

4.3.6 Water supply and water treatment

It is assumed the farm already has an established water supply eg 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.

4.3.7 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.

4.3.8 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.

4.4 References

Cassells, G. Brand-Gardner, S. and Maguire, G. How to Farm Marron in Western Australia. Draft Monograph. Department of Fisheries, Perth, Western Australia.

Physical Property Description

General Description

Total farm area	11.5	hectares
Area for growout ponds	5.00	hectares
Area for juvenile and broodstock ponds	0.46	hectares
Area for settlement/reed ponds	0.37	hectares
Area available for infrastructure	6.04	hectares

Growout Pond Dimensions and Requirements (at water level)

	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
Width of ponds	35.00	50.00	25.00	20.00	12.50	metres
Depth of ponds	0.00	0.00	1.50	1.60	0.80	metres
Pond surface area	0.12	0.25	0.10	0.05	0.02	hectares
Pond volume	0.00	0.00	1.50	0.80	0.13	megalitres
Ponded area	1,225	2,500	50,000	3,500	1,094	square metres

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	0	0%
Office	0	$0	$0	0	0	0%
Electricity connection to property/ponds	-	$0	$0	0	20	100%
Purging and Processing Facility						
Tanks	4	$700	$2,800	0	10	10%
Blower and aeration equipment	1	$750	$750	0	10	0%
Chiller or freezer	1	$750	$750	0	15	10%
Cold room (post processing)	1	$6,000	$6,000	0	20	10%
Scales	1	$500	$500	0	5	5%
Sort table	2	$350	$700	0	20	5%
False tank bottoms	4	$250	$1,000	0	5	0%
Pumps	2	$250	$500	0	5	10%
Vehicles and Machinery						
Utes	1	$10,000	$10,000	0	10	20%
Motorbikes / four wheelers	1	$7,000	$7,000	0	10	20%
Tractor / bobcat	0	$0	$0	0	0	0%
Bucket and blade	0	$0	$0	0	0	0%
Trailer	1	$600	$600	0	5	20%
Mower / slasher	0	$0	$0	0	0	0%
Ponds						
Growout pond construction	50	$3,883	$194,150	1	20	100%
Growout pond piping and infrastructure	50	$385	$19,250	1	20	20%
Growout pond electricity connection	50	$1,320	$66,000	1	20	100%
Juvenile and broodstock pond construction	14	$1,600	$22,400	0	20	100%
J and B pond piping and infrastructure	14	$215	$3,010	0	20	20%
J and B pond electricity connection	14	$100	$1,400	0	20	100%
Venturi aerators	12	$100	$1,200	0	10	20%
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	20	40%
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	0	20	100%
Reed/bioremediation pond construction	1	$4,000	$4,000	0	20	100%
Startup Stock						
Juveniles	-	$0	$0	0	0	0%
Breeding stock	-	$9,429	$9,429	0	20	0%
Other	-	$0	$0	0	0	0%
Other Infrastructure and Equipment						
Additional pumps	1	$3,500	$3,500	0	10	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	0	0%
Water storages	0	$0	$0	0	0	0%
Venturi pumps	9	$225	$2,025	0	0	0%
Aerator controllers	16	$100	$1,600	0	0	0%
Total capital outlay			**$501,714**			

5.0 Key features of the Pemberton Freshwater Research Centre tour

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

Today's field day highlight should be the tour of the Dr Noel Morrissy Pond Complex at Thompson's Flat Annexe, which 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 "Obtaining good survival in the pond and in the shed" 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 and outdoor tanks with the latter including 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 Thompson's Flat and this is listed in the attached Powerpoint summary.

The hatchery site has additional facilities to inspect including a nursery pond built to the Department's recommended commercial design. The simple but effective system for counting tiny summer juveniles, without allowing them to dry out or experience physical abrasion, is also displayed. There is also a nutrition facility largely designed for trout but the numerous posters on permanent display help explain aquatic nutrition and feed design and lupin usage options in a very user-friendly manner.

The recently expanded Pemberton Aquaculture Producers' marron processing, marketing and tourism facility is also open for inspection.

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 PFRC marron tour (Pemberton Freshwater Research Centre)

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

Pemberton staff

- **Tony Church (Manager)**
- **Terry Cabassi (Technical Officer)**
- **Marron/general Technical Officer (to be advertised)**
- **Dave Evans - Nutrition Technical Officer Casual 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

Pemberton Aquaculture Producers

- Efficient processors and marketers are critical for the industry
- Now have a tourism component

PFRC "hatchery" area

- Nursery pond design (very successful)
- Set-up for counting summer juveniles
- Swirl separator
- Trout production/feed storage facilities
- New trout feeds research area
  (posters on nutrition – Dr Brett Glencross)
- Meeting/Training room (available to Industry)
- Tail blister trial (continuation)