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Report to farmers

Aquaculture production survey Queensland 2005–06

Queensland Government
Department of Primary Industries and Fisheries

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The Department of Primary Industries and Fisheries (DPI&F) seeks to maximise the economic potential of Queensland's primary industries on a sustainable basis.

Contents

1. Production summary

The total value of the Queensland aquaculture industry increased by 4% over the last 12 months, with the value of production increasing from $67.9 million in 2004–05 to $70.5 million in 2005–06. This increase was largely due to an increase in the barramundi sector by more than 20% from $11.9 million to $13.9 million.

In Queensland, the total value of fisheries production including aquaculture in 2005–06 was $253.5 million, 9% lower than the previous year.

Although there has been an increase in aquaculture production of 4% over the last 12 months, the wild-catch fishery has declined by 12%. The proportion attributed to aquaculture has increased from 24% to 27% over the last 12 months. (Table 1)

Marine prawn production now includes all species of prawns (black tiger—*Penaeus monodon,* banana—*Penaeus merguiensis* and kuruma—*Penaeus japonicus*) grown in Queensland. This is the result of the demise of the kuruma sector, with only two farms producing small quantities for the Australian market.

Production in this sector increased by 11% from 2964 tonnes in 2004–05 to 3300 tonnes in 2005–06. The value of this sector only increased marginally from $45.9 million in 2004–05 to $46.3 million in 2005–06.

The area harvested decreased marginally from 804 hectares in 2004–05 to 802 hectares in 2005–06. The number of producing farms decreased from 31 to 29 over the same period.

The average price of $14.14/kg was considerably lower than the average price of all species of prawns in 2004–05. Comparable prices are difficult to estimate because the 2003–04 and 2004–05 figures include the higher valued kuruma prawns. Farms held considerable quantities of frozen stock as a result of the over-supply issues largely due to the imported vannamei prawns.

Barramundi *(Lates calcarifer)* production increased significantly (21%) from 1437 tonnes to 1745 tonnes in 2005–06. This was on top of a 20% increase the previous year. The value of the industry increased by 18%, from $11.9 million in 2004–05 to more than $14.0 million in 2005–06. The average price on a whole fish basis decreased from $8.30 to $8.04/kg.

The majority of production came from pond-based systems although the production from recirculating tank systems increased from 44 tonnes to 105 tonnes (+139%).

Over this period, the number of producing pond-based farms remained at 25 while the number of tank-based systems increased from 3 to 11. There was just one sea-cage operation.

Table 1. Queensland fisheries production—gross value (2000–01 to 2005–06)

	ABARE figures			Queensland figures(1)		
Year	Total fisheries ($m)	Aquaculture ($m)	Aquaculture (%)	Total fisheries ($m)	Aquaculture ($m)	Aquaculture (%)
2000–01	277.6	56.1	20.2	na	na	na
2001–02	281.3	75.2	26.7	na	na	na
2002–03	288.0	62.9	21.8	na	na	na
2003–04	324.6	67.7	20.8	328.2	71.3	21.7
2004–05	278.6	64.5	23.1	282.0	67.9	24.1
2005–06	253.5	69.3	27.0	254.6	70.5	27.6

(1) The Queensland figures include hatchery production for farm stocking and impoundment restocking. Farm stocking details are excluded from the ABARE figures. Details on numbers and values of the species stocked are included in section 8.2 of this report.

Sources: Australian Bureau of Agricultural and Resource Economics (ABARE), Department of Primary Industries and Fisheries

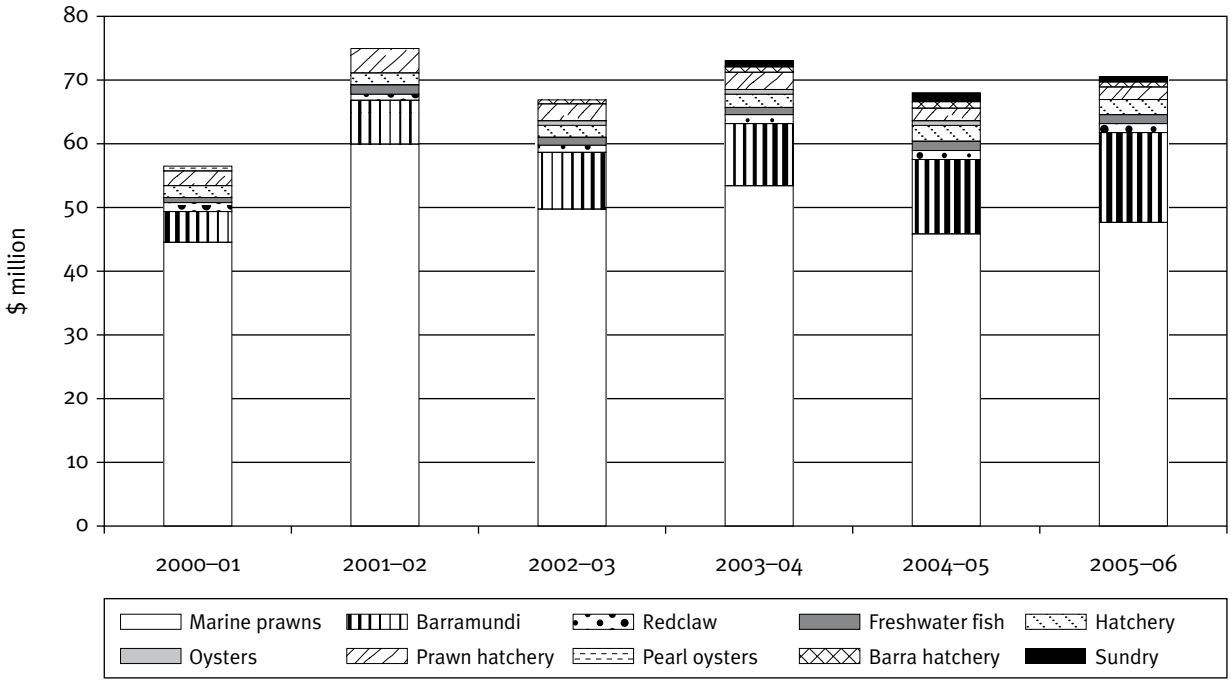

Figure 1. Total value of Queensland aquaculture production ($ million)

Redclaw crayfish (*Cherax quadricarinatus*) has continued its steady increase, with production rising to 105 tonnes in 2005–06. This is a 6% increase on the 99 tonnes produced in 2004–05. Over the same period, the value of redclaw sold as food increased only marginally from $1.28 million in 2004–05 to $1.30 million in 2005–06.

The number of producing farms was 59, 4 less than in 2004–05. There were 128 farms that reported no production at all for 2005–06, compared with 106 farms in 2004–05. Dry conditions resulted in some farms having to abandon production.

Average farm productivity decreased by 9% from 1648 kg/ha in 2004–05 to 1493 kg/ha in 2005–06. The average price obtained for redclaw crayfish has now decreased for the third consecutive year with the average price ($12.43/kg) being 4% below that achieved in 2004–05.

The freshwater fish growout sector currently produces silver perch *(Bidyanus bidyanus),* jade perch *(Scortum barcoo),* golden perch (*Macquaria ambigua)*, Murray cod *(Maccullochella peelii peelii)* and sleepy cod *(Oxyeleotris lineolatus)*. Golden perch and sleepy cod production cannot be reported separately for confidentiality reasons, as insufficient farms produced these species.

The total production of the freshwater fish sector increased by 45%, from 105 to 152 tonnes, with the value increasing by 64%, from $0.9 million to $1.48 million.

In 2005–06, silver perch accounted for 40% of freshwater fish production, jade perch 28%, Murray cod 28% and other species 4%; whereas in 2004–05, silver perch accounted for 60%, jade perch 29% and Murray cod was less then 10%. Recirculating tank systems accounted for 27% (40 tonnes) of the total freshwater fish production.

Murray cod production is now reported as a separate species entity. Production now exceeds 40 tonnes and is valued at $531 000, and it is now the most valuable species sector within the freshwater fish group with silver perch production valued at $512 000 and jade perch at $346 000.

There were 5 Murray cod producers, 8 jade perch and 16 silver perch producers. The average prices per kilogram for silver and jade perch were $8.37 and $8.25 respectively, while Murray cod averaged just over $12.50/kg.

Production from the eel sector *(Anguilla* spp.*)* has continued to decline and there were only three producers in 2005–05. As a result, information on production can not be included for confidentiality reasons.

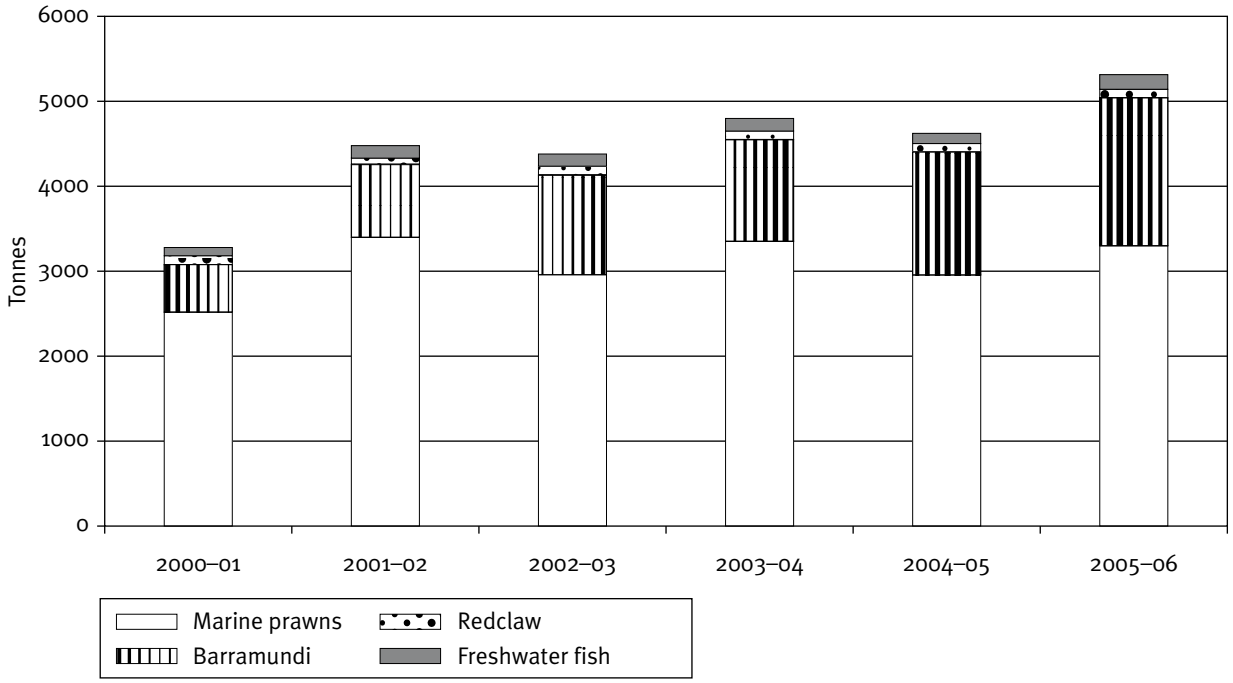

Figure 2. Queensland aquaculture total production (tonnes)

The hatchery sector, producing native fish fingerlings and ornamental aquarium species, increased sales by nearly 10% from approximately 9.5 million fingerlings to 10.4 million and the total value reached $3.4 million. Australian bass sales nearly doubled from the previous poor production year. Ornamental fish sales exhibited the greatest growth for the sector with sales of natives up 120% and exotics up 15%. Ornamental sales now total $1.26 million.

The reported oyster production all occurs on leases south of Hervey Bay and is confined to the culture of rock oysters *(Saccostrea glomerata)* on 'furniture' placed on tidal land, predominantly above mean low water. Oyster production rotationally harvested from rocky foreshore areas is no longer reported as aquaculture production and is now reported as part of the wild caught fisheries production.

Total edible oyster production decreased by 24% from 213 000 dozen in 2004–05 to 161 500 dozen in 2005–06, while the value of the industry increased by 20% to $574 000. The average price per dozen oysters increased marginally from $3.45 to $3.56 per dozen. This production was from 30 oyster areas compared with 34 areas in 2004–05.

The value of the pearl oyster industry in Queensland continues to fluctuate as some of the farms rebuild stocks of nucleated pearls. Two farms reported information this year and consequently the production information cannot be disclosed for confidentiality reasons.

The total permanent labour force in the aquaculture industry decreased from 512 units in 2004–05 to 455 units in 2005–06. The marine prawn sector accounted for 186 units or 41% of the total. When permanent and casual labour is combined, the employment in the Queensland aquaculture industry decreased by more than 15% from 686 full-time equivalents (FTEs) in 2004–05 to 584 FTEs in 2005–06.

2. Survey methods

Production statistics for the financial year 2005–06 were collected from farms producing marine prawns, barramundi, redclaw crayfish, freshwater growout fish, eels and hatchery and aquarium producers. Statistics collected from the edible and pearl oyster growers relate to culture areas.

Survey forms were mailed to development permit (aquaculture authority) holders for the species listed below. The number of forms mailed increased from 777 in 2004–05 to 784 in 2005–06. The results presented in this report reflect the information provided by the industry through the statistical returns. Non-producing farms were able to respond by ticking the 'nil production box' and were not required to provide further details about their operations. In some sectors, non-response by some of the larger growers can provide a result that under-represents the true industry situation.

The total numbers recorded for each species group are based on operations that have these species authorised on their development permit. Some development permits have more than one species on their approval. The 87% response rate for 2005–06 (Table 2) was higher than the 82% response rate achieved in 2004–05.

The following are conversion factors and definitions used in the report:

Conversion factors

Fish production is reported on a whole fish basis. For example gilled and gutted barramundi to whole fish (0.89:1 on weight basis) and filleted barramundi to whole fish (0.48:1 on weight basis).

Fingerling fish:

Small fish in the 2 to 10 gram range.

Juvenile crayfish

Immature crayfish in the 1 to 15 gram range.

Labour conversion

Labour Full-time Equivalents (FTEs) are calculated by adding the total permanent labour units to the casual labour units converted to FTEs. Forty hours per week casual labour for 48 weeks per year is considered as one FTE labour unit. Information collected in hours per week was converted to FTEs by dividing total hours by 40 hours.

Table 2. Response rates to survey questionnaire

	Number mailed	Number returned	Per cent returned
Marine prawns	59	53	90
Barramundi	134	115	86
Redclaw crayfish	211	187	89
Freshwater fish	144	124	86
Eels	35	30	86
Hatchery and aquarium	75	69	92
Edible oysters	112	99	88
Pearl oyster culture areas	14	8	57
Total	**784**	**684**	**87**

Note: All holders of development permits in Queensland are required, as a condition of their approval, to complete an Annual Statistical Return. The Department will be corresponding with all permit holders who have not completed the 2005–06 returns. Failure to accurately complete the statistical returns constitutes a breach of aquaculture approval conditions and will result in the issuing of a fisheries infringement notice.

From 1 March 2005, all aquaculture licences were transitioned to development permits as prescribed under the *Integrated Planning Act 1997*.

3. Marine prawns

3.1 General

The value of the Queensland prawn industry (including black tiger, banana and kuruma prawns) increased marginally (1%) from $45.9 million to $46.3 million in 2005–06. In addition to this hatcheries sold post larvae to a value of $1.6 million.

The number of producing farms has declined for the second time in the last five years from 31 farms in 2004–05 to 29 farms in 2005–06. There are a number of farms that have ceased production and one has sold as a result of import price pressures on Australian markets and lower overseas market prices.

Previous reports have separated the kuruma prawn *(Penaeus japonicus)* production from the other two main species—black tiger *(Penaeus monodon)* and banana prawns *(Penaeus merguiensis)*. Kuruma production has almost ceased in Queensland with only two farms producing limited quantities for the Australian market. This sector has declined slowly over the last three seasons as outlined in section 3.4.

Total prawn production information for the three species has been combined for the 2005–06 season in the following section. Previous year's information has also been combined to allow comparisons between years. The higher valued kuruma prawns have increased the average price ($/kg) for the 2003–04 and 2004–05 seasons but was not such a significant influence in 2005–06.

The value (ex-farmgate) of marine prawn production increased slightly from $45.9 million in 2004–05 to $46.3 million in 2005–06. Prices ranged from $11.00 to $19.00/kg, excluding the kuruma prawn prices. The average price was $14.14/kg. The majority of sales were in Australia (98%) while only 2% were exported, which was down from 7% in 2004–05.

There were 22 farms that produced over 20 tonnes in 2005–06, which was the same as the previous year. Twenty-one farms (16 in 2004–05) produced more than 50 tonnes (Table 4), while 12 (9 in 2004–05) produced more than 100 tonnes. Four farms (5 in 2004–05) averaged more than 6000 kg/ha/crop.

The total ponded area on farms decreased by 10%, from the 794 hectares in 2004–05 to 713 hectares at the end of 2005–06. Over the same period, the area stocked decreased by 6% from 885 to 835 hectares. The total harvested area decreased marginally from 804 hectares in 2004–05 to 802 hectares in 2005–06.

Pond sizes ranged from 0.40 to 1.70 hectares with an average size of 1.02 hectare. The average number of crops per pond per year remained constant at one crop per year. There were six farms (four in 2004–05) that produced more than one crop per year. The average stocking rate decreased from 36 post-larvae per square metre down to 33. Stocking rates varied from 13 to 50 with 4 farms stocking at 40 or more per square metre compared with 8 farms the previous season.

3.2 Marine prawn production

3.2.1 Growout

Production of marine prawns has increased by over 11% from 2964 tonnes (31 farms) in 2004–05 to 3300 tonnes (29 farms) in 2005–06.

Table 3. Marine prawn production by aquaculturists in Queensland (2003–04 to 2005–06)

	2003–04	2004–05	2005–06
Total production (tonnes)	3361	2964	3300
Average price ($/kg)	$15.86	$15.49	$14.14
Total value ($ million)	$53.3	$45.9	$46.3
Average yields (kg/ha/crop)	3457	3684	4118

Table 4. Number of approved marine prawn farms and production levels in Queensland (2003–04 to 2005–06)

	2003–04	2004–05	2005–06
Production (tonnes)	**No.**	**No.**	**No.**
0.1 to 5.0	1	3	3
5.1 to 10.0	3	3	1
10.1 to 20.0	6	3	3
20.1 to 50.0	6	6	1
50.1 to 100.0	5	7	9
100.1 to 200.0	9	7	7
More than 200	4	2	5
Number of producing farms	34	31	29
Number of non-producing farms	14	18	19
Number of hatcheries only	7	6	5
Total number of responses	55	55	53
Number of farms surveyed	60	60	59

The quantity of feed increased from 6653 tonnes in 2004–05 to 7325 tonnes in 2005–06. Over the same period, the estimated feed conversion ratio (FCR) has remained the same at 2.2:1. There was a change in the source of feed with an increase in the use of Australian feed. In 2005–06, feed sources were 36% from Australia (29% in 2004–05) and 64% from overseas (71% in 2004–05).

3.2.2 Hatchery

Fifteen (16 in 2004–05) prawn hatcheries in Queensland produced an estimated 338 million post-larvae (PL) (337 million PL in 2004–05). The number of PLs produced has returned to stable levels of between 320 and 350 million (Table 5). The large increase in 2003–04 was the result of one farm producing large numbers of banana prawns that were not stocked.

The between-year comparative figures are further complicated by the production of banana prawns, where pond reared spawners are being used for PL production rather than obtaining spawners from the wild.

3.2.3 Labour

The total labour employed on marine prawn farms over the last four years is shown in Table 6. There has been a continued increase in the efficiency of permanent labour with production increasing from 12.4 tonnes per unit (2004–05) to 18.9 tonnes in 2005–06. The decrease (–27%) in permanent labour follows a decrease of 16% the previous year.

Table 5. Marine prawn hatchery production in Queensland (2003–04 to 2005–06)

	2003–04	2004–05	2005–06
Number of spawners purchased	6546	4996	3521
Number of spawners used	6203	3969	3505
Number PLs produced (million)	710.5	330.8	338.5
Number stocked (million)	394.1	299.2	295.7
Number PLs sold (million)	166.5	142.0	97.7
Value PLs sold (million)	$2.81	$2.23	$1.56
Average value PLs (cents)	1.69	1.57	1.60

Table 6. Labour use on marine prawn farms in Queensland (2003–04 to 2005–06)

	2003–04	2004–05	2005–06
Permanent labour (tonnes–unit)	11.8	12.4	18.9
Total permanent (units)	285	239	175
Casual labour (hours/tonne)	51	72	41
Total casual labour (hours)	171 520	213 172	136 302
Full-time equivalent labour units	374	350	245
$ output per labour unit	$142 436	$131 254	$188 770

Total casual hours employed has decreased by more than 30% over the last 12 months from 213 172 to 136 300 hours. This has resulted in the casual hours per tonne decreasing from 72 to 41 hours per tonne. The dollar output per labour unit employed in the industry has increased by over 40% over the last 12 months. There has been a 30% decrease in FTEs employed in the industry. The FTEs have decreased from 350 to 245.

3.3 Hatchery sector

There were six marine prawn hatcheries in Queensland that only operated a hatchery facility and did not have growout ponds in the 2005–06 season. These hatcheries supply PL to the growout sector of the industry. Responses were received from five hatcheries that produced banana, kuruma and black tiger PL for the growout farms. They supplied 28% (84 million) of the marine prawn PL in 2005–06. The total value of production from these hatchery only operations in 2005–06 was $0.9 million, which compared with $2.2 million in 2004–05.

From the returns received, this sector employed 11 permanent employees (12 in 2004–05) and together with casual employees provides employment for 11 FTEs (14 in 2004–05). Total output per labour unit in 2005–06 was $80 500 compared with $136 300 in 2004–05.

3.4 Kuruma prawn sector

Kuruma *(Penaeus japonicus)* production has continued to decline and for confidentiality reasons (less than three farms in 2005–06) no production information can be provided in this report. In 2004–05, three farms produced 76 tonnes valued at $3.7 million. The small tonnages produced in the 2005–06 season have been included with the other marine prawn information.

The first farm produced these prawns in the 1990–91 season as a trial for the Japanese markets. Production of this prawn species peaked in 1996–97 with six farms producing more than 257 tonnes valued at $14.3 million. In that year, black tiger production was nearly 1100 tonnes valued at $15.8 million. Since then the industry has continued to decline as a result of production problems and lower export prices due to changes in currency exchange rates.

Table 7. Kuruma production by aquaculturists in Queensland (2003–04 to 2005–06)

	2003–04	2004–05	2005–06
Total production (tonnes)	112.5	75.6	na
Average price ($/kg CIF Japan)	$50.96	$49.23	na
Total value ($ million)	$5.7	$3.7	na
Average yields (kg/ha/crop)	1900	1400	na
Number of survey responses	5	5	na
Number of producing farms	5	5	‹3

3.5 Industry development

The Australian Prawn Farmers Association (APFA) and the Department of Primary Industries and Fisheries (DPI&F) continues to progress the industry development plan which initially commenced in May 2005. Significant progress has been made in relation to broodstock collection areas and methodologies which will provide long-term security for prawn broodstock. The APFA has also engaged its members in a marketing strategy to ensure long-term viability of their industry.

3.5.1 Media releases

The department and the APFA continued to raise issues regarding the importation of green prawns into Australia. In May 2005, the APFA Executive Officer, Scott Walter, again supported the recent comments made by the Premier that Queensland is 'committed to better labelling and will do everything to enforce it'. The current legislation states that a label on a package containing food must include a statement relating to where the food was made, produced, or indicating if it is imported. Unfortunately, many producers are able to distort this requirement or not even adhere to the law.

3.5.2 Policies/protocols

In May 2005, version 2 of The Aquaculture Translocation Protocol, *Health Protocol for the Importation of Selected Live Penaeid Species from outside Queensland's East Coast Waters* was released.

3.6 Achievements

A consortium of DPI&F, CSIRO, Australian Institute of Marine Science, APFA, individual farms and the Fisheries Research and Development Corporation (FRDC), has sustained 30 pedigreed families over three generations—a result unprecedented internationally. Improvements were noted for reproduction, health (viral load) and weight traits over the last two generations (data taken from same age animals across different generations). More details are provided in section 12.5.4.

3.7 Publications

Robertson, C. (2001). International Advances in Prawn Farm Recirculation Technology, Information Series QO 01008.

Lobegeiger, R. (2003). Editor. Prawn Farm Bioremediation and Recirculation—Proceedings of Prawn Farm Workshops, Information Series QI 3038.

Robertson, C.H., Burford, M.A. and Johnston, A. (2003). Recirculating Prawn Farming Project, Final Report, Information Series QO 03014.

Palmer, P. (2004). Wastewater remediation options for prawn farms, Project Report Series, QO 04018.

Robertson, C. (2006). Editor. Australian Prawn Farming Manual—Health Management for Profit, ISSN 0727-6273.

The Prawn Industry Development Plan is available on the DPI&F website at www.dpi.qld.gov.au/fishweb

3.8 Further information

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4. Barramundi

4.1 General

Barramundi (*Lates calcarifer*) growout production continued to increase strongly and has averaged more than 34% per annum over the past six years (from 569 tonnes in 2000–01). The product marketed (converted to a whole fish basis) was 1745 tonnes in 2005–06 compared with 1437 tonnes in 2004–05 which equates to a 21.5% increase. The majority of production came from pond-based systems although the production from recirculating tank systems increased from 44 tonnes to 105 tonnes (+139%).

The total value of production increased by 18%, from $11.9 million in 2004–05 to $14.0 million in 2005–06. The average price (whole-fish basis) decreased from $8.30 to $8.04/kg. In addition to growout production, hatcheries sold barramundi fingerlings for growout, stocking and to the aquarium trade. These figures are reported under sections 8.2 and 8.3.

4.2 Industry production

Of the 115 authority holders who responded, 37 produced marketable fish in 2005–06. This compared with 28 from 96 in the previous year. Production came from 25 farms using pond-based systems, 1 sea-cage farm and 11 using recirculating systems (Table 8).

Table 8. Barramundi production and authorities in Queensland (2003–04 to 2005–06)

	2003–04	2004–05	2005–06
Total production (tonnes whole-fish basis)	**1204**	**1437**	**1745**
Average price ($/kg)	$8.36	$8.30	$8.04
Total value ($ million)	$10.07	$11.92	$14.03
Pond production (tonnes)	**No.**	**No.**	**No.**
0.01 to 1.0	5	5	2
1.1 to 10.0	10	3	8
10.1 to 50.0	11	11	10
50.1 to 100.0	1	2	2
Over 100.0(1)	3	4	4
Number of producing farms(1)	30	25	26
Number of non-producing farms	57	51	52
Total pond-based farms responding(1)	87	76	78
Tank production (tonnes)	**No.**	**No.**	**No.**
0.01 to 1.0	4	0	3
1.01 to 5.00	2	0	4
5.1 to 10.0	1	1	1
More than 10.00	1	2	3
Number of producing farms	8	3	11
Number of non-producing farms	31	17	26
Total recirculation farms responding	39	20	37
Pond and tank production (tonnes)	**No.**	**No.**	**No.**
Total number of responses	126	96	115
Number of farms surveyed	142	122	134

(1) Includes one sea-cage farm.

4.3 Pond production

Total farm ponded area decreased slightly with 151 hectares available in 2005–06 compared to 162 hectares in 2004–05; however, the number of available ponds increased fractionally to 342 (338 in 2004–05). The number of ponds stocked decreased from 288 ponds in 2004–05 to 240 in 2005–06. During the same period the stocked area decreased from 118 hectares to 107 hectares. The average pond area remained unchanged at 0.4 hectares (Table 9).

Data from Queensland's only sea-cage farm is included with the pond figures as, for confidentiality reasons, it cannot be released in its own category. However, this data has not been included in the pond volume and density calculations as it is not directly comparable and would significantly alter these averages. The number of fingerlings stocked increased from 3.16 million in 2004–05 to 3.40 million in 2005–06. The density at which fingerlings were stocked into ponds increased from 24 800 fingerlings per hectare in 2004–05 to 29 800 in 2005–06.

All of the barramundi produced in pond-based systems was sold domestically in both 2004–05 and 2005–06.

Even though the production increased the total feed used in ponds decreased from 2940 tonnes in 2004–05 to 2710 tonnes in 2005–06. Over the same period the estimated FCR improved significantly from 2.0:1. to 1.7:1. All feed was manufactured in Australia.

4.4 Tank-based production

There were 46 tank-based farms authorised to grow barramundi (42 in 2004–05). Statistical returns were received from 37 farms. Production from the 11 farms (3 in 2004–05) that produced marketable fish was 105 tonnes which was an increase of 139% from the 44 tonnes produced in 2004–05. This sector is undergoing rapid expansion and has increased by 320% over the past three years (Table 10).

Traditionally, tank systems have been able to achieve a higher average price than pond systems due to an increased focus on direct sales to niche markets and a higher proportion of live sales. Although this advantage was not apparent in last year's figures, it is clearly evident again in the 2005–06 figures, with tank-raised fish averaging $10.57/kg compared with pond fish at $7.88/kg. This represents a 34% price premium over pond-raised fish.

Unlike the pond-raised fish the tank producers exported some of their product (35%) in 2005–06.

Table 9. Pond production information in Queensland (2003–04 to 2005–06)

	2003–04	2004–05	2005–06
Total production (t) whole fish basis(1)	**1 179**	**1 393**	**1 640**
Average price ($/kg)(1)	$8.33	$8.29	$7.88
Total value ($ million)(1)	$9.81	$11.55	$12.92
Market (% sold within Australia)(1)	99.5	100%	100%
Number of ponds stocked	253	288	235
Total area stocked (hectares)	116	118	107
Average area (hectares)	0.5	0.4	0.4
Total fingerlings stocked (million)(1)	2.45	3.16	3.40
Fingerlings stocked/hectare	19 150	24 800	29 800
Feed used (tonnes)(1)	2 572	2 940	2 710
Feed source (% Australia manufactured)(1)	99%	100%	100%
Estimated FCR(1)	2.2:1	2.0:1	1.7:1

(1) Includes one sea cage farm.

Table 10. Recirculating farm production information in Queensland (2003–04 to 2005–06)

	2003–04	2004–05	2005–06
Total production (tonnes whole-fish basis)	**25**	**44**	**105**
Average price ($/kg)	$10.07	$8.54	$10.57
Total value ($ million)	$0.25	$0.38	$1.11
Market (% sold within Australia)	100%	98%	65%
Number of tanks stocked	91	102	227
Total volume stocked (m^3)	1 780	1 600	1 400
Average volume (litres)	19 600	15 800	6 100
Total fingerlings stocked	140 000	205 500	533 000
Fingerlings stocked/m^3	79	127	384
Feed used (tonnes)	37	62	112
Feed source (% manufactured in Australia)	76%	100%	84%
Estimated FCR	1.5:1	1.4:1	1.1:1

4.5 Fingerling production

Barramundi fingerling production decreased from 6.5 million in 2004–05 to 5.3 million in 2005–06. Eleven farms sold fingerlings for aquaculture during the year (see sections 8.2 and 8.3 of this report for restocking and aquarium sales). A total of 3.0 million fingerlings worth $867 000 were sold for growout (3.2 million worth $860 000 in 2004–05). Average fingerling price was 29 cents each in 2005–06 compared with 27 cents in 2004–05.

4.6 Farm labour

Permanent labour employed in the pond growout sector of the industry decreased marginally from 86 units in 2004–05 to 85 units in 2005–06. Over the same period, permanent labour in the recirculating farms increased significantly from 5 to 18. Productivity on the pond farms has increased from 12.9 tonnes of fish per unit in 2004–05 to 14.1 tonnes in 2005–06. Productivity in tank farms decreased slightly from 5.7 tonnes per unit in 2004–05 to 5.3 tonnes per unit in 2005–06; however, this figure was significantly reduced due to some tank farms that did not sell product but recorded significant labour.

Total casual labour for the pond sector decreased from 42 660 hours in 2004–05 to 37 400 in 2005–06. Casual labour on recirculating farms decreased from 5100 hours in 2004–05 to 2670 hours in 2005–06. When the permanent and casual labour inputs are combined for both sectors, the total number of full-time equivalent labour units increased from 116 in 2004–05 to 124 in 2005–06. The dollar output per labour unit for the pond sector increased from $106 900 in 2004–05 to $123 700, while for the recirculating sector the output increased from $48 700 to $56 400 per unit.

4.7 Industry development

4.7.1 Barramundi industry development plan

An Australian Barramundi Industry Planning Workshop was held in Oonoonba, Townsville on 15 March 2006 to progress an industry development plan. While the results of that workshop were considered by the ABFA, later in 2006 it was decided to use FRDC funding to further develop a new plan.

4.7.2 Barramundi genetic register

The University of the Sunshine Coast completed a genetic register to distinguish different Queensland barramundi strains currently being held by industry. The register will be a useful reference tool for both future stocking and aquaculture development.

4.8 Publications

Curtis, M. and Wingfield, M. (2004). Recirculation Aquaculture Systems Information, Information Series QI 04047, Saleable Publication.

4.9 Further information

Industry Development and Policy Officer (currently under recruitment)—(07) 3224 2762

5. Redclaw

5.1 General

Production of redclaw crayfish (*Cherax quadricarinatus*) has continued its steady increase with production rising to 105 tonnes in 2005–06. This is a 6% increase on the 99 tonnes produced in 2004–05. Over the same period, the value of redclaw sold as food increased only marginally from $1.28 million in 2004–05 to $1.30 million in 2005–06. In addition to food sales, there was an additional $18 000 generated from juvenile sales ($101 500 in 2004–05) and sales to the aquarium trade are now reported under section 8.3 of this report.

From the 211 returns mailed (222 in 2004–05) there were 187 responses (169 in 2004–05). Fifty-nine farms produced redclaw crayfish compared with 63 in the previous year (Table 11).

5.2 Growout

The number of farms that produced more than 1 tonne increased from 11 in 2004–05 to 15 in 2005–06. These 15 farms produced 89% of the state's production with the top 4 farms producing 66% of the total production. There were 128 farms that reported no production at all for 2005–06 compared with 106 farms in 2004–05.

Table 11. Number of authorised redclaw crayfish farms and production levels in Queensland (2003–04 to 2005–06)

	2003–04	2004–05	2005–06
Total production (tonnes)	**91.3**	**98.6**	**104.9**
Average price ($/kg)	$13.54	$12.98	$12.43
Total value ($'000)	$1.236	$1.280	$1.304
Pond and tank production (kg)	**No.**	**No.**	**No.**
1 to 100	18	17	18
101 to 500	16	26	20
501 to 1000	7	9	6
1001 to 5000	15	6	11
More than 5000	4	5	4
Number of producing farms	60	63	59
Number of non-producing farms	123	106	128
Number of responses	183	169	187
Number of farms surveyed	224	222	211

Table 11 shows that after increasing for a number of years, the average price obtained for redclaw crayfish has now decreased for the third consecutive year with the average price being 4% below that achieved in 2004–05. The average prices were $13.92 in 2002–03, $13.54 in 2003–04, $12.98 in 2004–05 and $12.43 in 2005–06. Prices ranged from $7.00 to $30.00/kg, although most sold in the $10.50 to $15/kg range.

The total available ponded area on farms increased from 118 hectares (2004–05) to 125 hectares in 2005–06. There were 708 ponds stocked with redclaw in 2005–06 totalling 79 hectares; however, only 417 ponds (70 hectares) were harvested. The average pond size has decreased marginally from 1150 square metres to 1120 square metres.

Average farm productivity (calculated from harvested growout area) was 1495 kg/ha which was a slight decrease from the 1648 kg/ha achieved in 2004–05. The average yield for the 21 farms producing more than 500 kg was 1920 kg/ha. For the 15 farms producing more than 1000 kg the average was 2080 kg/ha, and for the 4 farms producing more than 5000 kg the average productivity was 2570 kg/ha. Average yields for the 15 farms producing more than 1000 kg ranged from 985 to 3830 kg/ha with 8 of these farms producing more than 2000 kg/ha.

Total feed purchased was 257 tonnes in 2005–06 compared with 264 tonnes the previous year. The estimated average feed conversion ratio improved slightly from 2.6: 1 in 2004–05 to 2.5:1 in 2005–06.

In 2005–06, the majority of product (86%) was sold on the domestic market; however, export sales increased significantly rising from 3% to 14% of production.

5.3 Tank-based production

Two tank-based systems reported a very modest amount of production in 2005–06. No tank-based production was reported in either of the two proceeding years. As specific details cannot be published due to confidentiality issues, the production data from tank-based systems has been included with the rest of the growout sector.

5.4 Juvenile production

Juvenile production increased from the 4 million produced in 2004–05, to 6.5 million in 2005–06. Sales decreased from 233 000 ($63 000) in 2004–05 to 83 000 ($18 000) in 2005–06. Over the same period, the average price paid for juveniles decreased from $0.27 to $0.22. The number of juveniles stocked increased from 3.6 million (43 farms) in 2004–05 to 4.95 million (46 farms) in 2005–06. The average stocking rate of juveniles into growout ponds increased from 4.8 per m^2 to 6.2 per m^2.

5.5 Labour

Total permanent labour employed decreased from 51 units in 2004–05 to 37 units in 2005–06 and the total hours of casual labour used on farms also decreased from 2046 to 1120.

In terms of labour efficiency, the number of permanent labour units used to produce one tonne of crayfish has decreased from 0.5 units in 2004–05 to 0.3 units in 2005–06. The number of casual hours has also decreased from 21 hours per tonne in 2004–05 to 10.7 in 2005–06.

When the permanent and casual labour inputs are combined, the sector employs 47 full-time equivalent labour units compared with 52 the previous year. The product output per labour unit increased from 1900 kg ($24 600) to 2220 kg ($27 500) in 2005–06.

5.6 Publications

Macbeth M., McPhee C., Burke M., Bartlett J., Jones C., Knibb W. (2003). Genetic selection of aquatic organisms including prawns with a special focus on the way to integrate a breeding programme into private industry. In: Goarant C, Harache Y, Herbland A, Mugnier C (eds). Styli 2003. Thirty years of shrimp farming in New Caledonia. IFREMER, New Caledonia, pp 106–112.

Wingfield, M., (2003). Proceedings of the 5th Annual Redclaw Conference—17 and 18 October 2003, Conference and Workshop Series, QC 04001, Saleable Publication.

O'Sullivan D., Fielder D., Jones C. (2003). Chapter 20. Freshwater Crustaceans, In: Lucas JS, Southgate PC (eds). Aquaculture: Farming Aquatic Animals and Plants. Blackwell Publishing, Oxford, pp 420–442.

McPhee C., Jones C., Shanks S. (2004). Selection for increased weight at 9 months in redclaw crayfish (Cherax quadricarinatus), Aquaculture 237: 131–140.

Stevenson, J. (2005). Notes from the 5th Annual Redclaw Conference—9 and 10 September 2005. Publication of the Queensland Crayfish Farmers Association.

5.7 Further information

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6. Freshwater fish

6.1 General

This section examines fish (other than barramundi) raised in fresh water for human consumption. For the last few years the main species that have been cultivated have been silver perch (*Bidyanus bidyanus*), jade perch and Barcoo grunter *(Scortum barcoo)*. In 2005–06 there was a significant increase in Murray cod *(Maccullochella peelii peelii)* growout production and some interest in the production of, sleepy cod *(Oxyeleotris lineolatis)* and golden perch *(Macquaria ambigua)*.

The very significant increase in Murray cod production in 2005–06 has resulted in some major changes to the structure of the freshwater fish section of this report and to the relative importance of the various species reported in this section. Murray cod production is now reported as a separate species entity (previously it was grouped in the 'other species' category). Furthermore, with Murray cod production now attaining $531 000 worth of sales, it is already the most valuable species sector within the freshwater fish group (with silver perch production valued at $512 000 and jade perch at $346 000).

Statistical returns were mailed to 144 licensed freshwater fish producers and 124 were returned. One hundred and three respondents used pond-based systems and 21 used recirculating tank systems. Many of the authority holders have a number of different species on their approval. The total production of the freshwater fish sector increased by 45% from 105 to 152 tonnes with the value increasing by 64% from $0.9 million to $1.48 million.

In 2005–06, silver perch accounted for 40% of freshwater fish production, jade perch 28%, Murray cod 28% and other species 4%; whereas in 2004–05, silver perch accounted for 60%, jade perch 29% and Murray cod was less then 10%. Recirculating tank systems accounted for nearly 27% (40 tonnes) of the total freshwater fish production.

6.2 Silver perch

Statistical returns were mailed to 125 authorised silver perch producers and 106 were returned. Sixteen authority holders produced and sold silver perch in 2005–06. Fifteen of the 16 producing farms used pond-based system with just 1 tank-based system producing silver perch. In 2004–05, 16 farms produced fish and all were pond-based.

In 2005–06, the silver perch industry dropped marginally in terms of both production and value. Production totalled 61.2 tonnes (62.5 tonnes in 2004–05) and the total value of the industry was $512 000 ($516 000 in 2004–05). However, the average price (whole-fish basis) increased marginally from $8.26 to $8.37/kg (Table 12). Table 12 combines production from both pond and tank systems.

6.2.1 Pond systems

The total ponded area on producing farms increased from 23 hectares in 2004–05 to 30 hectares in 2005–06. The total area stocked to silver perch increased from 16 hectares in 2004–05 to 20 hectares in 2005–06. Over this same period, the number of fingerlings stocked decreased from 402 600 to 358 200. The average stocking rate also decreased from 25 800 per hectare in 2004–05 to 18 000 per hectare in 2005–06.

The area harvested has increased from 13.5 hectares in 2004–05 to 17.1 hectares in 2005–06.

Total food used decreased from 245 tonnes in 2004–05 to 174 tonnes in 2005–06. Over this same period the FCR improved significantly from 3.9:1 to 2.9:1.

6.2.2 Recirculation systems

There were 21 farms utilising tank-based recirculation systems authorised for silver perch production. Only one of these operations reported any production in 2005–06 and therefore (for confidentiality reasons) the production details cannot be released. In 2004–05, there were 22 farms utilising tank-based systems and none of them reported any sale of product.

6.3 Jade perch

Statistical returns were mailed to 57 licensed jade perch producers and 50 were returned. Jade production in 2005–06 totalled 41.9 tonnes, which was a 36% increase from the 30.8 tonnes produced in 2004–05. In 2005–06, production came from six pond-based systems and two tank-based operations. Table 13 combines production from both pond and tank systems.

Table 12. Silver perch production by aquaculturists in Queensland (2003–04 to 2005–06)

	2003–04	2004–05	2005–06
Total production (tonnes whole-fish basis)	**55.8**	**62.5**	**61.2**
Average price ($/kg)	$8.05	$8.26	$8.37
Total value ($'000)	$449	$516	$512
Average yield (kg/ha)	3600	4600	3550
Number of survey responses	104	98	106
Number of producing farms	17	12	16

Table 13. Jade perch production by aquaculturists in Queensland (2003–04 to 2005–06)

	2003–04	2004–05	2005–06
Total production (tonnes whole-fish basis)	**38.5**	**30.8**	**41.9**
Average price ($/kg)	$7.69	$8.42	$8.25
Total value ($'000)	$296	$259	$346
Average pond-based yield (kg/ha)	5700	3950	6550
Number of survey responses	51	46	50
Number of producing farms	10	7	8

From the responses received, eight licence holders produced and sold jade perch in 2005–06 compared with seven farms in 2004–05. The total value of sales increased by 33.5% to $345 700 while the average price fell slightly from $8.42/kg in 2004–05 to $8.25/kg in 2005–06.

6.3.1 Pond systems

The total ponded area on farms decreased from 11.1 hectares in 2004–05 to 7.1 hectares in 2005–06. Over the same period, the total area stocked to jade perch decreased from 9.6 hectares to 6.3 hectares and the average yield improved from 3.95 tonnes per hectare to 6.55 t/ha. In 2005–06, the number of fingerlings stocked in ponds was 204 300 compared with 218 500 the previous year. Over the same period, the average stocking rate increased by 55% from 22 900 per hectare to 35 550 per hectare.

Total food used increased from 73 tonnes in 2004–05 to 88 tonnes in 2005–06 while the FCR improved slightly to an estimated 2.1: 1 (2.4:1 in 2004–05).

6.3.2 Recirculation systems

There were 17 farms utilising tank-based recirculation systems authorised for growing jade perch. Only two of these operations reported any production in 2005–06 and therefore (for confidentiality reasons) the production details cannot be released. In 2004–05 no production was reported from tank-based systems.

6.4 Murray cod

The 2005–06 year is the first time that Murray cod production could be reported in its own right. This is due to significant increases in both the quantity of Murray cod being produced and the number of growers that are now producing this species.

Statistical returns were mailed to 33 authorised Murray cod producers and 30 were returned. Murray cod production in 2005–06 totalled 42.2 tonnes, which was an increase of greater than 300% from the previous year. In 2005–06, five farms produced Murray cod. Three of the farms producing Murray cod were utilising recirculating tank technology and two were using partitioned pond-based systems.

The total value of sales was $530 700 while the average price achieved was $12.57/kg.

6.4.1 Murray cod production details

As all the Murray cod production came from five farms (two pond-based and three tank-based) all published information must combine production from the two systems so as not to breach client confidentiality. There were a total of 214 300 Murray cod fingerlings stocked. The total food used was 72.5 tonnes and the FCR was 1.7:1.

6.5 Other species

Other species authorised for production in both ponds and tank systems include golden perch, sleepy cod, Australian bass and sooty grunter. The relatively small quantities produced and the limited number of producers means that detailed information cannot be provided in this report. Total production for these species has, however, increased steadily over recent years (though with Murray cod no longer being listed under this category direct comparison with previous years is difficult). In 2005–06, production was 6.3 tonnes valued at $93 000. Most of the production was golden perch with a significant amount of sleepy cod. Due to both golden perch and sleepy cod being well regarded in the market place the average price was relatively high at $14.83/kg.

6.6 Labour (freshwater fish)

The total number of permanent labour units in the freshwater fish growout sector has nearly doubled from 16 in 2004–05 to 30 in 2005–06 (11 silver perch, 7 jade perch, 11 Murray cod and 1 for the other species). For silver perch the output has decreased slightly from 5.5 tonnes per unit in 2004–05 to 5.0 tonnes per unit in 2005–06. Over the same period, jade perch production decreased from 8.3 tonnes per labour unit to 5.8 tonnes (though it was 9 tonnes for pond systems). The output for Murray cod was 4.2 tonnes per labour unit. Output per labour unit was dragged back for both jade perch and Murray cod as there were some tank farms that did not sell any product but recorded significant labour.

Combined casual labour for all freshwater species was 1060 hours compared with 2500 hours in 2004–05. The total full-time equivalents for the freshwater sector were 31 units in 2005–06 compared with 18 units in 2004–05.

The dollar output per labour unit for the sector remained relatively stable at $48 000 ($49 000 in 2004–05). For silver perch the output decreased slightly from $45 200 in 2004–05 to $41 600 in 2005–06, and for jade perch it also decreased $70 200 to $48 100 ($73 700 pond-based). The dollar output per labour unit for Murray cod was $52 700.

6.7 Further information

Industry Development and Policy Officer (currently under recruitment)—(07) 3224 2762

7. Eel culture

7.1 General

Production from the eel aquaculture industry in Queensland has continued to decrease steadily since reaching 71.8 tonnes in 2001–02. Due to the very low number of producing farms in 2005–06, no production data from the eel farming sector can be reported as it would compromise client confidentiality. The two species of eels that are being cultured are the long-finned eel (*Anguilla reinhardtii*) and the short-finned eel (*Anguilla australis*).

Over the last two years all eels produced were exported and marketed live. Table 14 summarises the farm pond and tank descriptions, stocking details and production for the 2003–04 and 2004–05 seasons.

7.2 Industry development

A new policy, *Policy for Management Arrangements for the Commercial Harvesting and use of Juvenile Eels, February 2006*, was completed. Management of juvenile eel fishing was then transferred to Fisheries Resource Management, with only eel farming issues now handled by the Aquaculture Industry and Development team.

7.3 Publication

Gooley, G.J. and Ingram, B.A. (Editors) (2002). Assessment of Eastern Australian Glass Eel Stocks and Associated Eel Aquaculture, Final Report FRDC Project No 97–312.

Table 14. Eel farm stocking by aquaculturists in Queensland (2003–04 to 2005–06)

		2003–04	2004–05	2005–06
Ponds	—Total area (ha)	7.1	5.2	na
	—Average area (m^2)	2 030	2 350	na
Tanks	—Total volume (m^3)	96	176	na
	—Average volume (litres)	3 900	6 300	na
Stocking	—Elvers (kg)	0	0	na
	—Glass eels (kg)	87.6	97.4	na
Total production	—(tonnes)	47.2	42.7	na
	—($)	$517 000	$568 812	na
Average price	—($/kg)	$10.95	$13.33	na

7.4 Further information

Industry Development and Policy Officer
(currently under recruitment)—(07) 3224 2762

8. Hatchery and aquarium

8.1 General

Seventy-five fish hatcheries were surveyed and responses were received from 69. The hatcheries produced a wide range of fish for use in aquaria, commercial growout and stocking in public impoundments. Table 15 summarises statistics for the major species produced in 2004–05 and 2005–06.

The total value of this sector remained relatively stable at around $3.4 million. Sales for the sector increased by 11.5%, from 9.5 million in 2004–05 to 10.7 million in 2005–06. Fingerling sales were down slightly from the 2004–05 figures for most farm and stocking species. The most notable exception to this trend was in Australian bass where sales increased by 230% after a relatively poor year in 2004–05. Combined cod (Murray, Mary and sleepy cod) sales also increased slightly from 153 800 in 2004–05 to 166 570 in 2005–06. Aquarium sales generally increased with a moderate increase in exotic ornamentals (1.49 million in 2004–05 and 1.71 million in 2005–06) and a sharp increase (127%) in native ornamentals (380 800 in 2004–05 and 864 400 in 2005–06).

Table 15. Hatchery production of native fingerlings and ornamental aquarium species in Queensland 2004–05 and 2005–06

Species	2004–05			2005–06		
	Sales (no.)	Value ($)	Aver ($)	Sales (no.)	Value ($)	Aver($)
Barramundi (farm and stocking)	4 059 650	1 227 060	0.30	3 538 170	1 065 240	0.30
Golden perch (farm and stocking)	1 736 000	301 100	0.17	1 813 130	325 520	0.18
Australian bass (farm and stocking)	405 700	152 000	0.37	1 448 000	252 340	0.17
Silver perch (farm and stocking)	816 400	113 100	0.14	617 670	110 080	0.18
Jade perch (farm and stocking)	416 800	86 200	0.21	200 000	45 560	0.23
Murray cod, Mary cod and Sleepy cod (farm and stocking)[1]	153 800	106 200	0.69	166 570	113 220	0.68
Saratoga (aquarium and stocking)	1 378	42 600	30.93	420	14 700	35.00
Ornamental fish (exotics)[2]	1 486 550	623 360	0.42	1 710 110	843 210	0.49
Ornamental fish (natives)[2][3]	380 800	254 600	0.67	864 420	372 720	0.43
Ornamental invertebrates				305 000	45 320	0.15
Marine hatchery and aquarium[1][4]	[5]	505 000		[5]	242 700	
Total (returns received)	**9.46 m**	**$3.41 m**		**10.40 m**	**$3.38 m**	

Note:

1. Species combined as insufficient producers to maintain individual confidentiality.
2. Species grouped as individual species data was not obtained.
3. All native freshwater fin fish sold to aquarium trade (e.g. rainbows, native ornamentals and lungfish as well as barramundi, golden perch etc).
4. Includes oyster and pearl oyster spat, mangrove jack, mullet aquarium fish, seahorses, corals and sandfish production.
5. Combines a number of different phyla so not appropriate to include numbers.

The hatchery sector has been expanding over the last few years to include a number of hatcheries producing a range of marine species for the aquarium trade, commercial growout and for stocking. They are reported collectively in Table 15 as 'marine hatchery and aquarium'. There were 22 marine operations surveyed and responses were received from 20 of them. This group covers a diverse range of species including oyster and pearl oyster spat, marine aquarium fish, corals, sandfish, mullet and mangrove jack.

8.2 Stocking and growout species

The hatchery operations that produced the stocking and growout species listed below utilised 212 ponds in 2005–06 compared with 150 ponds in 2004–05. They covered an area of 47 hectares compared with 31 hectares in 2004–05. The average pond area increased from 2000 m^2 to 2200 m^2. The sector also used 160 tanks totalling 890 m^3.

8.2.1 Barramundi

Barramundi *(Lates calcarifer)* fingerlings were produced in 12 hatcheries (also 12 in 2004–05). Total production was down from 6.5 million fingerlings in 2004–05 to 5.3 million in 2005–06. The majority of fingerlings were sold to growout farms with 3.0 million sold for $867 000 in 2005–06. This was a decrease of 6% from the 3.2 million fingerlings ($860 000) sold to farms in 2004–05. A significant proportion of the fingerlings produced was not sold and were on-grown by the farms that produced them. The number of fingerlings sold for stocking decreased from 900 000 valued at $370 000 in 2004–05 to 561 000 valued at $198 000 in 2005–06.

8.2.2 Golden perch

Golden perch *(Macquaria ambigua)* fingerling production was undertaken by seven hatcheries (six in 2004–05). Production remained relatively constant at just over 1.8 million in both 2004–05 and 2005–06. Sales increased slightly from 1.74 million to 1.81 million. Stocking accounted for the majority of sales (1 568 000) valued at $281 500. There was still a significant quantity purchased by the farming sector (245 000) valued at $44 000.

Unfortunately there was no successful production of the Lake Eyre strain of golden perch fingerlings in 2005–06 or 2004–05, even though they had been available in 2003–04.

8.2.3 Australian bass

Australian bass (*Macquaria novemaculeata*) were produced primarily for impoundment stocking. Production occurred in five hatcheries (three in 2004–05). Production increased dramatically from 0.8 million in 2004–05 to 1.46 million in 2005–06. Sales also increased from 406 000 in 2004–05 to 1.45 million ($252 000) in 2005–06. Approximately 100 000 fingerlings were sold to the growout sector in 2005–06 compared with 30 000 the previous year.

8.2.4 Silver perch

Silver perch (*Bidyanus bidyanus*) fingerling production was undertaken by 10 hatcheries (7 in 2004–05) and decreased from 1.03 million to 705 000 fingerlings in 2005–06. The number sold decreased from 860 000 to 618 000. Sales to growout operations dropped significantly from 490 000 in 2004–05 to 261 000 ($43 000) in 2005–06. Sales to stocking increased slightly from 327 000 to 357 000 ($67 000) in 2005–06.

8.2.5 Jade perch

Jade perch or Barcoo grunter *(Scortum barcoo)* fingerlings came from four hatcheries (four in 2004–05). All sales were to the farm growout sector; however, a significant proportion was sold overseas. Sales decreased significantly from 417 000 in 2004–05 to just 200 000 ($46 000) in 2005–06.

8.2.6 Murray cod, Mary River cod and sleepy cod

Murray and Mary River cod (*Maccullochella* sp.) and sleepy cod (*Oxyeleotris* sp.) sales were combined to maintain confidentiality of the information for the small number of producers supplying these fish. Sales for these species increased from 154 000 in 2004–05 to 167 000 ($113 000) in 2005–06. Growout farms purchased 52% of the fingerlings with the rest going to the stocking program.

8.3 Aquarium and ornamental species

Sales of freshwater ornamentals (exotic and native fish and invertebrates) totalled 2.88 million with a value of $1.26 million. Freshwater ornamental aquarium species were produced and sold from 26 hatcheries.

The production of saratoga (*Scleropages* spp.) fingerlings decreased substantially from 1378 in 2004–05 to just 420 in 2005–06. There were only four producers of saratoga in 2005–06 compared with seven in 2004–05. Their average sale price increased slightly from $30.93 in 2004–05 to $35.00 in 2005–06.

The number of ponds used by aquarium and ornamental farms decreased from 454 in 2004–05 to 371 in 2005–06. They covered an area of 17.3 hectares compared with 22.9 hectares in 2004–05. The average area decreased from to 500 m^2 to 470 m^2. There were 1776 tanks on the farms in 2005–06 compared with 1115 tanks the previous year. The average tank volume decreased from 720 litres in 2004–05 to 670 litres.

8.4 Labour (hatchery and aquarium)

Statistics for the whole sector show that it now has 56 permanent staff (61 in 2004–05) and employed 19 500 hours of casual labour (13 200 hours in 2004–05). This equates to 66 FTEs employed in the sector, which was a decrease of eight units from 2004–05. Output per labour unit increased from $45 300 in 2004–05 to $50 900 in 2005–06.

8.5 Further information

Industry Development and Policy Officer (currently under recruitment)—(07) 3224 2762

9. Pearl oyster culture

9.1 General

The value of the pearl oyster industry in Queensland continues to fluctuate as some of the farms rebuild stocks of nucleated pearls. Two farms reported information this year and consequently the production information cannot be disclosed for confidentiality reasons. The value of the industry has been included in the sundry category throughout the report.

Thirteen Pearl Culture Areas (PCAs) were surveyed and responses were received for eight of these areas. One of the farms that responded has four authorised areas but only produced pearl oysters from one area.

The main species cultured are the gold lip oyster (*Pinctada maxima*), black lip oyster *(P. margaritifera),* and penguin oyster *(Pteria penguin)*. Three new lease areas are being stocked with the akoya pearls *(P. imbricata or P. fucata)*.

9.2 Labour

A total of four permanent labour units were involved in the industry in 2005–06 compared with 12 in 2004–05. Total casual hours employed in the industry decreased from 42 680 in 2004–05 to in 8160 2005–06. The total FTEs employed in the industry decreased from 35 to 8 as a result of one farm not submitting a statistical return.

9.3 Further information

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10. Edible oyster production

10.1 General

Changes to the system for the approval of oyster production in Queensland have resulted in only the oyster production from approved aquaculture areas being published in this report.

This production all occurs south of Hervey Bay and is confined to the culture of rock oysters *(Saccostrea glomerata)* on 'furniture' placed on tidal land, predominantly above mean low water.

Oyster production rotationally harvested from rocky foreshore areas is no longer reported as aquaculture production and is now reported as wild-caught fisheries production. The species harvested in this manner are the milky oyster *(S. amasa)* and the black-lip oyster *(S. echinata)*. Production is limited to selective harvesting, retention of broodstock and maintenance of areas.

A total of 112 oyster areas authorised for aquaculture were surveyed during 2005–06 with 97 statistical returns received. The total production in Queensland has decreased by 24% from 213 300 dozen in 2004–05 to 161 500 dozen in 2005–06. The value of the industry has decreased by more than 20% to $574 000. The average price per dozen oysters increased marginally from $3.45 to $3.56 per dozen.

Oyster sales are one measure of change in an industry. To provide other indicators on industry growth and performance the numbers of shells introduced on to the authorised areas, stock losses and the stock on hand were collected for the first time in 2004–05.

Industry have indicated that problems with obtaining QX disease-free stock from New South Wales was having a major impact on growth of the Queensland industry. The information in Table 17 supports this issue with introductions down 70% on the previous year. This has then affected the number of shells held on leases. These supply problems will impact on production in the 2006–07 season with further decreases expected.

Table 16. Edible oyster aquaculturists in Queensland (2003–04 to 2005–06)

	2003–04	2004–05	2005–06
Number of oyster areas surveyed	109	111	112
Number of responses	98	98	97
Production (dozens)	**No. of areas**	**No. of areas**	**No. of areas**
Nil	71	64	67
1 to 500	14	10	10
501 to 1000	4	4	5
1001 to 2000	5	6	6
2001 to 5000	6	7	2
5001 to 10 000	4	2	3
More than 10 000	5	5	4
Total producing oyster areas	**38**	**34**	**30**

Table 17. Edible oyster introductions, losses and stocks on hand in Queensland (2004–05 and 2005–06)

	2004–05	2005–06	Change (%)
Shells introduced (dozen)	426 300	131 900	–70%
Losses (dozen)	310 500	88 700	–70%
Number on hand (30 June)	619 200	340 500	–45%

Oysters are sold in a range of different sizes to meet the market requirements. The three main size oysters marketed are bistro, bottlers and plate size. The following table (Table 19) summarises the different product types, average prices and the percentage of each product type. Bottlers make up 66% of the product marketed at an average price of $2.91 per dozen. The highest value product ($5.78 per dozen) is the plate size and they make up 11% of the product sold. Bistro oysters at $4.78 per dozen accounts for 18% of production.

10.2 Labour

Total permanent labour employed in the industry was 15 units (18 in 2004–05), while total casual employment was 1050 hours (2890 in 2004–05). This converts to 16 FTEs employed in the industry, which was down 4 from 20 from the previous year.

In terms of labour efficiency, the production per FTE was 10 400 dozen compared with 11 600 in 2004–05. Total industry output increased marginally from $36 900 per labour unit in 2004–05 to $37 000 per labour unit in 2005–06.

10.3 Industry development

The Queensland Shellfish Water Assurance Monitoring Program (QSWAMP) continued during 2005–06 but some responsibilities are to be transitioned to industry, including the collection of samples. DPI&F will continue to administer the program and coordinate sampling with the assistance of the Queensland Oyster Growers Association. A sampling training day was held for interested growers and a sampling guideline developed to assist with the transition of sampling responsibilities. Oyster growers commenced routine sampling in May.

The annual Australian Quarantine and Inspection Service (AQIS) audit of export approved growing areas was completed in May. The North Stradbroke Island oyster growing area was removed from the list of export approved areas after there had been no exports from the growing area for the last two years. The area can be nominated to be included in the list of export approved areas if there is serious interest from industry to export product. The audit found that the Moreton Island oyster growing area complied with export requirements.

Work has continued with addressing the action items of the oyster industry development plan. A policy for maximising rock oyster production through the management of non-productive oyster areas will be released for consultation next year. This policy aims to address the issue of the large number of non-productive oyster areas in Moreton Bay. Development of an oyster industry management plan for Moreton Bay Marine Park has continued with input from industry. The plan will detail how the oyster industry is to be managed within the Moreton Bay Marine Park and will streamline Marine Park requirements of the Environmental Protection Agency.

Table 18. Edible oyster production in Queensland (2003–04 to 2005–06)

	2003–04	2004–05	2005–06
Production ('000 dozen)	197.7	213.3	161.5
Value ($'000)	$687.5	$736.0	$574.2

Table 19. Edible oyster marketing information—Queensland for 2004–05 and 2005–06

Packaging type	2004–05		2005–06	
	Price per dozen ($)	Market (%)	Price per dozen ($)	Market (%)
Bottlers	$2.79	69%	$2.91	66%
Bistro	$4.21	19%	$4.78	18%
Plate	$6.76	10%	$5.78	11%
Others	$1.99	2%	$2.64	4%
Average return—all oysters	**$3.45**		**$3.56**	

10.4 Publications

Queensland Oyster Industry Development Plan (2005) available on the DPI&F website at www.dpi.qld.gov.au/fishweb

QSWAMP Sampling Guideline. (2006)

10.5 Further information

Rebecca Paine (Industry Development Officer)—(07) 3239 3050 or rebecca.paine@dpi.qld.gov.au

11. Regional summary

Information has been analysed to provide a regional overview of the aquaculture industry in Queensland. The regions are based on the Statistical Divisions adopted by the Australian Bureau of Census and Statistics.

The information presented in Tables 20 to 24 was compiled from the Annual Statistical Returns received from licensed aquaculture producers. The totals include all sectors of the industry described in the earlier part of this report.

The results presented in these tables need to be interpreted carefully as they only summarise the information collected from the farms that responded and submitted statistical returns. The number of returns received varies between years as shown in Table 20. In any one year, it may not be the same producers responding and this can affect the trends. Rounding errors can cause minor discrepancies in some of the totals.

The main sectors (marine, barramundi, freshwater fish and freshwater crayfish) have a major influence on value and quantities produced.

Table 20. Response rates—Queensland (2003–04 to 2005–06)

	2003–04	2004–05	2005–06
Number of authorised producers (no.)	654	655	617
Questionnaires mailed (no.)	918	777	784
Questionnaires received (no.)	784	638	684
Response rate (%)	85%	82%	87%

Table 21. Farmgate value ($ million)—Queensland (2003–04 to 2005–06)

Statistical division	2003–04	2004–05	2005–06
Brisbane	$0.00	$0.00	$0.00
Moreton	$15.20	$11.99	$14.54
Wide Bay	$6.09	$5.73	$4.69
Darling Downs	$0.28	$0.26	$0.40
Fitzroy	$0.58	$0.55	$0.39
Central West	$0.00	$0.00	$0.00
Mackay	$7.65	$7.62	$9.13
Northern	$25.41	$19.00	$21.13
Far Northern	$17.27	$22.25	$20.21
Total	**$72.48**	**$67.40**	**$70.50**

The total farmgate value of production is highly dependent on marine prawns, which contributes approximately 68% (prawn growout and hatchery) of the total industry value and 62% of the total quantity of product sold. Barramundi is the next most significant industry sector with steadily increasing production. In 2005–06, barramundi growout and fingerlings contributed 21% of the total industry value and 27% of the total quantity of product sold. Four divisions (Northern, Far Northern, Moreton and Mackay) account for the majority of the production. The Wide Bay division also has significant production.

The largest increases in industry value occurred in the Moreton division (21%), Mackay division (20%) and the Northern division (11%), and as a result of increased marine prawn production in the south and increased barramundi production (21%) in the other divisions.

Mackay, Far Northern and Northern divisions have the majority of the ponded areas in Queensland with Wide Bay and Moreton also having significant areas.

The largest employment occurs in the Moreton, Mackay, Northern and Far Northern divisions with the Mackay and Wide Bay divisions having significant levels of employment. Total employment has fallen by 10% over the last 12 months.

Table 22. Total production (tonnes)—Queensland (2003–04 to 2005–06)

Statistical division	2003–04	2004–05	2005–06
Brisbane	0	0	0
Moreton	722	628	901
Wide Bay	268	264	267
Darling Downs	24	21	34
Fitzroy	21	26	23
Central West	0	0	0
Mackay	516	515	646
Northern	1748	1355	1676
Far Northern	1500	1826	1772
Total	**4799**	**4635**	**8319**

Table 23. Total ponded area (hectares)—Queensland (2003–04 to 2005–06)

Statistical division	2003–04	2004–05	2005–06
Brisbane	0	0	0
Moreton	172	180	171
Wide Bay	149	143	131
Darling Downs	22	17	18
Fitzroy	19	22	13
Central West	0	0	0
Mackay	262	239	225
Northern	345	267	255
Far Northern	262	309	309
Total	**1231**	**1177**	**1122**

Table 24. Total employment (full-time equivalents)—Queensland (2003–04 to 2005–06)

Statistical division	2003–04	2004–05	2005–06
Brisbane	0	0	0
Moreton	148	122	144
Wide Bay	88	92	64
Darling Downs	8	4	8
Fitzroy	16	7	9
Central West	0	0	0
Mackay	64	53	60
Northern	174	196	149
Far Northern	219	212	150
Total	**717**	**686**	**584**

12. Specialised areas—status report

12.1 Targeted active surveillance

The project was undertaken by the Queensland Government as part of the accreditation of Queensland law under the Great Barrier Reef Marine Park (Aquaculture) Regulations 2000 for disease and escape for aquaculture developments adjacent to the Great Barrier Reef Marine Park assessed as a material change of use in Queensland.

In response to concerns expressed by the Queensland aquaculture industry regarding overlapping regulatory arrangements, the Commonwealth and Queensland governments agreed to establish a single accredited environmental assessment process and performance standard that meets all Queensland and Australian government requirements, while maintaining the requisite degree of protection for the reef.

A surveillance plan to meet the disease and escape criteria was developed and agreed upon. The plan involved the sampling of 10 barramundi and prawn hatcheries for two specific diseases—viral encephalitis and retinopathy (VER) for barramundi and monodon baculovirus virus (MBV) for prawns. So far the project plan has been widely accepted by growers, who have fully cooperated with officers visiting to take samples. The results of the individual sampling will only be made available to that grower.

To date, no MBV has been detected in any of the prawn PLs and only one batch of barramundi fingerlings was found positive for VER. The sampling program will continue in a modified form this year, again sampling hatcheries for the two disease agents.

For further information contact Tiina Hawkesford (Senior Policy Officer) on (07) 3234 0701 or tiina.hawkesford@dpi.qld.gov.au

12.2 Aquaculture planning program

12.2.1 Marine aquaculture planning

DPI&F, in collaboration with the Department of State Development, has undertaken an initial desktop constraints/opportunities mapping exercise for marine areas in the Hervey Bay/Great Sandy area, and has identified a number of areas for further investigation. Further investigations will be in the form of characterisation studies undertaken by a consultant.

DPI&F will also seek local knowledge from targeted stakeholders to refine the proposed investigation areas.

The objectives of targeted stakeholder consultation are to:

- modify the desktop 'constraints/ opportunities' map using local knowledge
- refine the proposed investigation areas
- inform local stakeholder groups of the planning process
- provide a mechanism for feedback into the planning process.

Discussions are also underway with the Department of Environment and Water Resources to determine how best to address issues for marine aquaculture that fall under the *Environment Protection and Biodiversity Conservation Act 1999*.

12.2.2 Land-based aquaculture planning

A concurrent planning program is also being developed for land-based aquaculture.

A number of potential sites have been identified for coastal aquaculture (pond-based prawn and fish farms).

DPI&F will be working with local authorities, stakeholders and state agencies to promote a strategic approach to the development of sustainable aquaculture in these coastal areas.

12.2.3 Further information

Sam Miller (Senior Planning Officer)—(07) 3224 2108 or aquaculture.planning@dpi.qld.gov.au

Further information on aquaculture planning is available on the DPI&F website at www.dpi.qld.gov.au/fishweb

12.3 Research and development team

The Profitable Aquaculture Systems Program of DPI&F exists to support profitable, sustainable aquaculture industry development. This program works very closely with the Fisheries and Aquaculture Industry Development group of the department, and in partnership with species-based industries and agriculture. The majority of aquaculture research and development (R&D) is funded by the state because most of the species-based industries are not yet large enough to fund their own research.

12.3.1 Who are we?

The team includes approximately 44 scientists and their technical support staff located across the three DPI&F centres:

- Northern Fisheries Centre, Cairns (NFC)—21 scientific staff
- Freshwater Fisheries and Aquaculture Centre, (FFAC), Walkamin—four scientific staff
- Bribie Island Aquaculture Research Centre (BIARC)—19 scientific staff.

Work is also conducted on industry facilities.

12.3.2 What did we do in 2005–06?

- Conducted quantitative and molecular approaches to improve the performance of aquaculture species:
  - the selective breeding of prawns and barramundi
  - moulting control of soft-shell crabs and sex-change control of barramundi
  - identification of reproductive traits in the tiger prawn using a genomic approach.
- Investigated water use and environmental management systems, for example:
  - water-use efficiency, cleaning of waste water (remediation) by animal or plant species or mechanically
  - recirculation with marine, fresh and artesian aquaculture systems.
- Investigated and developed inland aquaculture systems—either integrated with existing agriculture or stand alone aquaculture ventures to improve or diversify whole-of-farm profitability, water use efficiencies and/or profitability of existing water use operations.
  - integrating aquaculture with cotton production systems
  - establishing inland finfish and prawn farming systems

  - exploit additional and currently unutilised water sources for aquaculture such as coal seam gas water.
- Seek to domesticate various aquaculture species to allow intensification and potential for land-based rearing, for example:
  - reef fish, tropical rock lobster, crabs (and scallops at sea).
- Assess 'new' and alternative species for future potential, for example:
  - tropical abalone, oyster, giant freshwater prawn and various fish.
- Support sustainable aquaculture, for example:
  - technology for sea cucumber production in the Pacific region and northern Australia
  - improving hatchery practices in Papua New Guinea and northern Australia .
- Export technology in the form of training.

In each of these areas the team works closely with the relevant industry.

12.4 Research and development outcomes

12.4.1 Wastewater remediation

A number of research projects within DPI&F are looking at ways to economically capture waste nutrients and suspended solids from production ponds, to allow on-farm water reuse or environmental release within regulated limits. While projects involving marine polychaete water remediation and freshwater partitioned barramundi systems are described separately in this document, other significant projects have been conducted this year to identify improved treatment options for aquaculture wastewater.

In collaboration with an industry partner, pilot-scale research is investigating the functioning of High Rate Algal Ponds (HRAPs) as a water treatment option for marine prawn farms. HRAP principles rely on precise pond flow dynamics to promote enhanced symbiosis between microalgae and aerobic bacteria, providing greater nutrient assimilation. They have been developed and used successfully to treat water from land-based agriculture (e.g. piggeries and dairy) and municipal effluent with minimal energy and labour input. A pilot-scale experimental facility was established at BIARC to assess whether these systems can function equally well in marine wastewater.

An independent evaluation was commissioned to assess the functioning and suitability of a commercial modular water purification unit for marine aquaculture farms. Designed as a bank-side water treatment plant, this system was originally developed for eutrophic freshwater lagoons and contained various biological and mechanical filtration and purification components in series. The advantages of this water treatment option to aquaculture farmers would be a reduction in the need to devote large ponded areas to sedimentation, and greatly reduced labour and management requirements compared with other biological remediation alternatives. Our testing showed, however, that treatment efficiency varied due to inherent instability in marine aquaculture ponds and further development is required for this to be a viable option.

Most attention this year has focused on bacterial processing of waste nutrients. Experiments have confirmed that promoting a swing towards heterotrophic (bacteria-based) processes in the pond provides a more stable and predictable environment by buffering against bloom/crash cycles typical in algal-dominated ponds. This can be achieved by adding carbon to the water, which bacteria use in conjunction with the surplus nitrogen and phosphorous in the water to build new cell material—thus waste nutrients are bound up as readily harvestable 'bioflocs'. Trials at BIARC have determined precise carbon-dosing requirements and evaluated methods for separating bioflocs from supernatant. A current trial in collaboration with researchers in Western Australia is growing barramundi in zero-exchange inland saline groundwater using biofloc treatment, with future research looking to utilise the protein in the generated bioflocs to feed additional crops (such as banana prawns).

For further information contact Dan Willett (Research Scientist) on (07) 3400 2037 or daniel.willett@dpi.qld.gov.au

12.4.2 Marine polychaetes and worm-assisted sand filtration

Work towards innovative marine wastewater treatment technologies has led us to investigate the concept of worm-assisted sand filtration. In a world first for DPI&F, prawn pond wastewaters are being filtered by constructed sand beds housing cultured populations of these benthic omnivores. Preliminary work seems to have addressed many of the necessary operating conditions and has provided encouraging nutrient removal and worm biomass production results.

Two species from the family Nereididae that occur in Moreton Bay have been trialled at BIARC over the last two years under a range of operating conditions that provide flexibility for their practical use. This low-power, low-maintenance approach may hold enormous benefits for mariculture interests in the future, because it appears to enhance the commonly used principle of sand filtration and because it has the potential to produce large volumes of this very useful and valuable by-product. Balancing the collective appetite of a worm bed with the increased waste as the prawn crop grows, and assessing the necessary scale, effectiveness and potential profitability of such an operation is the focus of current work.

Innovation funding from the National Landcare Program will see this new technology trialled at a commercial prawn farm in 2007. It is hoped that these developments will help alleviate pressures on wild baitworm fisheries, and open up a range of business opportunities by creating significant profit and public good from the functional uses of marine worms.

For further information contact Dr Paul J Palmer (Senior Biologist) on (07) 3400 2050 or paul.palmer@dpi.qld.gov.au

12.4.3 Assessment of lotus for wastewater treatment

This project aims to determine whether lotus lilies, (*Nelumbo nucifera*) a native freshwater plant, will trap sediment and improve water quality in a treatment pond that recycles water from a production pond full of fish (barramundi being the test species). It also aims to increase water use efficiencies and farm production efficiencies through allowing concentration of fish in particular areas permitting increases in feeding, harvesting and bird protection procedures.

This project has been hampered by issues including plant insect larval attack, excess rain and cyclone threat, which makes it difficult to establish the lotus plants in the ponds. The project has been modified slightly to see if a pioneer species of aquatic plant in the pond will assist with the establishment of the lotus plants. Meanwhile, the industry partner component of the project is progressing well. Preliminary assessment of the capabilities of lotus in extensive fish production systems suggested a high potential to assimilate nutrients.

This is a new project initiative supported by the Rural Industry Research Development Corporation (RIRDC) that will run for one production cycle and is due to finish in 2008. It was developed with support of the Aquaculture Association of Queensland and is working in conjunction with an industry partner (Daintree River barramundi). This project uses the pond facilities of the FFAC, Walkamin.

For further information contact Peter Graham (Fisheries Technician) on (07) 4091 9912 or peter.graham@dpi.qld.gov.au

12.4.4 Bioremediation for aquaculture in northern Australia and Papua New Guinea

The project aims to investigate the use of duckweed in partitioned recirculation systems to achieve essentially similar objectives to the lotus proposal for Australian aquaculture, above. This project also intends to investigate other methods currently being developed at BIARC, including bacterial floc and mechanical filtration techniques for water treatment on a pond scale.

This new project was developed with the Australian Barramundi Farmers' Association (ABFA) and aimed to investigate and compare two plant-based partitioned systems and evaluate their fish-carrying capacity limitations. This DPI&F-led project has funding support of the Australian Centre for International Agriculture Research (ACIAR) for a period of five years. The project commenced in June 2006 but, due to the departure of the project leader,

work has been delayed with fish now being stocked into ponds for the start of trial work in March 2007.

For further information contact Peter Graham (Fisheries Technician) on (07) 4091 9912 or peter.graham@dpi.qld.gov.au

12.4.5 Black tiger prawn genetic improvement

During the last two decades, there have been various attempts to close the life cycle of the black tiger prawn *(Penaeus monodon)*. No research or commercial group has been able to do this with numbers sufficient to permit a genetic program without a high level of inbreeding. A consortium of DPI&F, CSIRO, Australian Institute of Marine Science, APFA, core industry partners and FRDC, have successfully sustained 30 pedigreed families over three generations; a result unprecedented internationally. The following report reflects the contribution of all parties.

The genetic pedigree has been successfully maintained by both physical (Visible Implant Elastomer) and molecular DNA tags. This has created a platform for genetic improvement of a number of economic traits that has occurred over the last three generations. Improvements were noted for reproduction, health (viral load) and weight (growth) traits over the last three generations (data taken from same age animals across different generations).

The success of the research program in 2005–06 has resulted in industry making a commitment to commercialise this technology, targeting 2010 for completion of the transition from R&D to a fully commercial base. To grow stock rapidly and through winter in significant numbers to enable industry scale trials, a need to heat ponds at Bribie Island was identified as a critical issue. A business plan to cover the commercialisation of this work was undertaken and presented to DPI&F management who supported the capital investment of $310 000 at BIARC to allow this to occur.

The most cost-effective solution for heating the ponds was identified. It consisted of a structure to cover a single growout pond (1600 m^2), a gas-fired boiler system, heat exchange system and solar collector. BIARC now boasts a state-of-the-art, fully heated growout pond capable of maintaining 28 ˚C all winter and the capacity for seasonal production of thousands of mature broodstock prawns.

More recently, the black tiger prawn project has taken a different direction, the details of which will be given in the next annual report.

For further information contact Michael Burke (Senior Fisheries Technician) on (07) 3400 2051 or michael.burke@dpi.qld.gov.au

12.4.6 Genetic modelling

Different strains of aquaculture species may perform better in different commercial production environments. For example, a given strain of barramundi may be best suited in salt versus fresh water, or tropical versus subtropical temperatures. This genotype by environment (GE) interaction is difficult to measure without extensive trials which traditionally may take several generations of records of many families grown in different environments, thus making it prohibitively expensive.

Advanced computer simulation, or modelling, by a DPI&F scientist has revealed a novel experimental design that could provide an estimate of GE interaction in only one generation of recording. This method may be suited to many aquaculture species with high fecundity and is currently being written up for international publication.

These early estimates of GE have the potential to save many millions of dollars in aquaculture industries as:

- the best strains can be used to suit different commercial production systems
- they will provide early advice on the economic benefits of running one or more selective breeding programs for a given species.

For further information contact Michael Macbeth (Senior Scientist—Quantitative Genetics) on (07) 3362 9522 or michael.macbeth@dpi.qld.gov.au

12.4.7 Biotechnology applications

12.4.7.1 Advancing puberty in fish

The point in time when a fish begins to undergo gonadal development is a commercially significant one, as some species are late maturing and broodstock are required to be maintained for many years before any spawning occurs. Also, regulation of the time of puberty is important for reliable hatchery productions, as some species do not undergo natural reproductive development in captivity. The exact cascade of events that trigger puberty have still not been established. Puberty is the change from a fish that is spending all of its energy on growing, to a fish that will now spend significant energy resources into gonadal development.

In order to understand the mechanisms regulating the onset of puberty in fish, genes that are involved in reproductive function from the grey mullet *(Mugil cephalus)* were isolated and cloned. The mullet is a model species for late maturing fish. The key genes include those coding for reproductive hormones and the factors which regulate them. One of the cloned genes (GPR54), codes for a receptor similar to that identified in mammals, where it is considered to be the puberty gene. Characterisation of its expression in female grey mullet undergoing maturation also suggests its involvement in the process of puberty. The overall results provide groundwork for developing hormonal manipulations to control puberty.

12.4.7.2 Publications

Gardner, L., Anderson, T., Place, A. Dixon, B. and Elizur, A. (2005). Sex change strategy and the aromatase genes. J. Steroid Biochem.Mol. Biol., 94, 395–404.

Nocillado, J.N., Levavi-Sivan, B., Avitan, A., Carrick, F and Elizur, A. (2005). Isolation of dopamine D_2 receptor (D_2R) promoters in Mugil cephalus. Fish Physiol. and Biochem. 31:149–152.

Nocillado, J.N., Levavi-Sivan, B. Carrick, F. and Elizur, A. (2007). Temporal expression of G-protein coupled receptor 54 (GPR54), gonadotropin-releasing hormones (GnRH) and dopamine receptor D2 (drd2) in pubertal female grey mullet, Mugil cephalus, Gen. Comp. Endocrinol., 150(2):278–87.

Nocillado, J.N., Elizur, A., Avitan, A., Carrick, F. and Levavi-Sivan, B. (2007). Cytochrome P450 aromatase in grey mullet: cDNA and promoter isolation and brain, pituitary and ovarian expression during puberty, Mol. Cell. Endocrinol., 263, 65–78.

12.4.7.3 Regulating moulting in crustaceans

Moulting is an important physiological event in crustaceans as it is essential for their metamorphosis (change from larval to adult stages), growth, and reproduction. Moulting occurs in cycles and involves the shedding of the hard exoskeleton to expose a soft new shell, the uptake of water from the animals' immediate surroundings causing the new exoskeleton to expand, and finally the hardening of the new exoskeleton. It is at the soft shell stage, a very short window of between two and six hours that a particularly valuable seafood product (the soft shell crab) can be produced. The moulting process can be affected by a range of environmental cues (such as temperature and photoperiod) and is regulated by a cascade of hormonal signals. In spite of extensive research there is still no clear understanding of the hormonal processes involved in moult regulation.

The BIARC approach to study moulting in the blue swimmer crab (*Portunus pelagicus*) has been two-fold. In the first instance, classical molecular techniques were used to isolate several genes important to the moulting process. Second, a new and powerful technology—the microarray—has been used to offer a holistic approach to comprehensively study gene expression and to discover new genes involved in moult cycle regulation. This approach enables the examination of thousands of genes simultaneously. Using microarrays, the expression profiles of genes of interest have been tracked during the entire moult cycle and these profiles have been used to find new, as yet undiscovered genes. Of particular interest has been the isolation of genes involved in the process of shell hardening.

12.4.7.4 Identifying important traits in prawns

The identification of genes coding for important commercial traits in prawns was undertaken using a microarray approach. The available crab microarray has been used, and now a specific prawn microarray is under construction aimed specifically at examining genes associated with reproductive performance and fecundity.

The prawn research also involves the development of DNA markers. These include microsatellites that can be used in family tracking and pedigree analysis. Currently a new generation of DNA markers, single nucleotide polymorphisms (SNPs) are being developed in association with the isolation of genes relevant to commercial traits.

12.4.7.5 Publications

Kuballa, A.V., Guyatt, K., Dixon, B., Thaggard, H., Ashton, A.R., Paterson, B., Merritt, D. and Elizur, A. (2007). Isolation and expression analysis of multiple isoforms of putative farnesoic acid O-methyltransferase in several crustacean species. *Gen. Comp. Endocrinol*., 150, 48–58.

For further information contact Abigail Elizur (Principal Scientist) on (07) 3400 2055 or abigail.elizur@dpi.qld.gov.au

12.4.8 Inland aquaculture

12.4.8.1 Evaluating the potential for aquaculture in cotton catchments

DPI&F has been investigating the potential for aquaculture in Queensland's cotton catchments for a number of years as part of its integrated agri-aquaculture program. Further funded projects will build on DPI&F's experience, industry partnerships (Arrow Energy N/L, McVeigh Enterprises P/L) and the Cotton Catchment Communities CRC institutional support to enable significant, profitable and sustainable growth of aquaculture in cotton catchments to be achieved.

The testing of various aquaculture production system—both extensive and intensive—including floating raceways, on a range of species (Murray cod, barramundi, mulloway, whiting and/or prawns) provides an opportunity to offset the cost of current irrigated water and to add value to existing farm infrastructure, with water for irrigation now being a substantial and recurring cost to cotton farmers and to aquaculture. Further investigation into water-use potential has revealed a previously untapped source of water extracted as a by-product of methane gas extraction from coal seams. The millions of litres of water extracted daily are currently too costly to be treated for irrigation but aquaculture holds the potential to provide a cost-effective offset pricing of the water such that irrigators can now potentially use the resource.

If successful, integrated fish farming will provide cotton growers with an option to diversify their enterprises, and its adoption will also continue the aquaculture industry's broader movement towards environmentally sustainable production systems and the potential for inland aquaculture to become one of Australia's largest producers of fish.

Completed trials at BIARC utilising water extracted from coal seam gas mines has demonstrated the potential for use of this water to grow both barramundi and mulloway with a simple addition of potassium chloride (KCl). The addition of this important osmoregulatory ion (K^+) is simple, cost-effective and typically required in groundwater aquaculture operations in Australia. Construction of a 100 tonne demonstration floating raceway system based at Arrow Energy's Kogan evaporation dam should be completed in February 2007.

12.4.8.2 Production of marine prawns using low salinity groundwater

Previous trials have demonstrated that black tiger prawns (*Penaeus monodon*) can be grown at salinities as low as two parts per thousand in a recirculated pond system. An abundance of low salinity and brackish groundwater suitable for prawn production exists in several heavily irrigated regions of Queensland. The production of black tiger and banana prawns (*P. merguiensis)* in inland areas must, however, compete favourably with the cost of production of prawns in coastal regions and with imported product.

The series of trials now completed at Bauple has been able to demonstrate zero exchange production technologies and production of highly sought after product in Brisbane and Sydney markets. This seminal work has further consolidated results from a RIRDC sponsored project investigating the organic production of marine prawns in inland ponds.

12.4.8.3 Publication

Collins, A., Russell, B., Walls, A. and Hoang, T. (2005). Inland prawn farming—studies into the potential for inland prawn farming in Queensland, Information Series QI 05051, or available on the DPI&F website at www.dpi.qld.gov.au/far

For further information contact Michael Burke (Fisheries Biologist) on (07) 3400 2051 or michael.burke@dpi.qld.gov.au

12.4.9 Inland organic prawn production

The demand for certified organic foods continues to increase with a number of countries looking towards this type of product diversification. Organic seafood products, including farmed prawns, continue to attract a premium in overseas markets. This is the impetus behind ongoing research towards organic prawn production.

Following on from farm-based trials with the banana prawn at a commercial farm near Bauple in southern Queensland, and feed trials at BIARC in 2005, the RIRDC-funded project has been extended for another 12 months to conduct a further feed development trial. The focus in this later work is the black tiger prawn, and a range of newly available organic ingredients are under investigation.

The project's extension will also allow further work with modified atmosphere packaging by DPI&F's Innovative Food Technology group in Brisbane. This technology can satisfy organic standards in greatly extending the shelf life of fresh and frozen prawns. The project is laying a strong foundation for organic aquaculture research and development in Queensland.

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12.4.10 Tropical marine finfish

The Tropical Marine Finfish (TMF) project underwent a mid-term review that examined the direction/focus of the project along with project performance and management. The seven-member panel evaluated the alignment of current public research activities with the needs expressed by the private sector, and the strengths and weaknesses of public capital infrastructure at the NFC, Cairns.

The review panel found that there is scope for greatly expanding production of tropical marine finfish in Queensland. Taking into account the restrictions existing for expanded sea-cage aquaculture, the panel identified land-based pond aquaculture as the preferred method for industry expansion. Initially, the prawn industry is best positioned to benefit from tropical marine finfish culture technology and it was recognised that this could provide an opportunity for the industry to diversify and reduce the current negative impacts from cheaper, imported prawns. Grouper (*Epinephelus coioides* and *E. lanceolatus*) were acknowledged as marine finfish particularly well suited to such land-based, estuarine pond systems.

The review strongly recommended an increased focus on industry development and the extension of marine finfish culture technology. To enhance this process a TMF-Steering Committee was established with Industry and Departmental representation. The panel has been active in defining industry needs and how the TMF project can best assist industry. This collaborative approach has already resulted in significant changes to the operation of the TMF project.

To focus on grouper species best suited to estuarine conditions it was agreed that barramundi cod (*Cromileptes altivelis*) research would be finalised and the broodstock replaced with additional estuary cod (*E. coioides*), later to be joined by Queensland grouper (*E. lanceolatus*).

It was accepted that the TMF team would increase production of juveniles to enable more extensive farm-based rearing experiments. To achieve this increased production, the department has invested in construction of a new large-scale modular larval rearing system. This new system incorporates the experiences and technology developed within the TMF project and its associated ACIAR project.

Additional departmental funds have also been provided to enhance the quality of incoming sea water to support increased finfish production.

Implementation of the review recommendations, the commitment of significant additional departmental funds and the enhanced involvement of industry have resulted in a TMF project poised to make major advances in grouper aquaculture during 2006–07.

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12.4.11 Tropical rock lobster

Rock lobster aquaculture research achieved an important milestone in June 2006, with the first ever production of PL (puerulus) of the tropical lobster *Panulirus ornatus*. This occurred at the commercial hatchery of MG Kailis using technologies developed at the DPI&F NFC through a FRDC-funded collaborative research project. This outcome was an impressive example of collaboration between commercial partners and DPI&F, achieving commercially relevant outputs. Although that project has now been completed, the collaboration will continue for another three years within a new project currently being negotiated with the FRDC through the Rock Lobster Enhancement and Aquaculture Subprogram and other partners. Its focus will be on standardising the production of puerulus, and initiating the development of manufactured larval diets to replace the current reliance on the genus Artemia as the primary food source.

Given the stronger possibility of commercial rock lobster aquaculture production, now that the gap to being able to 'grow them on land' is being closed, a key issue in the negotiations concerning R&D has been intellectual property. As a foundation member of the R&D group that initiated rock lobster aquaculture research in Australia, DPI&F will have a prominent role in the negotiations and the potential commercial outcomes.

The aquaculture technology of this species in broodstock management and growout are now reasonably well understood. Hence, the primary focus will be larval rearing and achieving greater survival of larvae through the four to five month larval period, and more consistency in production. It is hoped that through development and use of manufactured diets, nutrition will be improved, and introduction of disease agents, via Artemia, will be reduced.

The work is extremely demanding nurturing the delicate lobster larvae that are normally accustomed to pristine oceanic conditions; multiple feeds each day involving 7 am and 10 pm feeds and seven days a week. The exceptional commitment of existing staff has been responsible for the successes to date, but additional resourcing is being sought to ensure the R&D effort necessary is sustainable in the longer term.

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12.4.12 Crabs

The crab aquaculture team at BIARC is collaborating with researchers from Queensland University of Technology (QUT) in a two-year ACIAR project that examines the feasibility of developing low cost feeds for mud crabs (*Scylla* spp.) in south east Asia. Institutions in Vietnam and Indonesia are working on corresponding diets using locally sourced ingredients. A PhD student from Vietnam also commenced a study at BIARC into carbohydrate digestibility in mud crabs (*Scylla serrata*).

Experiments this year showed no significant difference in growth rate of mud crabs fed diets of 35–55% protein content though the trend was for average growth to decrease as protein content fell. Increasing dietary lipid content between 5%, 10% and 15% saw a progressive rise in growth rate and no evidence of a reduction or plateau at high lipid levels. Digestibility studies showed that mud crabs could digest a number of readily obtainable plant meals; however, poultry meal showed most promise in fishmeal replacement trials to date. Palatability/attractiveness of plant meals remains an issue, but behavioural studies suggest that this can be overcome using attractants. While carbohydrate (e.g. starch) was generally highly digestible (depending upon the method of feed preparation), the growth rate of mud crabs did not respond to differences in dietary carbohydrate content.

This year we also completed an honours study through The University of Queensland on the behavioural responses of juvenile mud crabs to the odour of moulting crabs and to crab blood. This study found no compelling evidence that the crabs universally home in on the odour of moulting individuals—but it did find that larger individuals showed the greatest apparent interest in the odour of a damaged crab. This study raises a number of questions about the role of size in crab behaviour not the least because the effect was not consistently seen suggesting that it is an acquired rather than a 'hard-wired' response.

12.4.12.1 Publications

Mud crab aquaculture workshops, (2004). Copy on CD produced from the material presented at FRDC mud crab farming workshops in early 2004–05.

Shelly, C., (2004). Editor. Crab farming: a new opportunity for Australian aquaculture, Proceedings of a workshop held in Brisbane, 13 October 2004. Information Series QI 05067.

Marshall S., Warburton K., Paterson B. and Mann D. (2005). Cannibalism in juvenile blue-swimmer crabs Portunus pelagicus (Linnaeus, 1766): effects of body size, moult stage and refuge availability. *Applied Animal Behaviour Science,* 90, 65–82.

For further information contact Brian Paterson (Senior Research Scientist) on (07) 3400 2003 or brian.paterson@dpi.qld.gov.au

12.4.13 Scallop marking

The marking of scallops (*Amusium balloti*) for release and recapture is part of the FRDC-supported project designed to distinguish hatchery-produced stock from wild stock.

The saucer scallop fishery is one major component of multi-species fisheries in Queensland and Western Australia. Saucer scallop is widely recognised as the world's finest scallop meat and attracts landed prices of more than $20 per kilogram on domestic markets, and significantly more in overseas markets.

The majority of scallop production is destined for export to Asia, Europe and the US. Annual landings have fluctuated dramatically both in Queensland and Western Australia. Overseas experiences have shown that sea ranching of scallops could not only reduce the landing fluctuation but also increase production by more than 10 times. In Australia, to offset the variable catches of saucer scallops resulting from the wild fishery, sea ranching of saucer scallops is currently being undertaken by industry in Western Australia and Queensland using hatchery-produced juvenile.

One of the key issues to evaluate the success of the sea ranching venture is to be able to identify hatchery-produced stock. Managers can then determine the contribution of hatchery stock to the final harvest as well as having the ability to monitor survival and dispersal. Identification of hatchery seed is also essential to determine the optimal size of scallops and time for deployment to the seabed. However, the choice of identification method is restricted by the cost, ease of use, stability and precision.

A wide range of chemicals have been evaluated and tested for marking hatchery-produced juveniles. These chemical candidates must be harmless to the animals and safe for human consumption. Preliminary trials indicated that two of three chemicals showed very promising results. Based on these, experiments are being conducted to systematically evaluate a suitable treatment time and concentration of potential chemicals. Also, the retention time and intensity of these chemical marks on the juveniles are being assessed. The trials are also being extended to test additional mollusc species such as pearl oysters. The Australian Pesticide and Veterinary Management Authority has approved field trials of commercial numbers of scallops to test the suitability of a marker in the natural environment.

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