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The report of the Fish Farming Legislative Review Committee.

P. Rogers

FISHERIES MANAGEMENT DISCUSSION PAPER

No 2

THE REPORT OF THE FISH FARMING LEGISLATIVE REVIEW COMMITTEE

REPORT BY THE

CHAIRMAN MR P. ROGERS

TO THE

MINISTER FOR FISHERIES, THE HON. J. F. GRILL

FISHERIES DEPARTMENT
PERTH WESTERN AUSTRALIA
108, Adelaide Terrace, Perth 6000.

OCTOBER 1986

HON MINISTER FOR FISHERIES

I have pleasure in forwarding to you the report of the Fish Farming Legislative Review Committee, in accordance with the terms of reference dated 6 May 1985.

Any errors or omissions within this report are the responsibility of the Chairman.

P P Rogers

P P Rogers
CHAIRMAN
FISH FARMING LEGISLATIVE REVIEW COMMITTEE

28 October 1986

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1 INTRODUCTION

In 1975, amendments to the Fisheries Act provided for the licensing and control of commercial fish farming activities and, for specific declared species, further controls on their processing and marketing. To date, marron has been the only species to be declared a "farm fish".

During the last decade, much of the State's aquaculture impetus has focused on marron although more recently greater attention has been directed towards trout, yabbies and freshwater aquarium fish species.

On November 19, 1984, the Marron Growers Association of Western Australia (Inc) wrote to the Minister for Fisheries and Wildlife, seeking a general review of legislative provisions for freshwater aquaculture and licensing policies, following the experience of a decade of fish farming on marron.

The Minister for Fisheries and Wildlife at that time, the Hon H D Evans announced the appointment of a committee to review and report on the appropriateness of the fish farming provisions of the Fisheries Act and licensing policies of the Department of Fisheries and Wildlife. This review focuses upon freshwater aquaculture in south west Western Australia and not tropical aquaculture in northern Western Australia.

Membership of the committee included representatives of the Marron Growers Association of Western Australia, the Department of Premier and Cabinet, the Western Australian Recreational Fishing Council, the Western Australian Tourist Commission and the Fisheries and Wildlife Department (later to become the Fisheries Department).

The review committee was requested to examine existing legislation and policies for fish farming to ensure that initiatives for the future development of freshwater aquaculture in the south west of Western Australia were not being stifled.

The sale of small marron of less than the legal minimum size for human consumption and the leasing of agricultural dams by fresh water fish farmers were other issues to be explored. The committee was also required to report on the impact any proposed changes in rules for aquaculture might have on the sport fishery, as well as law enforcement requirements.

1.1 Membership of the Committee

The membership of the committee was

Chairman	Mr P Rogers	Fisheries Department
Members	*Messrs S Bennison D Holker	Marron Growers Association of Western Australia
	Mr Q Harrington	Department of Premier and Cabinet
	Ms G Cammerano	W A Tourist Commission
	Mr A Fink	W A Recreational Fishing Council
	Mr E Little	Fisheries Department
	Mr S Lang	Primary Industries Association

Dr N Morrissy, a senior research scientist with the Fisheries Department provided scientific research advice.

*Alternative member/observer Mr W Moore of the Marron Growers Association of Western Australia.

1.2 Terms of reference of the committee:

The Terms of reference for the Review were as follows:

1 To identify the constraints limiting the development of inland freshwater aquaculture in south west Western Australia.

2 To review current policies, regulations and enforcement requirements under the FISHERIES ACT 1905, for fish farming as they apply to trout, marron, yabbies, koonacs and freshwater aquarium fish.

3 To examine the proposal as to whether marron less than the minimum legal size of 76 mm carapace length be permitted to be sold for human consumption by registered fish farmers and to report on the possible mechanisms for implementing such a proposal, without detriment to the marron sport fishery.

4 To determine the licensing requirements for fish farmers.

5 To examine and report on whether the leasing of farmer's dams by fish farmers should be permitted and under what conditions.

6 To assess the impact of any proposed changes in regulations for freshwater aquaculture on inland sport fisheries in south west Western Australia, and on the requirements for fisheries enforcement, including staff and other resources.

7 To examine and report on the inter-relationships between the inland sport fisheries, tourism and freshwater aquaculture in south west Western Australia.

1.3 Information Obtained by the Committee

The committee called for submissions from licensed fish farmers, local authorities and the public. A total of twenty four written submissions were received as inputs to the committee's deliberation.

In addition, at the request of the committee, the Fisheries Department research branch developed a bioeconomic model simulating the data on the pond growth of marron for two sites in south west Western Australia. The information generated by this model, summarily reported in section 7, was used to assist the committee's consideration of the third term of reference on the proposal to permit the sale of small marron (below legal size) for consumption.

In addition, members of the committee undertook a fish farm inspection of the south west of Western Australia during the period 29 July 1985 to 1 August 1985. The inspection encompassed visits to fish farms which included examples of extensive aquaculture (fishing out of tank and gully dams) and others with a very high capital investment in the construction of ponds, hatcheries, buildings and water storage facilities associated with intensive pond aquaculture. Areas visited included properties at Dardanup, Wellington Mills, Greenbushes, Margaret River, Pemberton, Northcliffe, Albany and Mount Barker.

The committee also sought and obtained the considered views of several members of the W A Guild of Cooks and members of the restaurant industry to provide independent judgements on the marketability of different sized marron.

1.4 Marron Aquaculture, the Sport Fishery and Enforcement

The majority of the committee's deliberations focused upon marron as most fish farmers are involved in the farming of this species, and it is indigenous to Western Australia and provides the basis of a significant sport fishery.

The regulatory controls placed on marron aquaculture were designed to protect the significant recreational fishery on wild stocks as well as to provide the means for the orderly development of aquaculture.

This report describes freshwater recreational and commercial fish farming activities within south west Western Australia and together with information on Fisheries Department enforcement practices and economic data, based on modelling marron farm productions and costs, has been used to fulfill the terms of reference outlined in 1.2 above.

2 SUMMARY

Since the Fish Farming provisions under the Fisheries Act 1905 were proclaimed just over a decade ago, individuals have made significant investments of both time and capital in marron aquaculture. For various reasons, including poor management, cost of growing to the minimum legal size (76 mm carapace length - approximately 120 gm), a lack of knowledge of marron and fish farming techniques, problems with predation, the high cost of pond development and difficulties in obtaining sufficient broodstock, many have ceased.

South west Western Australian freshwater aquaculture today, continues to be dominated by marron aquaculture. However, more recent developments have seen moderate expansions in trout and aquarium fish farming. The industry continues to be dominated by small individual family fish farms using diverse approaches symptomatic of a developing cottage industry. The industry leaders tend to be those who have managed to survive the ten years of initial development, gaining much of their knowledge through experience. Some have diversified their fish farming activities into tourist facilities, consultancies, or remained in traditional agricultural industries to maintain viability.
There are currently 26 licensed marron farms, not all of which are actively engaged in aquaculture.

Success has been achieved in the hatchery production of marron and the sale of small (mainly less than 12 months old) live marron for stocking purposes to a ready market within the Eastern States and overseas. The production of juvenile marron within Western Australia and Australia is expected to expand rapidly in the next five years.

The interest in marron aquaculture throughout Australia has never been greater and many fish farmers close to the industry are extremely optimistic about its future.

The future of marron aquaculture in providing quantity supplies of legal size marron (76 mm carapace length -

approximately 120 gm) within Western Australia however, is still uncertain. Ten years on, fish farmers are yet to demonstrate the commercial viability of semi-intensive pond production for marron. Commercial data establishing beyond any reasonable doubt the viability of 'grow-out' by example within Western Australia is not available.

The review committee, in seeking answers to the future direction of marron aquaculture within Western Australia, commissioned modelling work on the semi-intensive pond production of marron, bringing together the cumulative knowledge of research and industry operating costs.

The conclusions reached favour the production of marron which can be marketed for food within Western Australia at 40 gm and above from a semi-intensive pond grow-out system.

The level of funding required to move from a successful hatchery phase to a self supporting grow-out stage will be substantial. The investment risks are also anticipated to be high and by necessity, venture capital would be required.

Any move to further encourage marron aquaculture must take into account the need to protect the wildstock sport fishery on marron from illegal commercial exploitation. The marron sport fishery which comprises in excess of 28,000 recreational fishermen (1985/86) generates fishing related expenditure of approximately $2.5 million annually. A change in legislation to permit the sale of marron less than 120 gm is expected to open the doors wider for illegal commercial fishing.

The committee in considering these issues concluded that the benefits to be achieved through the further encouragement of marron aquaculture were substantial compared with the potential risks to the marron sport fishery. For example, the establishment of 50 HA of ponds (5 viable 10 HA farms), which is almost insignificant by international standards, have the potential to exceed the total production of the sport fishery.

The committee came to the view that the sport fishery marron stocks were being depleted through high recreational fishing pressure and adverse environmental changes. There was an identified requirement to totally review management rules for the sport fishery, irrespective of the other policy changes proposed.

The further development of aquaculture, particularly the hatchery production of marron was identified as a safeguard against the final depletion of wild stocks. Aquaculture, in the longer term, could also provide the means to expand recreational opportunities through privately owned "fish out" ponds and these activities needed to be catered for legislatively.

Towards encouraging investment into commercial scale grow-out of marron for the food market, the committee defined a separate set of licensing guidelines which could be used by Government to attract venture capital and specific fish farming expertise. These guidelines provide for the licensing of up to ten fish farms for the production of marron of all sizes for the food market within a five year development period. In the development phase no further licences would be issued providing an incentive and the means to test finally the viability of "grow-out" for marron.

The control problems in the marketing of undersize animals were believed by the committee to be solvable. In any event the Fisheries Department officials will need to address the control problems of marketing undersize marron and requirements for protection of the marron sport fishery, due to the medium term potential for interstate imports of small marron into Western Australia for the food market.

The committee supported changes in penalties directed at illegal commercial fishing within the marron sport fishery, the appointment of additional enforcement staff and the further clarification of existing legislation as additional protective measures for the wild stocks. It was considered

essential that the ultimate penalty for a breach of regulations by a licensed fish farmer (eg "laundering" marron from the wild) be the cancellation of the licence.

Leasing of farm dams by marron farmers was not supported although seen as an acceptable mechanism for the fishing of koonacs and yabbies within farmers' dams. For ecological reasons, yabby farming in waters west of the Albany Highway was opposed. Other proposals examined and recommended by the committee included: (a) the introduction of quarantine procedures for live fish imported from the Eastern States; (b) support for the development of fish disease expertise within Western Australia; (c) support for the establishment of a research facility for aquaculture at a commercial scale; and (d) other measures to promote fish farm/tourist developments.

The other major recommendation supported by the committee was the introduction of a permit system to allow land owners having significant impounded waters on private land to sell size marron to fish farmers. This will enable fish farmers to more easily obtain broodstock. It would also partly overcome the inequities of a land owner not being able to sell marron from impounded waters within private land not forming part of any river or stream and not part of the public sport fishery. Should the permit system prove successful without contributing to an increase in illegal fishing of wildstocks, it was proposed future consideration be given to extending permit approvals to restaurant sales.

In putting forward these changes, the committee accepts that if all the recommendations are eventually implemented, the possibility of illegal fishing in the sport fishery may be increased, although minimally. Whether the increase will be significant or not will be shown through experience. The problems of managing the sport fishery must be tackled head-on whilst providing for the development of aquaculture.

The approaches proposed by the committee are cautious and to a degree retractable. Should these policies prove successful, the benefits to Western Australia are considerable.

The key to the strategy proposed by the committee's recommendations is guided gradual change and eventually further change with experience.

3 SUMMARY OF RECOMMENDATIONS

Term of Reference No. 1

To identify the constraints limiting the development of inland freshwater aquaculture in south west Western Australia.

1. That Government provide priority to the establishment of an inland fresh water research facility within Western Australia to provide data on aquaculture farming techniques at a commercial scale.

2. That town planning restrictions limiting subdivision of agricultural properties not apply when undertaken for fish farming purposes.

3. That Government take every opportunity in encouraging the further development of 'fish farming' skills within Western Australia.

Term of Reference No. 2

To review current policies, regulations and enforcement requirements under the FISHERIES ACT 1905, for fish farming as they apply to trout, marron, yabbies, koonacs and freshwater aquarium fish.

4. That the proposed policy guidelines controlling the import of live fish into Western Australia from interstate, as detailed in Appendix 2, be adopted.

5. That the Fisheries Act and Regulations be amended to enable fish farmers to legally have in their possession undersize marron and ovum bearing female marron.

6. That the penalty levels under the Fisheries Act 1905 for breaches of unauthorised selling of marron or exceeding the daily catch bag limit for marron, be modified to

incorporate a greater scale of penalty as a further deterrent to illegal commercial fishing of wild stocks of marron. The level of penalty should equate with those already applying to similar offences for rock lobster.

7. That the daily catch bag limit for marron be modified to apply from midday to the following midday, so that it is consistent with fishing practices of recreational fishermen.

8. That the "rights" of recreational fishing for marron extended to children under thirteen years of age not apply for children under six years of age.

9. That specific legislation be introduced defining the rights of land owners in the private domestic usage of marron grown within the confines of impounded waters on their properties.

10. That all applications to the Fisheries Department for a fish farm licence for freshwater aquaculture be referred to the Western Australian Water Authority for separate approvals in relation to water usage prior to licensing for aquaculture.

Term of Reference No. 3

To examine the proposal as to whether marron less than the minimum legal size of 76 mm carapace length be permitted to be sold for human consumption by registered fish farmers and to report on the possible mechanisms for implementing such a proposal, without detriment to the marron sport fishery.

11. That Government provide for the marketing of marron less than 120 gm for sale to licensed processing establishments (eg restaurants).

12. That the licensing of Fish Farmers to undertake production of marron less than 120 gm for the food market be restricted to between five and ten establishments within specific guidelines encouraging the further development of intensive hatchery and grow-out production methods and facilities.

13. That Government invite submissions from prospective developers and select those that offer the greatest prospect for commitment and success. The successful applicants to be granted a five year development period during which the further licensing of fish farms to produce marron less than 120 gm would not be approved.

14. That action by Government to encourage venture capital into marron aquaculture go hand-in-hand with the provision of additional measures to protect the sport fishery on marron.

Term of Reference No. 4

To determine the licensing requirements for fish farmers.

15. That the current criteria for the licensing of marron farmers to produce young marron from hatcheries and/or sized marron (76 mm carapace - approximately 120 gm) from intensive grow-out ponds continue to apply with minor modification, to take into account the need for more precise drainage and pond size specifications.

16. That a system of "permits" for land owners to sell marron be introduced to provide land owners a greater ability to undertake 'extensive' forms of marron aquaculture, through the commercial fishing of waters (dams, swamps and lakes) within private properties that are not part of any stream or river and do not form part of the public marron sport fishery.

17. That should a permit system be introduced as proposed by recommendation 16, the following requirements be met:

(a) That the permit define the property from which marron would be sourced, the quantity of sized marron to be taken and sold and the name of the sales outlet.

(b) The quantity of sized marron (76 mm carapace - approximately 120 gm) specified as capable of being sold on the permit be determined by a system of sampling to be instituted by Fisheries Department Enforcement Officers. The cost of the permit should cover sampling costs.

(c) At least in the early years of the scheme, a permit not be issued to any property owner having a total of less than 2.5 hectares of water containing marron on the property.

(d) The permit to expire on a common date of 30 April each year and not to be deemed a "permanent right" by applicants.

(e) That permits initially only be issued to private land owners to supply broodstock to fish farmers. This will help alleviate the expected (and current) severe shortage of broodstock that would seriously restrict the development of a viable marron aquaculture industry. This system of permits would be reviewed annually to ensure it could be adequately policed and once the initial demands of farmers for broodstock were satisfied, the system to be evaluated to determine if it should be expanded to allow permit holders to supply size marron for food consumption through licensed processing establishments.

(f) The Minister for Fisheries be granted the authority to abolish the 'permit' scheme at any time should experience demonstrate the system to be unworkable or indirectly cause an increase in the illegal fishing of wild stocks.

18. That high priority be given to the early introduction of the permit system proposed for the sale of marron caught from impounded waters within private property, not forming part of the public sport fishery. By necessity, this requires early consideration of manpower requirements by Government discussed under the sixth term of reference.

19. That the current policies for the issue of licences to undertake the fish farming of koonacs and yabbies be relaxed to provide for the "commercial" fishing of contained waters within private properties.

20. That the fish farming of the yabby not be permitted in any waters west of the Albany Highway.

21. That the current licensing policies for the registration of fish farms producing trout continue to remain operative. (Refer Appendix 4).

22. That the guidelines applying to the licensing of aquarium fish farms remain operative.

Term of Reference No. 5

To examine and report on whether the leasing of farmer's dams by fish farmers should be permitted and under what conditions.

23. That the leasing of farm dams by fish farmers under the authority of a single fish farm licence for the purposes of marron grow-out not be permitted.

24. That the Fisheries Department develop a licensing mechanism which would allow the more liberal commercial utilization of yabbies (east of the Albany Highway), gilgies and koonacs in waters on private properties.

Term of Reference No. 6

To assess the impact of any proposed changes in regulations for freshwater aquaculture on inland sport fisheries in south west Western Australia, and on the requirements for fisheries enforcement, including staff and other resources.

25. That a review be undertaken on the relevance of current management rules for the marron sport fishery.

26. That the recommendations supporting changes in licensing policies to further encourage south west Western Australian freshwater aquaculture not be adopted until Government provides the necessary funding for the appointment of two Fisheries Enforcement officers to be located at Manjimup.

Term of Reference No. 7

To examine and report on the inter-relationships between the inland sport fisheries, tourism and freshwater aquaculture in south west Western Australia.

27. That the Fisheries Act Regulations be amended to detail the appropriate legislative exemptions and requirements for 'fish-out pond' fishing by tourists on licensed fish farms.

28. That licenced fish farmers having joint farm/tourist restaurant facilities be provided with extended approvals under their fish processing licence to cook and serve undersize marron as meals for consumption on the premises.

29. That the Western Australian Tourism Commission further explore the market potential for developing a package tour focusing upon freshwater sport fishing and aquaculture.

4 DESCRIPTION OF FRESHWATER AQUACULTURE IN SOUTH WEST WESTERN AUSTRALIA

4.1 Marron

Since 1975, following amendments to the Fisheries Act to provide for fish farming, a significant level of private investment has occurred in marron aquaculture. Forty nine separate enterprises have been granted fish farming licences. Almost half of these have failed for various reasons and currently there are 26 operative licensed fish farms. The majority of the currently licensed farmers are not engaged in marron aquaculture to any significant extent (ie only 11 sold more than 100 kg of legal size marron or more than 1 000 juvenile marron in 1985).

Three distinct types of marron aquaculture have developed in Western Australia.

One form of marron farming simply involves a hatchery which concentrates on the production of large numbers of juvenile marron for subsequent sale for stocking agricultural farm dams and other fish farming enterprises. Hatcheries are considered an "intensive" form of marron farming.

A second form of marron farming involves "semi-intensive" grow-out ponds which involve the growth of marron to legal market size of 76 mm carapace (approximately 120 grams). Grow-out ponds are of two types : firstly, purpose-built gravity self-drainable ponds which enable the water to drain through an adequate sump for inventory or final complete harvesting of stocks; and secondly purpose-built ponds that depend upon a pump or syphon to remove the water. As a matter of licensing policy, since the commencement of the review, the Fisheries Department requires ponds to be gravity self-drainable before a licence will be

issued. These ponds vary in size from 100 square metres to between 1 and 2 hectares.

The third form of marron aquaculture involves the stocking and fishing of farm dams, as discrete small self-contained populations of marron. This form of aquaculture is described as "extensive" and is likened to the "fishing of private waters" with some minimal enhancement of the marron population through protection from predators and poaching and on occasions supplementary feeding.

The major distinction between "semi-intensive" and "extensive" grow-out ponds relate to expected yields, costs and use of management and capital investment, ie "semi-intensive" grow-out ponds produce higher yields, involves high construction costs, and require greater management expertise than "extensive" grow-out ponds.

Marron aquaculture initially involved the licensing of a limited number of fish farming establishments based upon a concept of "intensive" hatchery and "semi-intensive" grow-out facilities which could be easily inspected. Some of these farms were initially stocked by the capture of mature marron from wild stocks. The Fisheries Department's Pemberton Hatchery also supplied juvenile marron for stocking purposes, which was, however phased out from 1981 as the industry by this time was successfully producing large numbers of juvenile marron in hatcheries.

The commercial food production of legal sized marron in quantity from "semi-intensive" grow-out ponds has yet to be demonstrated. The failure of the commercial marron aquaculture industry to produce large quantities of edible marron in the last decade can be attributed to a range of reasons including farm management problems and technical difficulties associated with marron aquaculture. The requirement in the case of many fish

farmers for a cash flow to finance further development and the existence of a ready market for small juvenile marron has been a major contributing factor inhibiting larger scale investments into the grow-out of sized marron. To date, most of the supplies to the restaurant markets of marron for edible food consumption has come from fish farms using "extensive" marron farming methods or those animals surplus to breeding stocks held by fish farmers using more intensive farming techniques.

The lifting of the Commonwealth prohibition on the export of live marron in 1981 together with the increased interest in marron aquaculture within eastern Australia, particularly within Queensland, provided an expansive market demand for small juvenile marron for stocking purposes which thus far has not been satisfied. During 1985 in excess of 280,000 juvenile marron of O+ age (ie. between 0-12 months and 10-20gms) were sold by licensed Western Australian marron farmers (see Table 1). Current prices being paid for O+ sized marron fall within the range of $0.40 - 0.60 each.

TABLE 1 : SALES OF MARRON BY LICENSED FISH FARMERS

Year	INTRA STATE		INTER STATE		OVERSEAS		TOTAL	
	Legal sized (Kg)	0+ (Individuals)	Legal sized (Kg)	0+ (Individuals)	Legal sized (Kg)	0+ (Individuals)	Legal sized (Kg)	0+ (Individuals)
1980							641	9 737
1981							923	39 747
1982							1 140	136 525
1983							1 677	188 704
1984	2 156	50 610	263	255 663	93	15 400	2 512	291 673
1985	2 194	71 884	621	197 282	276	12 645	3 091	281 811

A major concern facing many of Western Australia's licensed marron farmers arises from the uncertainty as to the future market for small juvenile marron for stocking purposes. The much reported heavy investment by Queensland fish farmers into marron aquaculture has raised the prospect of these farmers eventually selling small juvenile marron for stocking purposes on the eastern states market as well as larger juvenile animals of 40 gm size and above on the food market throughout Australia (including Western Australia).

Western Australian marron farmers within the next few years may well be placed in the position of either ceasing hatchery operations or investing more into larger areas of ponds for on-growing 0+ marron for the food market. On an a priori basis, a significant proportion of the marron growers argue that it is much more viable to produce and market marron of less than the legal minimum size, through the harvesting of the total marron crop than to adopt grow-out strategies based on producing marron of 120 gms for local consumption.
This aspect is the focus of the modelling work detailed in this report. However, the sale for food of marron less than the legal minimum size required for the sport fishery also raises legitimate concerns on the need to protect wild marron stocks from illegal fishing.

The licensing of a limited number of 'extensive' marron farm developments in the late 1970's and early 1980's by the Fisheries Department has since raised concerns at the prospect of these establishments being used to 'launder' size marron from the wild stock fishery. These concerns, at the time of announcing the review, caused the Minister for Fisheries and Wildlife to suspend the further licensing of 'extensive' marron aquaculture farms. The matters of licensing policy are addressed later in the report under term of reference No. 4.

The summary data provided in Table 1 demonstrates the following:

(a) the current dependence of commercial marron farmers on sales of juvenile (0+) marron;

(b) the low quantity of marron sold to restaurant outlets for food consumption;

(c) the importance of the eastern states market for sales of small juvenile (0+) marron.

4.2 Koonacs and Yabbies

During the last five years, a small number of wheatbelt farmers have expressed the desire to sell yabbies (a non indigenous crayfish) and koonacs (a local native crayfish) grown within agricultural dams. Small quantities of these species have been sold as live animals for food consumption.

There is currently no intensive fish farming of these species being undertaken. However a number of entrepreneurs point to the potential for a small commercial fishery based on the permitted commercial fishing of farmer's dams under a leasing system. This aspect is considered later in the report.

4.3 Trout

There are five licensed trout fish farms in Western Australia which produced 15 tonnes of trout for sale in the last financial year. Three of these farms produce some fingerlings from hatchery operations although all are reliant in obtaining supplies for on-growing from the Fisheries Department hatchery at Pemberton.

The majority of these farms have been developed as joint tourist facilities, and provide as one of their tourist attractions, trout fishing for visitors from "fish out"

ponds. Their level of output to the food market is not substantial.

A more recent development by Burns Farming Pty Ltd provides an example of a modern, high technology, high volume throughput, intensive trout farm with production output targeted at quantities in excess of 100 tonnes per annum. The technology employed in this development is of a world standard and provides the best example of a semi-enclosed intensive fish aquaculture operation to be found in this State.

The major issues to arise from the licensing and control of trout farming operations relate to those of maintaining effluent water quality and protection against exotic fish disease introduction.

4.4 Aquaculture of Aquarium fish and plants

In the last decade the Fisheries Department has received three applications to undertake the commercial aquaculture of freshwater aquarium fish and plants. As a matter of policy, fish raised within self-contained aquarium units by hobbyists and fish dealers have not been registered by the Department.

The major policy issues controlling the licensing of such premises focus upon the need to prevent exotic fish from escaping into the natural waterways and minimising the risks of introducing exotic fish diseases. The maintenance of effluent water quality can be a problem depending upon farm size and production.

Thus far only one licence application has been approved.

The prospect for further development of aquarium fish aquaculture is limited by the size of the local Western Australian aquarium fish hobbyist market. (Refer Appendix 2). For commercial viability large scale

investment in this form of aquaculture needs to be directed towards interstate and overseas markets.

5 THE RECREATIONAL FISHERY IN INLAND WATERS OF SOUTH WEST WESTERN AUSTRALIA

5.1 Marron

The main inland sport fishery in the south west of Western Australia is that of marron fishing. For the casual marron fishermen, it is often a one night or afternoon social outing two or three times a year after a long drive from Perth, to catch and consume marron amongst friends or within a family group. For many dedicated marroners, the whole event is treated with almost ritual enthusiasm as part of the enjoyment of Western Australia's natural heritage.

For many others, especially more knowledgeable locals living in the south west, marron is sought, taken and consumed with the dedication of expert fishermen. Country residents generally achieve much higher catch rates than their metropolitan counterparts.

The history of management of the marron fishery, by Regulations under the Fisheries Act has been previously documented. (Reference: Morrissy, Fish. Res. Bull. W.A. 21). The major fishing techniques employed include capture by one of three legal methods: one scoop net, six drop nets and one snare per licence. To take marron an individual must hold an Inland Fisherman's Licence (altered to a Recreational Fishing Licence from 1 July, 1986) unless under the age of thirteen years.

The open season extends from 16 December to 30 April, the bag limit is twenty marron per day and the legal minimum size is 76 mm (rostrum) carapace length ($\cong$ 120 gm). The possession of marron which have spawn, eggs or larvae attached is prohibited. The use of any boat, vessel, barge or punt or floating platform is prohibited for taking marron by any means. The taking of marron by diving or traps is prohibited.

All controls taken together are aimed at reducing the effectiveness of exploitation of marron stocks whilst maintaining an equitable distribution of the available catch amongst licence holders in the face of increasing fishing pressure.

The total number of inland fisherman's licences issued during 1985/86 was 28,765. This compares with the previous peak number of 27,302 licences issued in 1983/84. The vast majority of recreational fishing licences are issued for marron fishing.

The recreational fishery on marron in the south west constitutes a large number of geographically and therefore reproductively isolated marron stocks. Since recreational fishing on marron has taken place, their distribution has been extended to include rivers north of the Harvey River to the Hutt River, east of the Kent River to Esperance, and numerous other swamps, streams, lakes and water catchment areas. With the introduction of aquaculture many agricultural dams have also been stocked with marron.

Recent appraisal of the marron recreational fishery points to a long term decline in catch rates for marron. This trend has been associated with increasing fishing effort.

The committee was of the view that there are few public waters where marron fishing does not take place. This apparently was not the case in the early 1970's, before light-weight four wheel drive vehicles became widely used by recreational fishermen.

Research evidence was also submitted to the committee indicating an observed decline in abundance with increasing fishing pressure that has been exacerbated by periods of drought and reduced river water flow. Marron stocks along the major rivers have also been adversely

affected upstream by eutrophication originating from inland agricultural catchments. (Reference: Morrissy et al Fish Rep. No. 65). Anticipated increases in water salinity and reduced water flow from water conservation measures and drought conditions will continue to exacerbate upstream eutrophication and extend this unfavourable influence downstream.

In the face of continued increases in fishing pressure, and more gradual environmental changes within south west rivers, marron abundance within wild stocks are expected to continue to decline. This trend will be reflected in reduced catch rates for marroners and an increase in their concern as the trends become more evident.

For example, recent comments received from long term marron fishermen completing research log books for the Fisheries Department point to increasing concerns at the current status of marron stocks.

The committee concluded that whilst currently there exists a case for reviewing management measures for the recreational sport fishery on marron, it was also of the strong opinion that aquaculture of marron within Western Australia should be further encouraged. It was believed in this way marron will continue to be available for all Western Australians. Aquaculture may provide the mechanism for enhancement of 'wild stocks' in the future given the uncertainties associated with managing a sport fishery encompassing many small discrete stocks covering diverse environments.

In considering this perspective, it is of value to note that the total recreational catch of marron, taking into account the fishing effort levels applied, is thought to be in the order of 50 to 100 tonnes per annum. At current market values, the recreational fishery would have a gross commercial value of between $1.5M and $3.0M.

However, recreational fishermen cannot sell marron and their value to the economy may be more accurately measured by the expenditure incurred in their capture. For many fish species, the cost of catching is often two to three times that of their market value. Applying the same multipliers, marron fishermen would be expected to spend between $3.0M and $9.0M on items associated with catching marron (eg. nets, bait, food, transport, accommodation etc).

An estimate of these costs using research data on the total number of trips taken by marron fishermen during a season and likely trip costs, provides an overall value for the fishery of between $2.5 - $4.0M per annum.

Depending on which approach a person may wish to use, the recreational fishery on marron is more or less valuable and significant. However, it is of sufficient magnitude to justify reasonable management controls to be implemented, in order to provide adequate protection to wild stocks whilst permitting exploitation.

5.2 Koonacs and Yabbies

The committee was made aware of a small sport fishery on yabbies and koonacs from farm dams and limited public freshwater bodies near Kojonup and from coastal lakes and swamps south of Northcliffe. The sport fishery whilst significant to local residents, does not support a major following of enthusiastic recreational fishermen and is unlikely to result in any conflict of interest if commercial fish farming of koonacs and yabbies is developed.

5.3 Trout

Trout stocks within Western Australian streams and rivers provide a small but viable sport fishery for a limited number of dedicated sport fishermen. The Pemberton Trout Hatchery administered by the Fisheries Department has provided annually up to 500,000 trout fry, although usually about 250,000 are used to stock public waters in Western Australia. Current stocking rates have been recently reduced in order to increase supply of fry to private and commercial Fish Farmers.

The only supply of trout to the food market comes from aquaculture and there exists little potential conflict between the sport fishery and the further development of aquaculture on this species.

6 ENFORCEMENT OF RULES FOR INLAND RECREATIONAL FISHERIES AND AQUACULTURE

6.1 Background

The fisheries investigations branch of the Fisheries Department has forty five land based field officers of which twelve are regionally located outside the metropolitan area in the range of the marron fishery i.e. between Lancelin and Albany. These officers have a wide range of other fishery management priorities, but they individually spend varying proportions of their time conducting marron related patrols. There are a similar number of field officers based in the Perth metropolitan area who likewise have other commitments to their time, but who on occasions are involved in investigations or routine patrols connected with the management of the marron fishery. It is relevant to note here that much of the activity in the marron fishery occurs during the peak period of other seasonal fisheries and therefore coverage during peak periods of activity in the sport fishery is minimal. It is for this reason the Fisheries Department maintains an inland fisheries patrol unit of two experienced field officers, operating from the metropolitan area dedicated to provide enforcement surveillance of inland sport fisheries as well as the developing aquaculture industry.

An analysis of the time spent by the mobile inland patrol on enforcement indicate that about 70% of the total enforcement effort is focused upon water authority irrigation and water supply dams and 13% on rivers and streams in the Bunbury - Northcliffe area (Table 2).

TABLE 2: BREAKDOWN OF MARRON RELATED DUTIES OF THE INLAND FISHERIES PATROL UNIT.

	ENFORCEMENT AREA	TIME SPENT
1.	Irrigation Dams	50%
	(Wellington, Stirling, Harvey, Waroona, Logues Brook)	
2.	Metropolitan Water Supply Dams	20%
	(South Dandalup, Wungong, Serpentine, Canning, Churchman's Brook)	
3.	Rivers and Streams	
	Perth - Bunbury	5%
	Bunbury - Northcliffe	13%
	Northcliffe - Albany	2%
4.	Duties other than marron	10%

These values compare with about one third of marron parties fishing in public irrigated dams for marron with the majority fishing Western Australia's rivers and streams, indicating perhaps undue emphasis being placed on public dams.

The reason more time is allocated to marron inspections at dam sites is due to the higher concentration of marron parties in those areas and therefore it is easier to make contact with large numbers of persons engaged in the sport fishery, especially as most fishing is conducted at night.

The use of road check points within the area of the marron fishery are essential for apprehending people who fish the more inaccessible areas of Western Australian rivers and streams and take large numbers of marron in excess of their bag limits and/or less than the legal minimum size.

The maintenance of a dedicated inland enforcement patrol is a necessary requirement to ensure the assemblage of rules to protect the sport fishery on wild stocks are not breached. Since the implementation of fish farming provisions under the Fisheries Act, this requirement has taken a higher level of priority due to the need to guarantee that extensive commercial fishing of wild stocks for sale through "legitimate" fish farm enterprises do not occur.

The mobile patrol unit dedicated for inland fisheries enforcement accounts for the main proportion of apprehensions in the marron fishery. Records maintained in recent years indicate that reports concerning illegal marroning activities represent approximately 10% of all breach reports received by the Fisheries Department - as shown in Table 3.

TABLE 3: NUMBERS OF BREACHES OF FISHERIES REGULATIONS

Year	Marron Reports	Total No. of Reports
1982	35	412
1983	40	333
1984	34	284

Each reported incident usually concerns more than one person and there are often multiple offences connected with each.

An estimate of the numbers of marroning offenders prosecuted can be determined on the basis that an average of two offenders are prosecuted for every breach report received. Similarly for every report received an average of four prosecutions result. These averages take into account those reported incidents where letters of warning are issued and no prosecution action is taken. It is relevant to note here that officers engaged in field patrols issue, as a matter of course, numerous verbal warnings to offenders for minor offences in addition to submitting the written reports described above.

Policing of the management rules designed to give some measure of protection for the wild stocks in the marron fishery is both difficult and time consuming both in the recreational fishery and commercial aquaculture sector and may best be summarised as follows.

6.2 Recreational Marron Fishery

Much of the illegal activity is conducted at night in isolated areas. While officers conducting marron patrols have a high level of dedication to the task, regular offenders are now familiar with inspection techniques and they take elaborate precautions to avoid apprehension.

Offenders are often affected by alcohol and many are aggressive when confronted by fisheries officers.

These difficulties are further compounded by the lack of accessibility and remoteness of fishing areas in the rivers of the south west area. Offences and practices which are of concern to the enforcement branch of the Fisheries Department are:-

(a) There is evidence that many marroning parties consume undersize marron at the fishing site and thus avoid detection for taking undersize fish and taking numbers in excess of the regulated daily bag limit.

(b) Many parties claim bag limits for children in their groups. Children under the age of thirteen are not required to hold an Inland Fisherman's Licence. In some instances no person in a party may hold a licence and the accompanying adults state that their children caught the marron.

(c) Advice suggests that boats are often illegally used to take marron in the river systems away from areas normally accessible by officers conducting land patrols.

(d) There seems to be a high incidence of taking marron during the closed season, much of which occurs around Water Authority dam sites.

(e) There is a constant danger of physical assault upon officers by offenders. This threat is more apparent in this fishery than any other managed by the Fisheries Department.

(f) There have been several instances where offenders have been apprehended for taking marron from the wild for the purpose of sale. Investigations

concerning such activities are complex and obtaining evidence necessary to sustain a successful prosecution action is not always achieved.

6.3 Marron Aquaculture

The Fish Farming provisions of the Fisheries Act provide for the development of marron aquaculture whilst protecting wild stocks from commercial exploitation by the following combination of principles:-

(a) The licensing of fish farms under strict licensing requirements to ensure that each fish farm is able to quantify through its own hatchery or purchases, the source of juvenile marron. The licensing requirements therefore encompassed the concept of a hatchery and managed self-drainable grow-out ponds for reasons of audit and fish management.

(b) The licensing of all processors and distributors of marron, including restaurants, to enable the Fisheries Department to monitor all sales transactions. This approach was designed to follow the flow of marron produced from a fish farm to its final destination through statistical returns, that is through a production/distribution audit.

(c) The continuous maintenance of enforcement surveillance on wild stocks to ensure persons are not exploiting marron and other freshwater fish species for commercial gain.

(d) Regular visits to fish farms by Fisheries Enforcement Officers, to monitor fish farming developments and progress.

To date, controls providing for the orderly development of aquaculture while at the same time giving a measure of

protection to the 'wild stock' fishery have been reasonably successful. A significant contributory factor enabling the Fisheries Department to maintain a reasonable level of control arises from the relatively low number of fish farmers that have persisted with development. In addition, the low number of licensed restaurant outlets authorised to 'process' the small output has also assisted control.

In describing this perspective, the committee is aware of concerns raised about the integrity of some processors and expressions of concern at the operation of a "black market" for marron. This issue has been brought to the publics attention by members of the commercial fish farming community itself. The "black market" marron are presumably being sourced from wild stocks, although there was the belief among some members of the committee that the origin for much of this product came from agricultural farm dams and metropolitan water supply dams.

The Fisheries Department enforcement branch, while accepting that some black marketing of 'wild marron' stocks took place, could not identify any supporting evidence indicating that the practice was widespread.

The application of the fish farming provisions to marron aquaculture has raised a number of difficulties for enforcement and administration by the Fisheries Department. These are detailed as follows:

(a) Legislation under the Fisheries Act does not satisfactorily provide a demarcation between marron taken from wild stocks and those grown within private waters or on the premises of a fish farm. Technically a fish farmer is in breach of legislation by being in the possession of undersize marron or berried female marron.

(b) There is a requirement to legally separate the trading activities of fish farmers and the control problems associated with the possession of undersize marron where they are taken from waters within private property as opposed to public waters. This raises the issue as to whether the rules for the sport fishery in public waters should be applied equally to fishing of impounded waters within private property.

(c) Licensing criteria based on minimum size standards for hatcheries and ponds without specific design criteria are difficult to implement and enforce. In an industry which has a diversity of views on the correct methodology for marron aquaculture and is still experimental in approach, it is not surprising that inconsistencies in licensing have occurred.

(d) The monitoring of fish farms where production is based on 'extensive' farming methods or 'recovery' from non-drainable ponds and dams has proven to be extremely difficult. Sampling techniques to monitor progress and provide estimates of production for control purposes are time consuming and expensive.

Without this level of monitoring, the Fisheries Department cannot project yields. This information is required to minimise the risk of 'wild stocks' being exploited and sold through a licensed fish farming establishment.

(e) The monitoring of all sales transactions as an enforcement tool is of minimal value. The time proven method of enforcement that is most effective is by direct observation and gathering of evidence following informant advice.

(f) The only effective method of controlling poaching of 'wild stocks' of marron is in field enforcement and surveillance. It is recognised that with the limited resources available dedicated to enforcement of the marron sport fishery, little real coverage is provided for rivers and streams, especially within the lower south west.

(g) The penalties applied to breaches of recreational fishing rules for marron fishing do not take into account the interrelationship between the sport fishery and the potential for illegal fishing for commercial gain.

It can be seen from the foregoing discussion that one of the major issues facing the review committee relates to the requirement to protect the sport fishery on marron while, at the same time, providing for the orderly development of aquaculture.

In essence any relaxation of existing controls or licensing policies in favour of aquaculture has the potential to lead to abuse of fishing Regulations to the detriment of wild stocks and the sport fishery. The effectiveness of Fisheries Department enforcement and its ability to accommodate changes in rules is thus an important element in the committee's consideration of its terms of reference.

Enforcement surveillance of other freshwater fisheries is not an area of great activity or priority. Rules in relation to trout fishing are enforced on an opportunistic basis by the inland fisheries patrol noting that the distribution of trout as a sport fishery is overlapped by marron.

Visiting of fish farms, other than those involved in marron aquaculture, is undertaken on a needs basis rather than as a regular monitoring programme.

There is virtually no regulation of the sport fishery on koonacs.

There is no public sport fishery on yabbies as the majority of stocks are limited to dams within private property.

7 BIOECONOMIC MODEL FOR SEMI INTENSIVE POND GROW-OUT OF MARRON

During the course of this review, the committee benefited from the development of a model simulating known biological and economic data for the 'grow-out' of marron within a postulated semi-intensive marron farm. Full details of this analysis conducted by Morrissy *et al* is detailed in Appendix 1.

The model enabled the review committee to seek and obtain answers on the relative viability of growing marron from juveniles (ex release from female marron) to different sizes over varying time spans, thus testing various harvest strategies. This approach brings together detailed biological research data together with realistic cost projections enabling the committee to assess the relative value of allowing marron farmers to sell marron as a total harvest that includes both size animals (greater than 120 gm) and animals less than the legal minimum size, to as low as 40 gms. Marron less than 40 gms were excluded from the analysis as the committee considered very small marron would not be sold in the restaurant food market as a consequence of their high preparation costs.

In practice however, where a total harvest strategy is applied, it is likely a marron farmer would either sell the marron less than 40 gms for stocking purposes or place them within a new cohort for further grow-out. In either event these small marron would have a greater intrinsic or market value than zero assumed in the model. Therefore whilst the modelling work assumes a lower minimum size of 40 gms in practice, a lower minimum size is neither practical or necessary.

The committee acknowledged that the cost factors built into the model would vary between locations and differing management practices that are used. However, as a guide

to the future direction for marron aquaculture, it was the best available, given the failure of the aquaculture industry to establish, beyond any reasonable doubt, field data on the success of commercial scale pond grow-out of marron for edible food consumption. Much of the data used in the model was based on results from the Pemberton research site. Other areas of the State would be far more favourable to grow-out than Pemberton.

The major conclusions to be drawn from these analyses are as follows:

(a) There are major profit and cash flow advantages to be achieved by fish farmers in the relaxation of the minimum size restrictions to enable marron of less than 120 gm to be sold on the food market. A removal of the restrictions on minimum size could potentially double returns for marron farmers using intensive grow-out methods.

(b) The present minimum legal size of 76 mm carapace length (≅ 120 gm) for farmed marron for the food market excludes from sale a significant proportion of the harvest taken at any time up to two years from "seeding" semi-intensive pond grow-out with juvenile (0+) marron.

(c) A lower size limit of 40gm (≅ 52mm carapace length), assuming market acceptance, would permit the sale of more than 95% of most harvests. This would allow total harvest strategies to be employed by fish farmers which in turn adds to greater management flexibility.

(d) With a lower size limit of 40 g for harvests from a final grow-out density range of 1.5 - 2.5 M^{-2}, return on capital can be in the range 10-20% for the Pemberton research locality and can be expected to be higher at warmer localities recommended for

marron farming.

(e) Site selection, taking into account micro climate variances, is a key factor in determining marron growth rates and therefore profitability. There could be an optimal mix for hatcheries and grow-out facilities at different sites.

(f) The rates of return estimated for marron aquaculture given the uncertainties associated with translating experimental data to hypothetical commercially operated ponds, places the feasibility for grow-out of marron for the food market in the 'high risk' investment category.

The removal of minimum size restrictions will not by itself remove marron aquaculture from the 'high risk' investment category.

(g) Successful development of a semi-intensive marron farming venture is clearly dependent upon an establishment requiring substantial capital investment in suitable grow-out/hatchery facilities and cash resources for development over a medium term start up period. Specialist management skills in fish farming are also an essential requirement. (This conclusion is further evaluated later in this report in relation to future licensing policy).

8 TERM OF REFERENCE NO. 1

"To identify the constraints limiting the development of Inland Freshwater Aquaculture in South West Western Australia".

The committee, taking into account views expressed in the public submissions, focused upon the following areas in its consideration of the first term of reference:

8.1 Government Policy
8.2 Management expertise
8.3 Brood Stock
8.4 Predators.

8.1 Government Policy

It was argued in some submissions that the restrictive licensing policy and the tight controls on the distribution and marketing of marron within Western Australia was a significant inhibiting factor towards preventing the development of more "extensive" farming methods for marron and yabbies in particular. The requirements placed within licensing policies for either intensive hatchery and/or pond development before licences are issued coupled with the licensing of fish farms on a property by property basis, has reduced the ability of fish farmers to capitalize on all available opportunities in the use of both intensive and extensive farming methods. It is for this reason one of the terms of reference focuses specifically on licensing policies and licensing arrangements sought by fish farmers.

These criticisms are valid, if taken out of context of the need to protect the sport fishery on marron. It could be argued however, that the emphasis of licensing policies, favouring more intensive aquaculture methods, has contributed to successes experienced in the hatchery production of large numbers of 0+ marron.

The high capital costs for hatchery/pond development has been a limiting factor for fish farmers seeking to extend their scale of operations. The failure by local fish farmers to attract substantial venture capital into marron aquaculture can be partly attributed to the tight controls placed on licensing and the sale of marron within the local market. The lack of research data relevant to the feasibility assessment of commercial "scaled" pond aquaculture of marron has also been a major hurdle.

The lack of facilities and funds for research targeting on the translation of experimental data to a field or commercial scaled size pond has been and continues to be a serious limiting factor in assessing the commercial potential for marron aquaculture and future direction for development. For principally this reason, venture capital needed to establish large aquaculture developments employing their own management and technical expertise has thus far not been forthcoming within Western Australia.

The committee in consideration of research requirements as a first priority supported the need for a commercial scale aquaculture research facility in south west Western Australia. In supporting this proposition, it was recognized that a number of options may be available. These include the use of industry facilities by Government research personnel or alternately, the establishment of commercial sized ponds for research purposes, attached to the Pemberton Trout Hatchery operated by the research branch of the Fisheries Department.

Other areas of research identified as a high priority in marron aquaculture included nutrition, and genetic improvement through selection or hybridization.

A facility of this type can then be used as a basis for future research into other freshwater species including aquarium fish, depending on development interest.

A further possible constraint, limiting the potential for aquaculture developments arise from town planning controls. Within some shires in the south-west there exists town planning restrictions preventing agricultural holding falling below a certain minimum land area. People interested in fish farming ventures may therefore be required to obtain much larger holdings than they might otherwise. This requirement simply adds to the total entry cost for would be fish farmers and was stated within submissions to be a high unnecessary cost to entry. The Committee was in accord with this view.

Recommendations

1 That Government provide priority to the establishment of an inland fresh water research facility within Western Australia to provide data on aquaculture farming techniques at a commercial scale.

2 That town planning restrictions limiting subdivision of agricultural properties not apply when undertaken for fish farming purposes.

8.2 Management Expertise

Symptomatic of many developing industries, the committee identified a lack of aquaculture expertise among most fish farmers. The reasons are varied, encompassing a mixture of individual backgrounds, levels of commitment, both personal and financial, and a lack of training through experience, advice or education.

The observation, that many marron farmers were very much 'individuals' and "doing their own thing" towards solving

their own fish farming difficulties, whilst not by itself necessarily wrong, often created circumstances whereby each farmer was "re-inventing the wheel". Farmers often have their own ideas on stocking densities, ratio of sexes for breeding, hybridization, aeration of ponds, pond construction and optimum sizes, predation control and other aspects. So much so, that for the most part they tended not to be aware of or even ignore available research data and overseas experience on pond culture. This is also a reflection of the different initiatives taken by farmers within a developing industry.

The lack of 'training', often manifested itself on the part of individual fish farmers in them not adequately monitoring the progress of cohorts of marron in pond culture situations. This in turn resulted in fish farmers not being able to identify or learn from the monitoring of key environmental or population parameters for future grow-out or adding to the body of knowledge on marron aquaculture.

The success of individual approaches used were measured in kilos of product produced with little real knowledge as to the causative factors, leading to successes or failures.

In the circumstances, it was therefore not surprising that the committee found a large divergence in skills and levels of performance between fish farmers.

The committee in recognizing that the lack of fish farming management skills within Western Australia was a constraint on the future development of fish farming, saw little practical value in involving the Education Department through the division of Technical Education, in providing specifically designed long term courses for "fish farmers". Persons with specific skills in marron aquaculture are not readily available and such a

development could be premature although a desirable future requirement.

The low number of operative fish farmers within Western Australia limits the cost-effectiveness of longer termed courses vis a vis the value of short term courses delivered by private experts acknowledged in the fish farming field within and outside of Western Australia.

In a similar vein, the provision of a technical fish farm extension service would be a desirable medium term objective. The cost benefit of an extension service currently however is doubtful, without an adequate research/industry pond grow-out facility operating successfully at a commercial scale.

The committee recognized the value in fish farm owners employing personnel having specific training and experience in fish farming ventures. By necessity, this may require the introduction of overseas sourced expertise.

Recommendation

That Government take every opportunity in encouraging the further development of 'fish farming' skills within Western Australia.

8.3 Brood Stock

The lack of marron brood stock available for aquaculture was raised in a number of submissions as a constraining factor limiting development growth.

It seems the requirement for early cash flow by many fish farmers has led individual farmers to maximize their sales of 0+ juveniles to the detriment of re-investment into producing their own brood stock. This in turn, due

to the relative low fecundity for marron and two-three year time lag between buying 0+ and producing animals of sufficient size for breeding, has limited the rate of expansion for would be investors in large scaled pond grow-out facilities.

To date, the joint attraction of the 0+ market and the inability for fish farmers to quickly add to their own breeding stock, has placed a real limit on the rate of expansion of both marron hatchery and grow-out facilities.

Brood stock can be sourced from three areas:

(a) other fish farmers - at present the only legal way;

(b) from wild stocks - at present not permitted;

(c) the purchase of brood stock from land owners having discrete stocks of marron within their properties from waters which do not form part of the 'wild stock' sport fishery.

The committee does not support the taking of marron from waters which form part of the sport fishery. In stating this position however, the committee believes there are some benefits to be achieved by the permitted capture of small numbers of marron from differing wild stocks for breeding purposes, to allow the infusion of genetic diversity within the overall marron brood stock, utilized by fish farmers. Such approvals should be limited, both in terms of numbers of marron permitted to be collected and numbers of individuals granted collection rights.

The view was also expressed by researchers on the need to maintain genetically secure populations of different 'races' of marron and koonacs to ensure that

hybridization within the 'wild stock' does not lead to a loss in genetic diversity. The committee supports this requirement as a means of ensuring genetic material for future research and development. The maintenance of viable populations of different native freshwater crayfish races within ponds by either the Fisheries Department or other research organizations is considered to be of priority.

The committee's attention was also drawn to the reported abundance of marron which can be found in Western Australian Water Authority's water supply catchment dams. These stocks are not exploited for reasons associated with meeting drinking water quality standards and as a measure to ensure adequate protection of water supplies held in storage for human consumption purposes.

The Minister for Water Resources, during the course of this review, made it clear that the taking of marron from water catchment dams used for human water supply was not an acceptable activity and therefore could not be used to augment breeding stocks for fish farmers.

The committee has no alternative but to accept that stance as a Government water resource management policy but strongly supports the continued review of this policy with changes in water management policy.

As a measure to enhance the supply of marron for brood stock purposes, a limited number of approvals have been provided for individual farmers to acquire marron from land owners on a single consignment basis. This method of augmenting supplies has only been allowed where the possibility of marron being part of the wild stock fishery had been totally discounted. On all occasions inspection supervision had been provided.

The proposed changes in licensing policy, reported under Term of Reference No. 4, to provide for the sale of legal

sized marron under a permit system, would allow fish farmers to augment brood stock supplies from private water sources. Should Government adopt the recommendations, the constraints on development caused by a lack of marron brood stock will be greatly alleviated by initially restricting the granting of permits, to land owners, for the supply of legal size broodstock to fish farmers, thus ensuring brood stock supplies for the establishment of the marron aquaculture industry.

8.4 Predators

The theft of marron or poaching appears to be a major problem for fish farmers. As this is a criminal matter and offences are reported to the police, there appears to be little the committee can accomplish other than emphasising the need for the criminal code to reflect a realistic penalty for the offence. Indiscriminate theft of marron brood stock from a property has the potential to severely damage long term breeding programmes at substantial cost to the fish farmer. A fish farmer can seek remedy by taking civil action in the courts against a person causing damage to property.

A significant level of expenditure has been incurred by fish farmers to control predation by protected species of birds and water rats. The Department of Conservation and Land Management has jurisdiction over protected species. The permitted destruction of predatory animals under the authority of damage licences are rarely granted and fish farmers have used other avenues of prevention control.

These include

(a) Protective enclosures,
(b) Scare systems, and
(c) Underwater cover for marron.

All three are expensive, especially if they do not work. Development and research into new systems is also expensive and time consuming.

To date, the most effective device appears to be protective enclosures, eg netting over ponds and electric fences to prevent water rats entering ponds. This method of prevention is expensive to establish and to maintain.

Predation of marron by birds can be minimized by turbid waters or by using sonic or other common scare systems. Invariably these devices, although effective initially, become less so as fauna become used to them.

The damage and cost of predator control varies between fish farmers depending on their location relative to natural water resources. Site selection is therefore a key factor in determining potential for predator problems within marron aquaculture.

A number of submissions to the review sought greater flexibility in the destruction of 'problem' fauna by the issue of an open 'damage' licence, particularly for water rats and cormorants.

The committee whilst sympathetic to the difficulties experienced and supportive of the need for destruction of fauna under a 'damage' licence for dealing with problem fauna, were of the opinion that the industry itself must deal with problems caused by predation and take the initiative.

This can be achieved by fish farmers continuing to utilise established predatory control techniques developed elsewhere in Australia and overseas and the industry as a group seeking special dispensation under the Wildlife Conservation Act for an open damage licence to destroy cormorants and water rats, once having taken

control measures to minimise predator impact on individual fish farms.

Other matters raised

The committee's attention was drawn to apparent inequities under taxation law in the application of taxing principles. It seems, whilst it is considered that a person who conducts a business of farming marron or freshwater lobster is a primary producer for income tax purposes, the view is held by the Commissioner for Taxation that the person is not engaged in agricultural industry for the purposes of sales tax legislation. In order that a marron or freshwater lobster farmer may gain the benefit of sales tax exemption, the farmer is required to demonstrate that his operations involve manufacture and that particular equipment used in those operations qualifies as an aid to manufacture.

The committee in briefly considering this issue, whilst not purporting to be expert in the area of taxation, could not identify the differences in principle between the intensive methods of raising poultry and that of marron aquaculture. It certainly seems from the committee's perspective that the treatment of fish farming akin to that of raising livestock is logically more consistent than treating marron aquaculture for sales tax purposes as a manufacturing industry.

The committee therefore supports the case presented by the W A Marron Growers Association, that for sales tax purposes fish farming be treated the same as agriculture.

In stating the above position, the Committee could not accept taxation laws as being an inhibiting factor in the development of fish farming on the basis of evidence presented to it.

9 TERM OF REFERENCE NO. 2

"To review current policies, regulations and enforcement requirements under the Fisheries Act 1905, for fish farming as they apply to trout, marron, yabbies, koonacs and fresh water aquarium fish."

The committee received a wide variety of suggestions and responses to the second term of reference in the public submissions. Much of the material dealt with licensing policy which is reported under Term of Reference No. 4.

The subject material presented to the committee caused it to focus upon three areas in particular in its consideration of the above term of reference:

9.1 Interstate Transport of Live Fish into Western Australia

9.2 Relevance of Current Legislation taking into Account the Requirements of Enforcement and Aquaculture

9.3 Western Australian Water Authority Approvals.

9.1. Interstate Transport of Live Fish into Western Australia

During the course of this review, the committee's attention was drawn to the lack of real control on the interstate movement of live fish into Western Australia. This lack of control has caused the committee to more fully explore the subject of quarantine for fish and the need to reduce disease risks associated with the import of fish interstate. This aspect of disease risk will become more critical with further development of mariculture and freshwater aquaculture within this State.

The Fisheries Department also independently held discussions with Animal Quarantine Service - Department

of Agriculture, the Western Australian Marron Growers Association, the Australian Fish Health Reference Laboratory, and the Western Australian Pet and Aquarium Dealers Association on the requirements for more explicit controls on the movement of fish from interstate into Western Australia.

From these discussions, a set of policy arrangements controlling the import of fish from interstate have been proposed. Appendix II outlines these in detail.

The review committee supports the general principle of adopting quarantine procedures to reduce the risk of fish disease pathogens being introduced into Western Australia. The guidelines developed are essentially an adaption of those operating for imports into Australia so that they meet the needs of interstate trade.

In the development of these guidelines, the committee strongly supports prohibitions on the entry of live freshwater crayfish into Western Australia, except under very strict quarantine measures designed to eliminate the risk of introducing the crayfish plague fungus.

Recommendation

That the proposed policy guidelines controlling the import of live fish into Western Australia from interstate as detailed in Appendix 2 be adopted.

9.2 Relevance of Current Legislation taking into Account the Requirements of Enforcement and Aquaculture

9.2.1 Legislative Anomalies

During the course of this review, attention was drawn to a number of anomalies within the Fisheries Act and Regulations in relation to marron aquaculture.

The legislation in its current form makes it an offence for any person to have in their possession marron less than the legal minimum size or ovum (egg) bearing marron. Fish farming by its very nature, requires a fish farmer to hold breeding females and to produce, hold and sell undersize marron for stocking purposes or for grow-out. The Fisheries Act and Regulations need to be modified to take into account the anomalies arising from commercial fish farming practices and legislation designed to protect the sport fishery.

Recommendation

That the Fisheries Act and Regulations be amended to enable fish farmers to legally have in their possession undersize marron and ovum bearing female marron.

9.2.2 Penalties

The committee examined the various penalties for different offences in relation to breaches committed by recreational fishermen when breaking rules designed to protect the sport fishery. For the most part, the committee believed the level of penalties applied under the Fisheries Act 1905 and Fisheries Regulations to be adequate, assuming that they are regularly adjusted in line with consumer price indexes so the relativity of penalties with inflation were maintained.

The committee was concerned however at the potential for individuals to fish 'wild stocks' of marron on a commercial basis. It was argued that penalties designed to protect the sport fishery should discriminate between a recreational fisherman breaching a rule on the spur of the moment or through "ignorance" of the law, as distinct from a person who undertakes a premeditated and deliberate act to break laws for commercial gain.

The committee believed that the penalty levels for persons exceeding bag limits or undertaking unauthorised selling of marron needed to be modified to provide a clear directive to the courts that commercial fishing of marron from wild stocks was unacceptable.

As a guiding example, the committee proposed the following alternatives for breaches of daily catch bag limits for marron according to the scale of breach.

For a breach where the bag limit was exceeded by less than 10 individual marron - Maximum penalty $50

For a breach where the bag limit was exceeded by more than 10 but less than 20 individual marron - Minimum penalty $ 50 Maximum penalty $150

For a breach where the bag limit was exceeded by more than 20 individual marron - Minimum penalty $150 Maximum penalty $500

Alternatively the penalty could be structured in terms of a fine per individual marron in excess of the daily bag limit. In this way the penalty applied to a person grossly exceeding the bag limit would be adequately reflected in the relativity of fines imposed.

On a similar basis the committee supported the view that the penalty for unauthorised selling of marron should equate to that for unauthorised selling of rock lobster. That is there be an additional penalty calculated at the rate of ten times the wholesale value at the time of the offence.

Recommendation

That the penalty levels under the Fisheries Act 1905 for breaches for exceeding the daily catch bag limit for marron, or for unauthorised selling of marron, be modified to incorporate a greater scale of penalty as a stronger deterrent to illegal commercial fishing of wild stocks of marron. The level of penalty should equate with those already applying to similar offences for rock lobster.

9.2.3 Changes in Rules for Recreational Fishing

The committee was made aware of the practices of some recreational fishermen choosing to exceed the bag limit for marron by claiming a separate bag before and after midnight whilst fishing.

In addition, some fishermen also sought the protection of their children by arguing each child is entitled to and caught a separate "bag" of fish. For the majority of situations, such claims are legitimate, however on occasion, Fisheries enforcement officers are faced with the ludicrous situation whereby a two year old child is said to have caught the legal "bag limit" of marron. The rules as they stand allow any child under the age of thirteen years to take marron without holding a Recreational Fishing Licence and catch, daily, the bag limit of marron.

The committee in their consideration of these aspects, came to the opinion these legal "loopholes" to fishermen should be minimised.

It was therefore proposed that the daily bag limit for marron should relate to the period of major fishing activity for marron, that is from midday to midday, consistent with early afternoon and night fishing.

In a similar vein, a bag limit of 20 marron should not be claimable by the parents for a child less than six years of age. The committee was of the opinion, for the most part, that pre-primary children do not fish for marron without parental supervision and common sense suggests these children are usually not capable of taking a separate bag of marron without assistance. Where children are catching marron as a recreational activity, they need to be of sufficient age to be aware of the principal rules concerning their capture to justify a separate "bag" by their own fishing.

Recommendations

1 That the daily catch bag limit for marron be modified to apply from midday to the following midday, so that it is consistent with fishing practices of recreational fishermen.

2 That the "rights" of recreational fishing for marron extended to children under thirteen years of age not apply for children under six years of age.

9.2.4 Taking of marron from Impounded Waters within Private Property

During the last decade, large numbers of farmers in agricultural areas have stocked water supply dams on their property with marron, koonacs and yabbies.

The regulations controlling recreational fishing make it a requirement for a person to hold a recreational fishing licence to catch marron from any river, stream, brook, creek, lake or lagoon but not from impounded waters contained within a private dam.

However, the legislation controlling the minimum legal size for marron and the daily catch bag limit encompasses the taking of marron from all Western Australian waters

including impounded waters on a person's private property.

Technically the legislation as it stands requires a land owner having a dam in which marron have been introduced, to utilise the marron in accordance with the rules applying for the recreational sport fishery although not necessitating the requirement for a recreational fishing licence. That is, the marron taken from certain private waters within a farming property, can only be consumed during the open season, be of a size greater than the legal minimum size and so on.

In these circumstances the Fisheries Department has chosen not to enforce the letter of the law whilst the marron remains in the possession of the land owner and is utilized for private consumption purposes on the owner's property. That is, the land owner has been allowed to use the marron at any time during the year and utilize product of any size. To attempt to enforce the legislation is neither practical or morally sensible where marron caught by the land owner for his own use has been taken from the confines of impounded water on private property which does not form part of the public waters sport fishery.

Where marron is taken away from the property, out of season or as undersize marron, or the person in possession does not have the authority of capture extended by a recreational fishing licence, that person is liable to prosecution.

The moral argument could be raised that where marron have been sourced from private impounded waters on a land owners property, the intent of the regulations designed to protect the sport fishery has not been abrogated and therefore the possession of marron taken from private waters should be treated differently to the capture of them from public waters.

The committee in consideration of this issue, whilst mindful of the moral arguments that may ensue, came to the opinion that the regulations drafted to protect the wild stock sport fishery on marron should take priority over any moral or legal loopholes that might exist concerning the capture and utilization of marron in private waters. To do otherwise would make the enforcement of rules for the sport fishery impractical. For the sake of clarity, the committee saw merit in amending the legislation controlling the marron sport fishery, so as to make absolutely clear to land owners their rights in the utilization of home grown marron for consumption on and off their properties.

Recommendation

That specific legislation be introduced defining the rights of land owners in the private domestic usage of marron grown within the confines of impounded waters on their properties.

9.3 Western Australian Water Authority Approvals

During the course of this review, it became abundantly clear to the committee that the controls relating to water resource usage and licensing of riparian water rights were detailed and complex.

Each application for a fish farm licence needs to be assessed in terms of water usage, potential for nutrient loading of effluent, details of pond/dam construction and potential for increasing water turbidity and siltation. The requirements for each of these factors were also seen to vary depending on location, source of water, disposal of water outflow, species of fish to be farmed and individual farming methods to be applied by the respondent fish farmer.

The Western Australian Water Authority has the responsibility for water resource management and therefore it is not appropriate for the Fisheries Department to make independent decisions on licensing without referral to that Authority.

As a matter of licensing policy, since the commencement of this review, all applications for a fish farm licence to the Fisheries Department, requiring the usage of fresh water, are referred to the Western Australian Water Authority for their consideration. A fish farm licence should not be issued for freshwater aquaculture without the necessary water usage approvals being issued.

Recommendation

That all applications to the Fisheries Department for a fish farm licence for freshwater aquaculture be referred to the Western Australian Water Authority for separate approvals in relation to water usage prior to licensing for aquaculture.

10 TERM OF REFERENCE NO. 3

"To examine the proposal as to whether marron less than the minimum legal size of 76 mm carapace length be permitted to be sold for human consumption by registered fish farmers and to report on the possible mechanisms for implementing such a proposal without detriment to the marron sport fishery".

The modelling work undertaken by Morrissy et al described in Appendix 1, suggest there are significant advantages in providing for the removal of the restrictions on the minimum size for fish farmers using intensive grow-out methods. The committee upon reviewing this conclusion, believed it was appropriate for it to develop a mechanism whereby certain fish farming ventures could produce and market undersize marron for consumption within Western Australia. To do otherwise would be to simply ignore the realities of investments being made in Queensland and New South Wales into marron aquaculture, where there are no minimum size constraints, and the real prospect of marron flesh (including undersize marron) eventually being marketed in Western Australia sourced from interstate fish farms.

The control problems of managing the marketing of undersize marron in Western Australia is an issue which the Fisheries Department and Government will have to accept, if not as a result of changes in licensing policy proposed later in this report, then as a consequence of longer term market changes.

In addressing this issue, the committee was conscious of the difficulties incurred by the fisheries enforcement branch of the Fisheries Department in managing the marron sport fishery. It could also be argued for some areas of the south west, that the level of field surveillance within the fishery is low and not sufficient to prevent abuse of fishing rules.

The committee in consideration of these aspects were of the opinion that any changes in licensing policy to accommodate the sale of undersize marron needed to go hand-in-hand with an

increased surveillance presence, especially within the south west at the centre of the recreational sport fishery on marron.

The only mechanism the committee could identify as being workable for the sale of undersized marron was that of licensing a restricted number of fish farmers under very specific criteria.

The proposal to limit initial licensing of fish farms producing and selling undersize marron to a restricted number of farms, for a reasonable period of time, would enable would-be investors to more fully assess the commercial viability of marron aquaculture given the uncertainties of translating experimental results of grow-out to a commercial field operation.

The licensing of a restricted number of fish farms, to sell undersize marron, to between five and ten, in the early years of the programme would also allow the Fisheries Department to develop appropriate mechanisms for monitoring the production and the distribution of undersize marron onto the market. This restricted licensing of fish farms specifically for grow-out of undersize marron will also ensure a range of environmental locations are assessed thereby increasing the prospect for commercial success.

Potentially on the production figures available to the committee, 50 hectares of ponds, (5 viable 10 HA farms) which is a small area of water by international standards, has the potential to produce 100 tonnes of marron each year, which is the estimated level of production of the entire sport fishery.

In attempting to identify systems of control to ensure the protection of the sport fishery, the committee believed that the licensing criteria for fish farms producing and selling undersize marron needed to be detailed. The criteria developed needs to ensure significant investment into ponds, the employment of the best available fish farming expertise

and a level of production to warrant, for market and audit purposes, an appropriate packaging system.

The committee was of the opinion that by attracting substantial risk venture capital into marron aquaculture, the risks of individual fish farmers seeking to take wild stock marron for 'laundering' through their fish farms would be substantially reduced. The ultimate sanction for any fish farmer caught in the act of 'laundering' marron from the wild stock fishery, must include the loss of the licence to farm fish.

The real threat perceived by the committee to the sport fishery through a change in the permitted market size of marron for the food market arises from the infiltration of this market by individuals, not associated with the fish farming community, selling undersize marron caught from wild stocks in Western Australia's rivers and streams.

The only effective controls to minimize this potential are:

(a) To increase the direct level of surveillance of Western Australia's sport fishery for breaches of the Fisheries Act.

(b) To increase penalty levels for fishing of marron within the sport fishery, for illegal commercial purposes.

(c) To place precise controls on the packaging requirements of undersize marron sold onto the market.

(d) To limit the processing of marron to licensed outlets as already specified under the Fisheries Act.

(e) To maintain a reasonable level of surveillance of

licensed fish farming establishments and licensed processors.

In the committee's examination of a set of licensing criteria for the production of undersize marron for domestic sale, the following requirements were considered desirable:

(a) The farm would need to be capable of producing sufficient juvenile animals for stocking of ponds using an established breeding stock.

(b) A minimum total pond area of 2.5 hectares as self drainable pond units, each being not more than 0.50 hectares in size.

(c) A capability for packaging live or processed marron for the restaurant trade allowing product identification at the market.

(d) Have access to experienced fish farming expertise covering hatchery and pond grow-out production.

(e) A finance capability to sustain the anticipated costs of establishing an adequate level of breeding stock and subsequent technical delays in establishing an efficient management/production system. The achievement of this objective will by necessity require adequate medium term cash reserves and a research and development capability.

(f) The selection of a site whereby water usage requirements will not be limiting on marron production and will satisfy the licensing requirements of the Western Australian Water Authority.

In setting down these guidelines for the licensing of fish farms for sale of marron less than the legal minimum size for

food, the committee recognized that two approaches could be used by Government for initiating development.

The most positive approach is to use these guidelines to invite submissions from prospective developers and for Government to make a determination from the various proposals received, as to the successful applicants. The successful applicants would then be granted a five year period to undertake the development proposed with the understanding that no further licences would be issued for the production of undersize marron for the market during this development phase. This approach for reasons of integrity, would need to include minimum performance requirements in relation to timing of development.

The other approach, is for the Fisheries Department to consider each application which meets the proposed guidelines for production of undersize marron and to grant approvals until the number of licences sought for the development phase has been reached.

The committee prefers the approach of Government actively seeking proposals and the granting of "development" licences for a clearly defined period to those which offer the greatest prospect for success and benefit to this developing industry.

Whether further licences will be issued after the initial development phase would be dependent on: (a) the level of success achieved in terms of production; (b) controls on the marketing of marron less than 120 grams and (c) whether the changes in marketing indirectly impacts the sport fishery through any abuse from illegal commercial fishing of wild stocks. The enforcement implications are addressed under Term of Reference No. 6.

The committee believes the expected benefits to Western Australia in promoting the further fish farming of marron as suggested above, by attracting venture capital and expertise, outweigh the potential risks to the sport fishery. However,

this view is dependent on separate measures being adopted to lessen the potential impact of illegal commercial fishing on the sport fishery.

Recommendations

1. That Government provide for the marketing of marron less than 120 gm for sale to licenced processing establishments (eg restaurants).

2. That the licensing of fish farmers to undertake production of marron less than 120 gm for the food market be restricted to between five and ten farms within specific guidelines encouraging the further development of intensive hatchery and grow-out production methods and facilities.

3. That Government invite submissions from prospective developers and select those that offer the greatest prospect for commitment, and success and benefit to the industry. The successful applicants to be granted a five year development period during which the further licensing of fish farms to produce marron less than 120 gm would not be approved.

4. That action by Government to encourage venture capital into marron aquaculture go hand-in-hand with the provision of additional measures to protect the sport fishery on marron.

11 TERM OF REFERENCE NO. 4

"To determine the licensing requirements for fish farmers"

11.1 Marron

Appendix 3 of this report details the current licensing policy being applied by the Fisheries Department for the licensing of freshwater crayfish fish farms.

These guidelines appear to be adequate (with one minor exception) for the semi-intensive hatchery production of marron for sale as 0+ animals and the on growing of marron in ponds for sale as sized animals to the food market.

Since these guidelines have been introduced, fish farmers intending to use more extensive fish farming techniques have sought to meet the guidelines by the construction of large ponds exceeding, in some situations, 1-2 hectares of water and incorporating small capacity draining facilities. The methods used in stocking these ponds and in pond management fall between the fishing of "private waters" and management practices employed in semi-intensive pond aquaculture.

The proposed licensing guidelines specified in Appendix 4, more precisely provides for the separation of fish farming establishments which will be undertaking semi-intensive farming methods vis a vis those which do not.

The licensing criteria as it currently stands for the issue of a fish farm licence to grow marron, has been sufficient to attract investment in hatchery and grow-out facilities at a modest level which has enabled a number of fish farmers as family or small business concerns to supplement their incomes from fish farming with agriculture and tourism.

On the evidence obtained from the committee's inspection of fish farm facilities and the modelling work reported, it would appear that the viability of grow-out of size marron using intensive farming methods for many of the currently licensed fish farmers, at the scale of farming undertaken, is somewhat doubtful.

However, the viability of hatchery operations for the sale of 0+ marron appears well established at current prices.

Should the market for 0+ marron collapse, the majority of established fish farmers will need to invest into larger grow-out facilities to maintain incomes from fish farming. Capital for this expansion for many of these farmers is likely to be a limiting factor.

During the course of the committee's enquiries and fish farm inspections, it also became evident that a number of fish farmers were in reality practising "extensive" fish farming methods.

These varied from place to place but included the construction of large dams or ponds which in practice were never drained. These ponds/dams were stocked with marron with production being enhanced in some cases by supplementary feeding and the provision of protective habitat. Recovery of marron was achieved by baited traps or seine nets.

The major part of investment by the fish farmer was in the dam structure with often very little operating costs. The level of marron production being achieved per hectare of water was low and variable between years and localities.

Figures of 100 kg of sized marron per hectare of water have been used as an indication of potential yields, but even this value fluctuated significantly with nutrient

levels of the water, levels of natural aeration and available cover from predation. Yields were also influenced by age of the dam, water source and quality, and geographic location.

The committee also concluded that for large areas of the coastal plain the construction of self drainable ponds for growing marron, except after considerable expense, was not a practical option for reasons of topography and the presence of a high water table. In many areas there were also swamp and water table lakes that are within private properties and did not form part of any river or stream. These lakes and swamps, if they were to contain marron did not directly or indirectly contribute to the sport fishery. In addition, within the south west, many farmers have constructed large dams for water conservation purposes, that contained viable populations of marron.

The Fisheries Act prevents the sale of marron from dams, lakes, swamps or non drainable grow-out ponds that fall within private property, where a fish farm licence has not been issued. This licensing containment policy had been supported on the basis of encouraging semi-intensive hatchery and pond grow-out of marron, together with an overriding need to protect the valuable sport fishery from widespread abuse of fishing rules.

Any relaxation in the thrust of this licensing policy has been identified by the proponents of the sport fishery as diminishing the effectiveness of enforcement for the protective management of that fishery.

The committee in its review of licensing policy explored the value in changing policy, to allow marron from waters on private property, (not forming part of any river or stream), to be fished commercially by property owners for sale to fish farmers as a source of breeding stock and

product (food) for licensed processors or dealers (eg restaurants, fish shops)

In the short term the committee recognised there would be a serious conflict of objectives if permit holders were initially allowed to allocate their marron stocks to the food market at the expense of supplying broodstock to licensed farmers, to enable the marron aquaculture industry to develop.

It would also allow those farmers interested in more fully utilizing dam water supplies, and water table swamps and lakes on their properties, to undertake 'extensive' aquaculture of marron as a means of supplementing their agricultural incomes.

In proposing such changes, having a potential to indirectly impact on the marron sport fishery and the development of the marron aquaculture industry, the committee focused upon five requirements seen as essential to allow for this form of marron production. These are detailed as follows:

(a) Approvals to sell marron from private properties to be provided by means of a single permit defining the property from which the marron would be sourced, the quantity to be sold and the name of the sale's outlet to which the marron would be sold.

(b) The issue of a permit to be based upon an inspection procedure to validate the source of marron and to estimate by sampling, quantity of sized marron available for sale. The cost of inspection sampling would need to be met by the permit holder.

(c) As an additional requirement, the property owner would need to have a minimum of 2.5 hectares of water containing marron on his property to justify

the expense of inspection and sampling required, so that a permit could be issued.

(d) The permit to expire on a common date of 30 April each year and not to be deemed a 'permanent right' and for the Minister of Fisheries to have the authority, should subsequent experience show the permit system to be unworkable, to withdraw it.

(e) That permits initially only be issued to private land owners to supply broodstock to fish farmers. This will help alleviate the expected (and current) severe shortage of broodstock that would seriously restrict the development of a viable marron aquaculture industry. This sytem of permits would be reviewed annually to ensure it could be adequately policed and once the initial demands of farmers for broodstock were satisfied, the system to be evaluated to determine if it should be expanded to allow permit holders to supply size marron for food consumption through licensed processing establishments.

In setting down these guiding principles, the committee recognized that additional manpower resources would be required by the Fisheries Department to implement the changes suggested. The sale and movement of marron from one property to the next under the authority of the permit would need to be closely managed. To implement the permit system without adequate support would lead to public concern at the possible effects of increased illegal fishing on the wild stocks of marron. To defer the introduction of the permit arrangements would seriously reduce availability of broodstock to marron farmers and slow down the rate of investment and expansion of venture capital development in marron aquaculture.

The provision of adequate manpower resources to manage the permit system and provide increased protection of the sport fishery is fundamental to the overall objective of encouraging marron aquaculture whilst providing adequate protection to the public sport fishery.

The committee in recognizing the nexus between encouraging development, access to adequate broodstock and effective management of the permit system proposed, strongly supported the early introduction of the permit proposals as a key component to the success of the total package of proposals.

Recommendations

1 That the current criteria for the licensing of marron fish farmers to produce young marron from hatcheries and/or sized marron (76 mm carapace - approximately 120 gm) from intensive grow-out ponds continue to apply with minor modification, to take into account the need for more precise drainage and pond size specifications.

2 That a system of "permits" for land owners to sell marron be introduced to provide them with a greater ability to undertake 'extensive' forms of marron aquaculture, through the fishing of waters (dams, swamps and lakes) within private properties that are not part of any stream or river and do not form part of the public marron sport fishery.

3 That should a permit system be introduced as proposed above the following requirements be met:

(a) That the permit define the property from which marron would be sourced, the quantity of sized marron to be taken and sold and the name of the sales outlet.

(b) The quantity of sized marron (76 mm carapace - approximately 120 gm) specified as capable of being sold on the permit be determined by a system of sampling to be instituted by Fisheries Department Enforcement Officers. The cost of the application for a permit should cover sampling costs.

(c) At least in the early years of the scheme, a permit not be issued to any property owner having a total of less than 2.5 hectares of water containing marron on the property.

(d) The permit to expire on a common date of 30 April each year and not to be deemed a "permanent right" by applicants.

(e) That permits initially only be issued to private land owners to supply broodstock to fish farmers. This will help alleviate the expected (and current) severe shortage of broodstock that would seriously restrict the development of a viable marron aquaculture industry. This system of permits would be reviewed annually to ensure it could be adequately policed and once the initial demands of farmers for broodstock were satisfied, the system to be evaluated to determine if it should be expanded to allow permit holders to supply size marron for food consumption through licensed processing establishments.

(f) The Minister for Fisheries be granted the authority to abolish the 'permit' scheme at any time should experience demonstrate the system to be unworkable or indirectly cause an increase in the illegal fishing of wild stocks.

4. That high priority be given to the early

introduction of the permit system proposed for the sale of marron caught from impounded waters within private property, not forming part of the public sport fishery. By necessity, this requires early consideration of manpower requirements by Government discussed under the sixth term of reference.

11.2 Koonacs and Yabbies

The licensing requirements as described for marron (refer Appendix 3) currently also apply for koonacs and yabbies.

As there does not exist a substantial sport fishery on these species within public waters, the requirements for tight rules in the aquaculture of these species are not apparent except for perhaps ecological reasons. Without exception, the aquaculture of koonacs and yabbies thus far in Western Australia have focused upon extensive fish farming methods and therefore the continued maintenance of licensing requirements for these species seems superfluous. During the course of this review, concern had been expressed at the introduction of yabby (Cherax destructor) to Western Australia and at the practise of transplanting this species from dam to dam between properties. Evidence was presented to the review indicating that the yabby is becoming established in the Kalgan river system with a potential to displace the local native koonac population.

It is also common knowledge among fish farmers that yabbies within farm dams, in certain situations can seriously affect the viability of a marron population. There is also the potential for genetic changes through strain selection and hybridization.

For these reasons together with associated unknown disease risks that may be transfered from the yabby to marron, the committee expressed strong concern at the introduction of the yabby inside the range of wild marron

stocks in the south west. The committee noted however, that the yabby is exotic to Western Australia and had been widely introduced into the warmer waters of wheat belt dams, as an alternative to the less hardy marron.

The committee acknowledges that there is no real prospect of eliminating the yabby from the wheatbelt or from the isolated introductions in the wetter regions of the south west. Its further distribution, however, needs to be discouraged through education and licensing policies. In an endeavour to contain the distribution of yabbies to the drier areas of the south west, the committee supported a prohibition being placed on the fish farming of this species within any waters westward of the Albany Highway. In suggesting such a proposal, the committee accepts this may disadvantage some property owners west of the Albany Highway, especially in the Kojonup area. However, the potential consequences of the further spread of this species into the catchment areas of the south western rivers and streams was of overriding concern. The Albany Highway was identified as a useful demarcation boundary separating the wetter regions of the south west from the drier wheat belt.

Recommendations

1 That the current policies for the issue of licences to undertake the fish farming of koonacs and yabbies be relaxed to provide for the "commercial" fishing of contained waters within private properties.

2 That the fish farming of the yabby not be permitted in any waters west of the Albany Highway.

11.3 Trout

Whilst a sport fishery on trout exists in the south west of Western Australia, the committee accepts there is no commercial prospect of illegal fishing of wild stocks to support a trout farming venture. Indeed the risks of any illegal commercial fishing for trout within the sport fishery are virtually non-existent. Catch rates and numbers of fish are simply not sufficient to support even the most cost effective commercial operation.

The major issues arising from the licensing of trout fish farms relate to controls on water usage and effluent disposal from nutrient loading and minimising the risks of exotic disease introduction.

The proposed quarantine procedures outlined in Appendix 2 and the current water licensing policies being applied by the Western Australian Water Authority seem adequate to meet trout fish farm licensing requirements.

The committee did not support any containment policy in the issue of additional licences to farm trout for market reasons.

The removal of the requirement for inland anglers to hold a Recreational Fishing licence to catch trout within Western Australia will also erase any legal difficulties caused through the fishing of trout within "fish out" ponds by tourists. There is no legal inhibition imposed on any registered fish farmers seeking to sell trout to tourist clients or charging a fee to fish.

Recommendation

That the current licensing policies for the registration of fish farms producing trout continue to remain operative. (Refer to Appendix 4).

11.4 Aquarium Fish

The committee received little information during the review on licensing requirements for aquarium fish aquaculture.

The major licensing concerns relate to the risks of exotic fish disease introduction, the potential for ecological damage through the escape of exotic fish fauna into Western Australia's streams and rivers and nutrient loading potential by the addition of food and wastes to effluent water.

The licensing guidelines specified for aquarium fish in Appendix 4 aim to minimise the risk of exotic fish introduction by the treatment of all effluent water through a sump that is not connected to any stream or river and the correct siting of facilities away from high risk flooding areas. The use of a sump also minimises the potential for fish larvae or egg losses into natural waterways.

Once these principles are adopted, it will allow the small number of licence applications received, to be assessed independently, on their design merits, with specific approvals being granted for the farming of each fish species.

It is noted that these guidelines do not apply to the breeding of fish in aquarium facilities but to the breeding of aquarium fish in pond grow-out facilities.

Recommendation

That the guidelines applying to the licensing of aquarium fish farms remain operative.

12 TERM OF REFERENCE NO. 5

"To examine and report on whether the leasing of farmer's dams by fish farmers should be permitted and under what conditions".

12.1 Marron

During the twelve month period prior to the implementation of this review, a number of entrepreneurs sought approval from the Fisheries Department to lease farmer's dams, essentially for the on-growing of juvenile marron, yabbies or koonacs and the commercial fishing of waters falling within private property. It was intended that the land owner and person holding the fish farm licence would enter into a commercial agreement to share the proceeds of the harvest with the licence holder undertaking the responsibility for stocking, grow-out of juveniles, harvesting and marketing.

This form of development thus far has not been permitted due to the constraint of a single fish farm licence being issued for each property, generally in the name of the property owner.

The committee upon consideration of this issue believed that the "permit system" proposed for the sale of marron under Term of Reference 4, more than adequately dealt with the needs of farmers wanting to sell legal sized marron. A change in licensing procedures to allow the leasing of farm dams for grow-out was identified as being akin to the commercial fishing of marron on private properties, at a scale that could not be effectively controlled. The existence of lease agreements between property owners and licence holders would be used as *prima facie* evidence that marron were available on a property and the ability for the Fisheries Department to effectively monitor production for each property would be substantially reduced.

More importantly, the responsibilities of the property owner in ensuring compliance with the fish farming provisions of the Fisheries Act would be substantially reduced.

The ludicrous situation could easily arise where evidence is obtained on the stocking of a dam from "wild stocks" and in defense, the landowner and the licensed fish farmer, leasing the private waters, could easily apportion the blame to each other. The Fisheries Department in such circumstances would be faced with the most difficult task of determining where the responsibility for the offence rested.

The scope for the illegal fishing of wildstocks under this scenario was also considered by the committee as being far more likely, due to the lessened responsibilities of the land owner.

The system of leasing impounded waters on private property would also lessen the Minister for Fisheries ability to control the expansion of, or put an end to, extensive aquaculture farming methods for marron. Action of this type may be required should experience demonstrate an increased incidence in illegal fishing of wildstocks of marron within public waters. The removal of a fish farm licence together with its plethora of investment and lease agreements between a number of parties is believed to be more difficult than the withdrawal of permit approvals having limited duration.

Recommendation

That the leasing of farm dams by fish farmers under the authority of a single fish farm licence for the purposes of marron grow-out not be permitted.

12.2 Koonacs and Yabbies

Within the wheatbelt of south west Western Australia there are a large number of small dams containing populations of koonacs, and yabbies.

The absence of a substantial sport fishery on these species reduced concerns for the control of illegal exploitation of wildstocks.

The harvesting of koonacs , gilgies and yabbies from wheatbelt farms could be achieved under the umbrella of a fish farm licence by allowing the authority of the licence to extend over more than one property. Alternatively, it could be administratively simpler to issue a restricted number of commercial fisherman licences to allow the fishing of impounded waters on private property.

The latter arrangement would provide greater flexibility to the licence holder in entering into agreements with landholders to stock and fish impounded waters. It would also reduce the administrative workload in defining areas that may be fished on behalf of the fish farm licence holder.

The holder of the commercial fisherman's licence or the fish farm licence, whichever the case, would be restricted to the "fishing" or farming of waters in the case of the yabby to private land east of the Albany Highway.

For control purposes, it would also be essential that possession of marron or the taking of yabbies west of the Albany Highway by a person holding a commercial fisherman's licence to take yabby, gilgies and koonacs would result in the automatic loss of the licence. This penalty should also apply to illegal fishing in public waters. Should the proposals to free-up the capture and

sale of yabbies and koonacs be adopted, the committee believes there would be merit in the Fisheries Department further exploring the relative value of the two control methods proposed before implementation.

Recommendation

That the Fisheries Department develop a licensing mechanism which would allow the more liberal commercial utilization of yabbies (east of the Albany Highway), gilgies and koonacs in waters on private properties .

13 TERM OF REFERENCE NO. 6

"To assess the impact of any proposed changed in regulations for freshwater aquaculture on inland sport fisheries in south west Western Australia, and on the requirements for fisheries enforcement, including staff and other resources".

In times of Government constraints on funding and therefore manpower resources, the committee examined in detail the implications of the proposed changes outlined in this report on the marron sport fishery in particular and the requirements for supervision of the developing aquaculture industry.

The committee were particularly concerned at the low level of enforcement currently provided for the protection of the sport fishery on marron. The problems of recreational fishermen taking and consuming undersize marron, exceeding bag limits, using boats to fish and fishing out of season seemed to be more akin to a lower level of compliance by recreational fishermen than problems manifested by allowing for the development of a commercial aquaculture industry on marron.

There already seems to be an a priori case for Government and the Fisheries Department to review their priorities towards providing additional manpower to ensure compliance with Fisheries Regulations and a higher profile through education on the need for management controls to protect the marron sport fishery. Fishing effort within the sport fishery for marron would appear to have increased substantially in the last decade resulting in falling catch success for individual fishermen and reduced abundance of marron through fishing and environmental changes.

The committee queried the relevance of the current season for fishing marron in view of changes in the level of

exploitation and the need for a review of management rules for the sport fishery.

The committee was of the strong opinion, that apart from changing penalty levels and making legislation more precise in accordance with the intent of management objectives, the only effective method for improving compliance within the sport fishery and minimising abuse of rules by fish farmers, is through adequate in-field enforcement and surveillance. Education is of minimal value unless reinforced through an effective enforcement presence encouraging compliance.

The committee was critical of the reported low level of surveillance for south west rivers and streams, but in being so it was aware of the significant problems involved in mounting patrols into remote areas. It accepted the view that dedicated marron patrols were essential to achieve the level of effectiveness required to undertake the detailed investigations of breaches involving the illegal poaching and commercial fishing of wild marron stocks.

The committee's proposals outlined in this report to further encourage freshwater aquaculture should not be implemented without adequate enforcement resources being made available to the Fisheries Department. These resources are required to provide adequate protection to the sport fishery and to supervise aquaculture developments.

Towards this objective, the committee supported the creation of two additional Fisheries Enforcement positions within the Fisheries Department to be located at either Manjimup or Pemberton. This would place two officers within the "central region" of the sport fishery and provide a greater level of coverage to the concentration of registered fish farms within the region. It was already acknowledged that the south coast rivers

received less than adequate supervision from Perth based officers. This occurs as a consequence of the region's distance from Perth and priority for the supervision of fishing within Western Australian Water Authority dams where there is a concentration of sport fishing activities.

The committee argued against the location of these officers at regional centres such as Albany or Bunbury, on the basis that their enforcement priorities could easily be altered to meet the regulatory requirements of marine fisheries. The incidence and value of informant advice in the detection of illegal fishing activities in the south west, would be enhanced through the location of these officers within local communities. This is particularly so where local communities have a substantial interest in the conservation of the marron sport fishery and in fish farming. Informant advice can only be effective where a level of trust and communication develops between the enforcement agency and local residents.

The cost of two additional dedicated officers to undertake the responsibilities proposed were estimated at approximately $90,000 annually.

This additional impost on Government could be offset by a modest increase in fees for recreational fishing for marron and from revenues collected through the issue of "permits" to sell marron proposed by recommendation 16 (see Summary of Recommendations). The current licence fee for marron per person is $6.00 per year. An increase in licence fees of $2.50 would raise half the additional inspection costs required. The committee believed the case for increasing licence fees to marroners was reasonable as a direct benefit to the longer term protection of the sport fishery. Funds could also be obtained from the proposed private waters permit system

and charges for sampling from dams for permit applications.

Whether additional resources would be needed by the Department to accommodate the changes in policy proposed by this report only experience will show.

The committee perceived that much of the clerical work and inspection of farms for the issue of restricted permits to sell marron (fish farm licences or permits to fish private waters) would be undertaken by the dedicated marron enforcement personnel as field managers for the sport fishery and developing aquaculture fishery.

Recommendations

1 That a review be undertaken on the relevance of current management rules for the marron sport fishery.

2 That the recommendations supporting changes in licensing policies to further encourage south west Western Australian freshwater aquaculture not be adopted until Government provides the necessary funding for the appointment of two Fisheries Enforcement officers to be located at Manjimup.

14 TERM OF REFERENCE NO. 7

"To examine and report on the inter-relationships between the inland sport fisheries, tourism and freshwater aquaculture in south west Western Australia".

The major issues arising from the public submission on this term of reference were:-

14.1 The Licensing of 'Fish-Out Pond' Recreational Fishing on licensed Fish Farms.

14.2 Sale of Undersize Marron Within a Tourist/Fish Farming Premises.

14.3 The Encouragement of Tourism Focusing Upon Aquaculture.

14.1 Licensing of 'Fish-Out Pond' Recreational Fishing on Licensed Fish Farms

The Fisheries legislation as it now stands, no longer requires a person to hold a recreational fishing licence to take trout. Those fish farmers developing 'fish-out pond' trout fishing facilities are therefore free of restriction in the sale of trout to the public, outside those controls involving the issues of processing and health/hygiene. Where fish are taken off the property, the fish farmer needs to ensure they are properly packaged, identifying the time of sale and the supplying fish farm.

The fishing of marron from impounded waters on private property can be legally undertaken without the requirement for a recreational fishing licence provided (a) it takes place within the fishing season, and (b) the marron are of a legal size and not berried. Philosophically, the committee supports the concept of

registered fish farmers, where they provide tourist facilities and are open to the public on a regular daily basis, the legislative authority to be able to charge visitors for 'fish-out pond' fishing and the consumption of marron produced on the fish farm, within the confines of that property.

The committee in supporting these arrangements believes the Fisheries Act Regulations need to be amended to clarify what fish farmers and visiting tourists may and may not do in relation to the requirements for licensing, out of season fishing and the taking of product away from the fish farm, where 'fish-out pond' fishing is allowed.

The committee favours the utilization of fish farm products at any time on the premises of the licensed fish farm by paying tourists without the need for additional licensing or other restrictive controls.

The taking of legal sized product by tourists away from the fish farm for eventual home consumption is also supported provided adequate measures are taken by the supplying fish farm. The fish farmer needs to ensure that goods sold are adequately receipted so that a tourist faced with a fisheries enforcement inspection off the premises is able to verify the source, time and quantity of product procured, with the minimum of embarrassment.

Recommendation

That the Fisheries Act Regulations be amended to detail the appropriate legislative exemptions and requirements for 'fish-out pond' fishing by tourists on licensed fish farms.

14.2 Sale of Undersize Marron Within a Tourist/Fish Farming Premises

During the course of the review, the Fisheries Department received two requests from licensed fish farmers having tourist restaurant facilities on their properties for approval to sell marron less than legal size as meals on the premises. This enabled the fish farmers to offer a range of marron sizes for sale to tourists noting that children, and adults on occasion, often wanted to taste marron but parents were reluctant, due to the high individual costs of marron of legal size, to pay for the experience.

The Department provided the approval for the two fish farmers concerned, through the authority of a processors licence, to cook both size and undersize marron on the premises for consumption at the premises. In both cases the marron came from stocks grown on the adjoining fish farm.

The ability for fish farmers, providing tourist tours as part of their total fish farm package, to enhance that experience through on site food preparation and "tasting" of the final product is desirable and essential in the promotion of marron.

Recommendation

That licensed fish farmers having joint farm/tourist restaurant facilities be provided with extended approvals under their fish processing licence to cook and serve undersize marron as meals for consumption on the premises.

14.3 The Encouragement of Tourism Focusing on Aquaculture

During the inspection of fish farms, the committee were impressed with the diversity of fish farm facilities and associated scenery on different private properties.

The committee saw substantial potential in package tours being designed for visitations to three or four fish farming establishments to cover the diversity of operations undertaken. With proper planning, these tours could be arranged to coincide with the spring season for wildflowers and provide a range of experiences for tourists having an interest in freshwater fishing, aquaculture and marron.

The committee believes there is an opportunity for an entrepreneur in the tourist industry to develop a marketable package tour over a three or four day period focusing on existing fish farming facilities.

Recommendation

That the Western Australian Tourism Commission further explore the market potential for developing a package tour focusing upon freshwater sport fishing and aquaculture.

15 ACKNOWLEDGEMENTS

The Review Committee sincerely thanks the fish farmers and organisations who allowed the committee to visit and inspect their fish farms during the period 29 July 1985 to 1 August 1985. Thanks is also extended to Fisheries Officers J Breeden, J Kelly and Technical Officer C Fellows for their assistance during the inspection tour.

The fish farms visited were:

Ferguson Valley Marron Farm
Freshwater Lobsters of Western Australia
Greenbushes Fish Farm
Margaret River Marron Farm
Marron Brook Farm and Pottery
Burns Farming Pty Ltd
Pemberton Trout Hatchery
B de Russet
F & P Howard
Denmoore Marron Farm.

Valuable assistance was also received from representatives of the Western Australian Guild of Cooks who attended a meeting of the committee and a product display providing advice on restaurant and marketing aspects for marron over a range of sizes.

Dr J Humphry and Dr J Langdon from the Australian Fish Health Reference Laboratory also provided a valuable input on fish disease introduction risks.

The typing was undertaken by Mrs C Porter, Editorial assistance was provided by Dr N Morrissy and Mr P Millington. Special thanks is also extended to Mr B Jones and other clerical officers of the Fisheries Department who provided secretarial support to the committee.

16 APPENDIX I

Bioeconomic model for semi-intensive pond grow-out of marron (Cherax tenuimanus)

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CONTENTS

I OBJECTIVE

The current minimum legal size limit for amateur fishing and the sale of marron for food by licensed marron farmers is 76 mm carapace length (approximately 120 g).

The objective in developing this model is to examine the contention that a lower size limit would remove a present, major, economic disincentive to development of commercial marron farming (grow-out).

Marron farming deals in weights of marron rather than lengths. An equation and table for inter conversion of carapace lengths and weights and other aspects are given in Section IX (Appendix).

II TYPE OF MARRON FARMING MODELLED

Considerable confusion exists over two types of outdoor marron farming which differ significantly in expectations (yield as kg ha^{-1} yr^{-1}), technology, management and costs.

"Extensive" culture in farm dams is based upon a total biomass of marron composed of a number of successive year-classes maintained by natural breeding in the dam, i.e. sizes and ages of marron are similar to those in a natural population. Fishing is employed to harvest legal-sized marron for sale and the low annual sustainable yield appears to be of the order of 100 kg ha^{-1}. The emphasis in achieving a worthwhile total annual production from this type of marron farming is on utilising a large total area of water, hence the term "extensive".

On the other hand, "semi-intensive" culture is based upon a single year-class cohort of marron seeded at the start of each "grow-out" schedule as early 0+ year olds (0 - 11 months) at a predetermined density. Regular feeding is

employed to ensure high growth rate and survival at densities above those found naturally. Ponds must be specially constructed to allow efficient management and harvesting by draining. To justify capital and operating costs (food, aeration, continuous water supply, etc) the yield should be at least 1000 kg ha $^{-1}$, if not 2000-3000 kg ha^{-1}.

The present model is developed for the above semi-intensive grow-out of marron. The size and surviving numbers of a single year class cohort are considered, at monthly intervals from seeding, in relation to costs and value.

III COHORT DYNAMICS

(i) Data base

Empirical data for variation in size between individual marron of the same age (weight frequency distributions), mean growth in weight with time, survival, and biomass were obtained at the Fisheries Department's Pemberton marron pond research facility. Short term (three-four months) grow-out trials were conducted over the period 1974-78 (Morrissy 1979). Subsequently, from 1978, grow-out trials were carried out using single year-class cohorts monitored at three-four month intervals from seeding as early 0+ year old marron to a final harvest at two years of age. Relationships obtained apply to the cool Pemberton climatic locality where closely managed, small (100m^2) ponds were employed.

(ii) Variability in size between individuals of the same age

Empirical weight frequency distributions (n=79) from Pemberton trials were adequately described statistically, in skewness and kurtosis, by the parameters of the lognormal distribution. Hence, the model provides a weight frequency distribution about

successive mean individual weights describing the growth of a pond cohort at monthly intervals from seeding to harvest at two years of age. Thus, at any month the proportion of the pond biomass greater than any size limit can be calculated and assigned a total monetary value from the value(s) of individual sizes of marron present.

Fig. 1 illustrates simulated weight frequency distributions at twelve, eighteen and twenty four months of grow-out at Pemberton for a final mean size/density combination of 105g/2.0 m^{-2}.

The very large influence of individual size dispersion on cohort dynamics and in relation to sizes of 40 and 120 g is apparent.

(iii) Variation in growth rate with season, density and locality

Seasonality in growth and grow-out schedules

Growth rate, ie. the mean individual weight of marron in a pond year class cohort over successive months, varies seasonally. The length of the growing season is the warmer period of the year when water temperatures exceed 12-13°C, ie. from late September to early May at Pemberton, ie 8 months (Morrissy 1976a).

The model, incorporating a sinusoidal curve in calculation of growth rates, was fitted by least squares (Cloern and Nicholls 1978), to describe the seasonal changes in growth rate shown by the Pemberton pond cohort data overeach two years of grow-out (n=8). This average curve gave a mean size at two years of 89.5 g and was adjusted to fit any other two year size determined by a growth/density relationship (see below).

MARRON SIMULATION - RUN 6

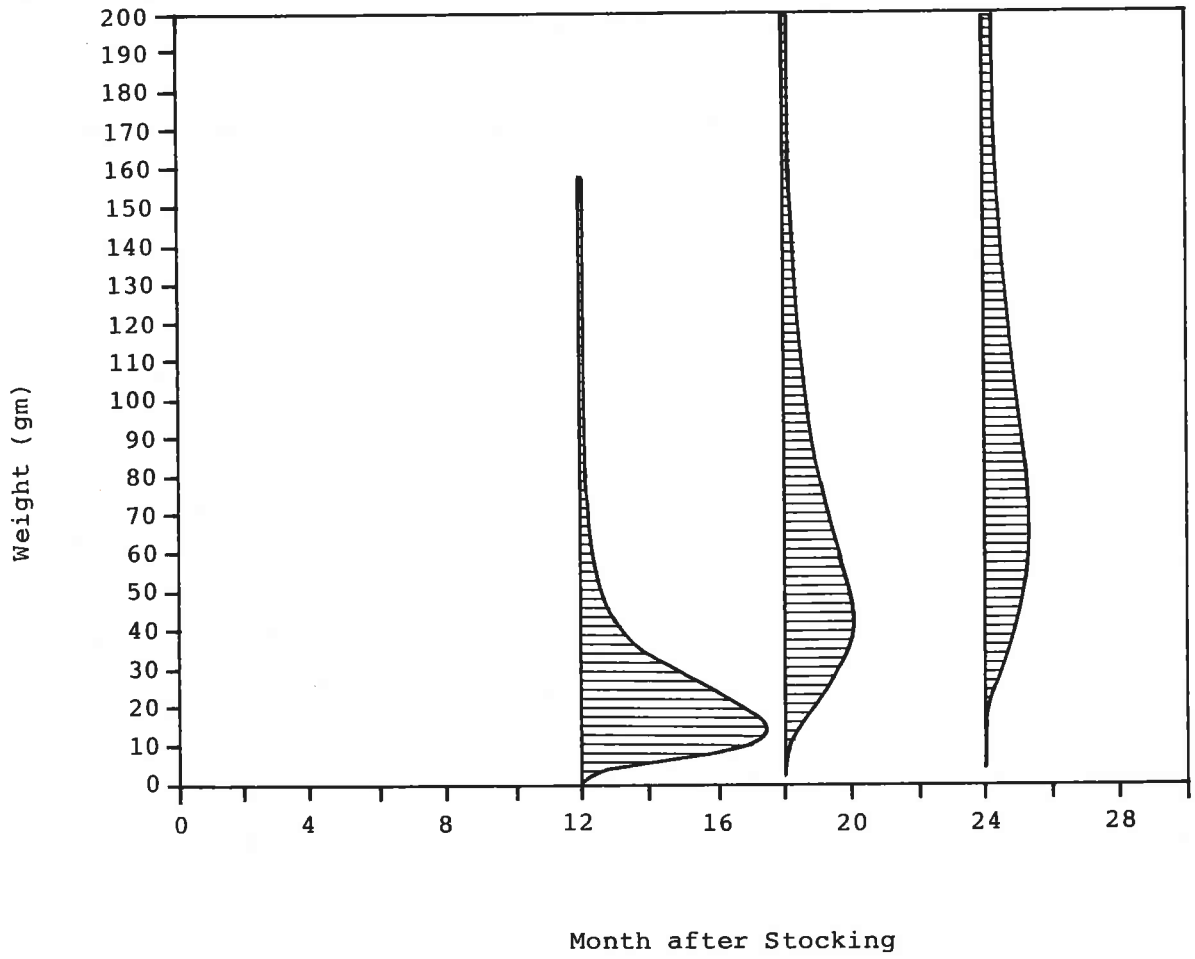
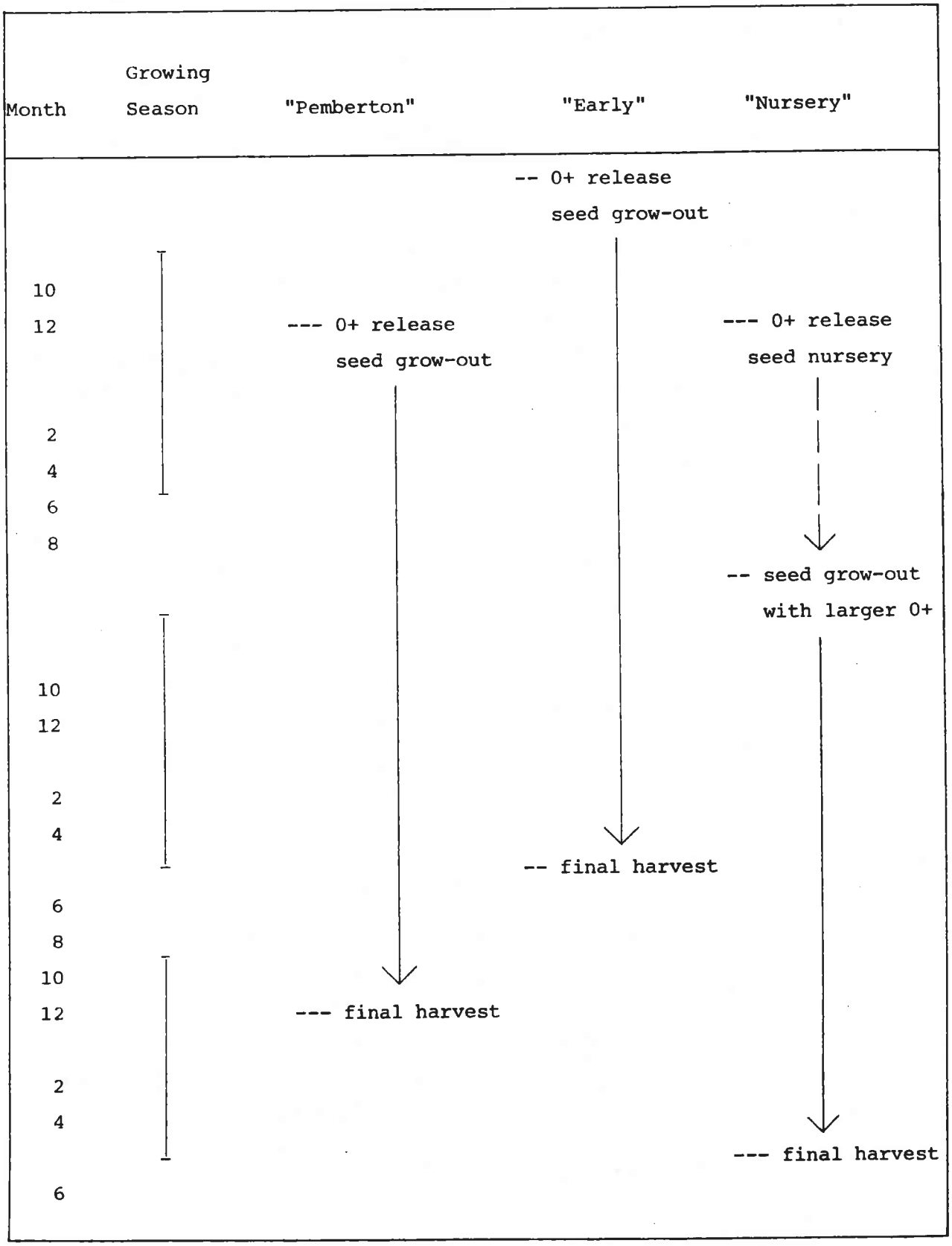


Fig. 1 Weight frequency distributions for Pemberton grow-out at twelve, eighteen and twenty four months at a two year mean size/density combination of 105g/2.0m^{-2}.

The model primarily employed the Pemberton grow-out schedule with 0+ year old marron considered as being released from females and stocked in a grow-out pond on the first day of January at a mean size of 0.06 g. Grow-out then proceeds for two years, with the option to harvest in any month, over two growing and over wintering seasons. It is possible that growth and biomass gains could be made by the early release and stocking of 0+ marron at the start of the growing season (S. Bennison pers. comm.)

This and other possible schedules are shown in Table 1.

Table 1: Options for grow-out production schedules with spawning, pond seeding and harvesting at different times of the year in relation to the growing season



Growth/density relationship

Establishment of a density-dependent growth equation is critical for pond culture of any bottom-living crustacean (Pardy et al 1983).

The growth rate of marron is markedly influenced by density, there being a negative hyperbolic, or similar, relationship (Morrissy 1980). The cohort dynamics and economics of this model are highly influenced by this relationship. Most of the marron research conducted in the pond facilities at Pemberton over the past decade, or more, has sought to establish this relationship and, in particular, the optimum operating density range for semi-intensive grow-out and, hence, the initial seeding (stocking) density necessary; aspects which were previously unknown for crayfish.

Cohort biomass, eg. the total weight of marron harvested, as kg $ha,^{-1}$ is the product (x10) of mean individual weight, g, and density, $-m^{-2}$. Thus, biomass is highly influenced by the growth/density relationship. Because of the nature of this relationship it is not possible to maximize both growth rate (eg. to give the largest and most valuable individual marron at harvest) and biomass at the same time. Only an optimum combination of growth and density can be found, giving a maximum monetary value for the biomass.

The maximum growth rate of marron is shown only at very low densities, approaching 0.1 m^{-2} in farm dams; but while mean weight approaches 300 g at this density at two years of age, biomass is only 300 kg ha^{-1} (Morrissy 1974, 1980). To justify a semi-intensive grow-out operation, biomass needs to be 2 000 - 3 000 kg ha^{-1}, or at least in excess of 1 000 kg ha^{-1}, requiring densities exceeding 0.5 m^{-2} and of the order of 2 to 3 m^{-2}. For example, taking an annual survival rate of 50%, to arrive

at a density of 2.5 m^{-2} after two years of grow-out would require an initial seeding density of 10 0+ marron m^{-2}.

For example, from the Pemberton data, survival rate over each three-four month period between pond inventories was expressed as a monthly value. These values ranged from 0.923 to 0.997 (n=42) with no significant trend (p=0.12) from four to twenty four months of grow-out. The mean survival rate was 0.960 $month^{-1}$ (4% mortality $month^{-1}$ or 61% survival $year^{-1}$). Mean survival rate over the first four months of grow-out from seeding was 0.679, due to handling-induced mortality at seeding. Taking a survival rate $month^{-1}$ of 0.960 for months two, three and four, a rate of 0.767 was calculated for the first month. This value agreed well with a more closely observed value of 0.790 for similarly handled 0+ marron used in aquarium tests.

These mean survival rates applied to a seeding density of $10m^{-2}$ give a surviving density at twenty four months of grow-out of 3.0 m^{-2}. Individual pond trials showed considerable variability from this mean value, eg. up to $4.7m^{-2}$, and to obtain final densities below $2.5m^{-2}$ it was necessary in practice to seed initially at $5m^{-2}$. In the model, given the seeding density (N_0) and the final twenty four month density (N_{24}), an adjustment was made to monthly mortalities such that the necessary survival over 24 months was achieved.

The observed range of twenty four month cohort density, D, at Pemberton was 0.8 - 4.7 m^{-2} and the corresponding range of mean sizes, w, was 156 to 37g. The relationship between mean size and density used in the model was;

$w = 197 - 55.4\ D + 4.69D^2$

as shown in Figure 2. The corresponding empirical range for biomass was 1200-2400 kg ha^{-1}. The size/density combination predicted by Morrissy (1979) from earlier short term pond trials was 60 g/$3.75m^{-2}$, which agrees closely.

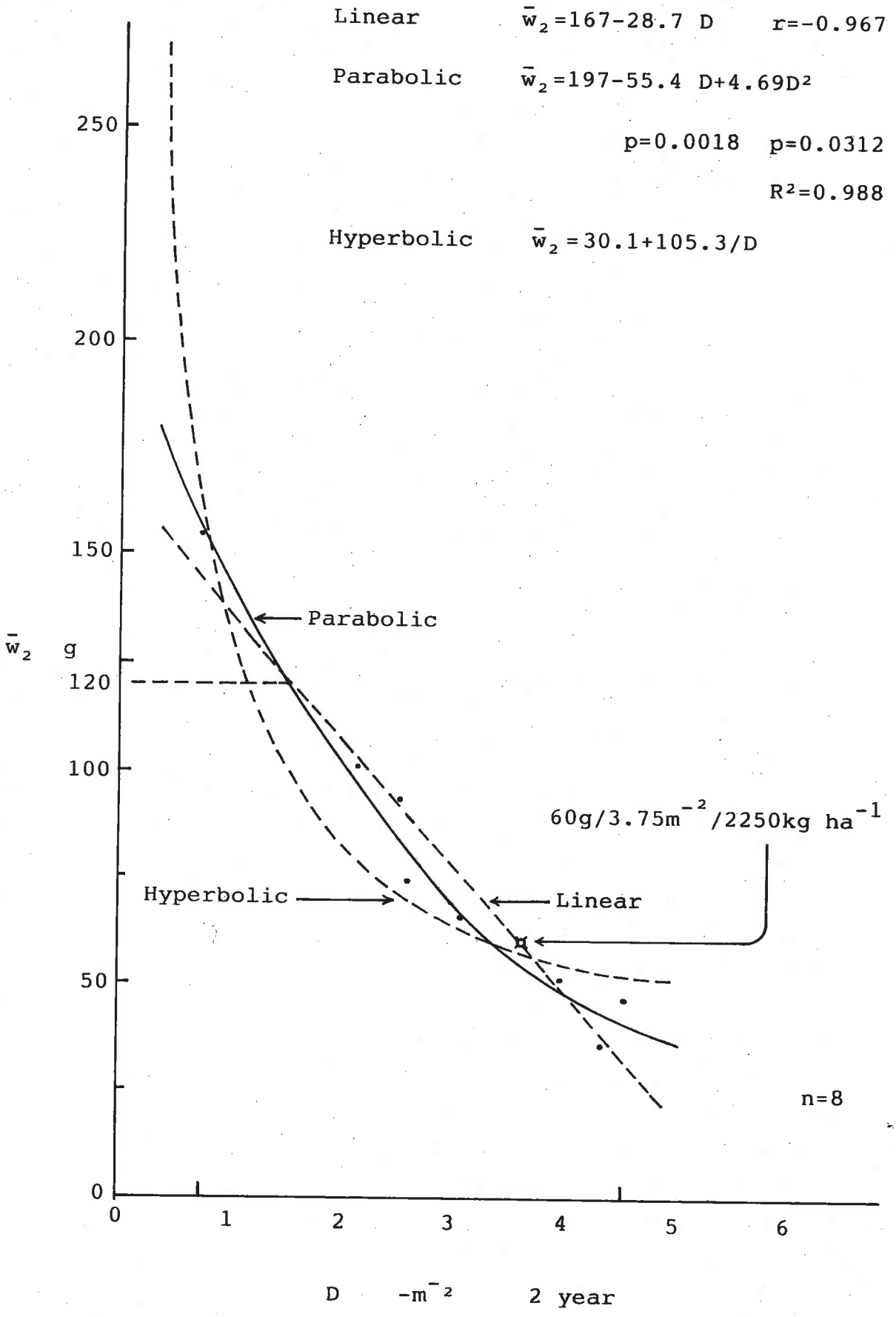


Fig.2 Growth rate density sub-model

Locality

Unfortunately no reliable empirical data are available for grow-out at warmer localities than Pemberton. A warmer locality would provide a longer growing season and therefore would be more favourable to growth and, hence, total biomass production.

On the basis of short term pond trials at Pemberton and mean annual air temperatures, Morrissy (1979) predicted a combination of mean size, density and biomass (111 g/2.9m^{-2}/3175 kg ha^{-1}) at two years of grow-out for the general Margaret River area, previously identified as the most favoured climatic locality for marron farming (Morrissy 1976a). Since the Pemberton mean size at 2.9m^{-2} is 77g, this prediction suggested an approximately 50% higher growth rate due to the longer growing season. However, the implied above mean size/density combination at twenty four months is different from the Pemberton one and may not be valid. The complex and unknown aspect is the relative degrees of dependence of survival rate on growth rate and density. Various runs of the model were carried out to explore the boundaries of this problem.

IV PREDICTION ECONOMICS

(i) Values of different sizes of marron

Predictions were sought from the seafood catering industry on 18 February 1986, as to the likely values \$/kg^{-1} that would be paid to growers, for various size ranges of marron, from the current legal size and larger (> 120g) down to a minimum acceptable size of 40 g. The latter was considered to be the smallest size acceptable for presentation as one of a number of whole marron on a diner's plate. Considerable difficulty was seen in presenting marron below 40 g in size, eg. as peeled tail meat, because of processing costs.

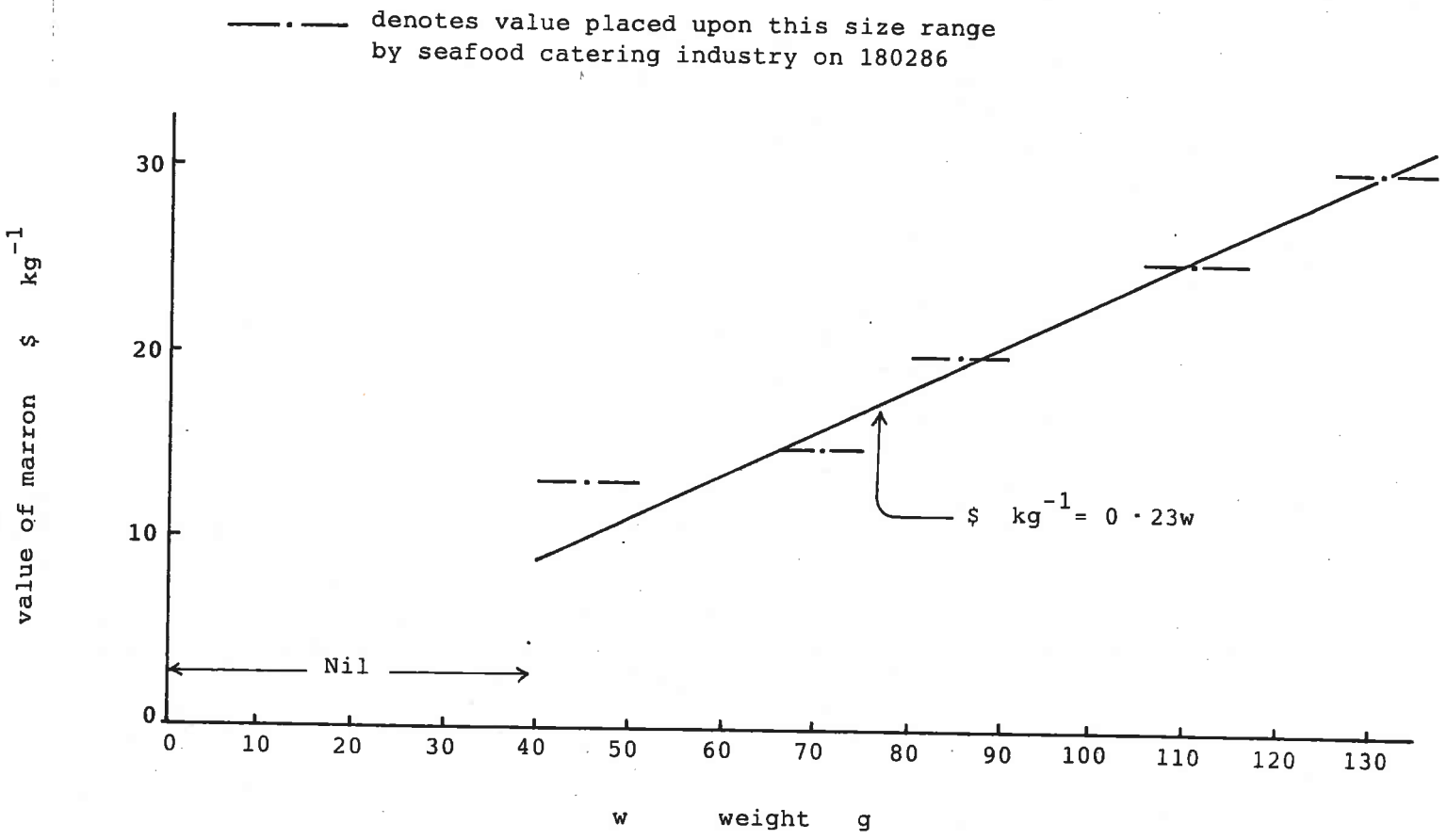


Fig. 3 Marron size/value submodel.

"Present agreed" values were \$10 kg^{-1} for the lower limit of 40 g and \$30 kg^{-1} for marron larger than 130 g. Suggested prices for intermediate sizes fell, approximately, on a linear interpolation between these extremes so that values could be expressed by a simple equation, $\$/kg^{-1}=0.23w$ (Fig. 3). Hence, a value can be placed on any fraction of a total pond biomass of marron at any specified harvest date. In effect, therefore, the model employs a proposed minimum saleable size (MSS) of 40 g. Alternatively, the model provides the option for any other specified minimum saleable size (> 40 g) using the "present agreed" price equation, e.g. the present size limit of 120 g.

(ii) Cost of 0+ marron for seeding grow-out ponds.

The recent development of marron hatcheries has been to cater for the demand for seed elsewhere. Hatcheries enable efficient collection for despatch. However, grow-out does not require such a high level hatchery operation. In practice, seeding for large-scale grow-out is seen as more efficiently carried out by release in a grow-out pond from females held in caged or penned off areas of the grow-out pond (Morrissy, 1976b, S. Bennison, pers. comm.).

The current ex-hatchery price of early 0+ year old marron for seeding ponds elsewhere is \$0.50 $marron^{-1}$. Of this, the cost of hatchery production is said to be \$0.10 $marron^{-1}$ and handling and packaging trebles this value (S. Bennison, pers. comm.).

The cost of seeding can be viewed either as the first operating cost incurred at the start of a cohort grow-out schedule or as the value of the marron which must be taken out of the later harvest

and held as future breeding stock to provide a cohort seeding. The model employs the first approach but the cost of seed can be most realistically calculated by the second approach. Small ponds for holding breeding stock are included in the cost of grow-out pond construction.

The seed cost for stocking of marron in a one hectare grow-out pond, estimated from the value of future breeding stock held out of a harvest, is \$0.032 - \$0.096 marron^{-1}, corresponding to 300 - 100 0+ released per female. The mean individual weight of marron held out of harvest at two years of age, to supply broodstock, is assumed to be 110 g with a value of \$25 kg^{-1}.

Survival over one year to spawning as three year olds is taken as 50% for a female to male ratio of 5:1 with 75% of the females spawning. Factors adding to the cost of breeding stock would be feeding and maintenance. Balancing these additional costs are probable use of two year old spawners, sale of post-, or non-, spawners and four year old spawning.

Therefore, the cost of 0+ seed in the model has been taken as \$0.10 marron^{-1} (with the option for other values as in all subsequent costs).

(iii) Cost of feed and feeding rate

The model uses a value of \$0.30 kg^{-1} corresponding to the cheapest commercial stock feeds. The option is provided for use of more expensive feeds, e.g. formulated pellets at \$0.70 kg^{-1}, although these are unnecessary for outdoor pond grow-out

For feeding rate, the method of feeding crayfish in ponds differs in practice from that applied to intensive fin-fish culture and, therefore, requires

a brief explanation. In the latter method, feed is supplied at a certain percentage of body weight per day. This method requires an exact knowledge of the relationship between the percentage necessary for maximum growth, body size and water temperature and assumes that the fish are solely and directly dependent on the supplied feed and consume it all. In large outdoor ponds marron are not solely and directly dependent upon the "feed" supplied, average size of marron from week to week is usually unknown, or imprecisely known, individual sizes vary widely, and water temperature can fluctuate widely. Moreover marron are dilatory, destructive and highly selective feeders, all of which result in considerable, apparent wastage of feed. Marron and other crustacea are also highly dependent on natural feeds in a pond for adequate nutrition.

Consequently, the feeding rates currently employed have been related by experience to size of marron and season but more especially, at a maximum level, to a decomposing organic loading which must be countered by a pond's natural and applied aeration systems. A similar maximum value of 30 g m^{-2} $week^{-1}$ is used for yabbies and other crayfish and prawns (e.g. Mills and McCloud 1983).

The following table shows feeding rates as g m^{-2} $week^{-1}$ (Table 2).

Table 2: Feed Rate

Fixed values in the model as g m^{-2} $week^{-1}$ by month of year for 0+ and 1+ marron and different seeding options

Feed Rate: g m^{-2} $week^{-1}$

SEEDING OPTION								
	PEMBERTON			EARLY			NURSERY	
MONTH	0+	1+	MONTH	0+	1+	MONTH	0+-1+	1+(-2+)
01*	10^{S}	30	10	10^{S}	30	10	20^{S}	30
02	10	30	11	10	30	11	20	30
03	10	30	12	10	30	12	30	30
04	10	30	01*	10	30	01*	30(1+)	30(2+)
05	10	20	02	20	30	02	30	30
06	10	20	03	20	30	03	30	30
07	10	20	04	30	30	04	30	30
08	10	20	05	20	20	05	20	20
09	10	20	06	20	-	06	20	-
10	20	30	07	20	-	07	20	-
11	20	30	08	20	-	08	20	-
12	20	30	09	20	-	09	20	-

^{S}seeding month,

* January

(iv) Establishment-capital and operating costs

This aspect of the model is most contentious both because there is no empirical basis from actual operation of existing farms and because there is the potential for inclusion, or omission, and distortion of numerous items.

The conventional method of cost accounting for new business projects (with projected yearly cash flows from start up, establishment costs based upon borrowing and loan repayments and depreciation included in operating costs, etc) appears to be totally unrealistic for high risk aquaculture ventures, particularly when such short term scenerios are offered for wide participation to a totally inexperienced audience (eg FACT 1986, Villarreal 1986). Therefore, for the semi-intensive marron farming modelled here a more realistic economic model would seem to be that for a steady and, hopefully, viable level of production in the medium to long-term, i.e. some three-five years, or more, after start-up. The importance of the financing strategy and accounting practice should be subordinate to the attainment of this production goal for any developer entering this field.

The present model is, therefore, ... "a static one for an idealized steady state, planning horizon using current cost projections" (Allen et al 1984).

Establishment - capital costs

The model employs a capital value of \$70,000 ha^{-1}, based upon a 10 ha (of pond water) farm, estimated by Morrissy and House (1979) as follows (Table 3).

Table 3 : Capital establishment costs for 10 ha.

	$ 1979
Land (20 ha - Margaret R.)	30,000
Pond construction (5 000m² ponds)	
earthworks	67,810
water supply and drain system	68,800
	136,610
Buildings	
home for manager (transportable)	20,000
garage and storage shed (9 x 6m)	2,500
processing shed (9 x 6m)	2,500
washing, grading facilities, fittings, tanks, water supply	1,000
cooking facilities	3,500
cold storage, freezing facilities	11,400
	40,900
Equipment	
single items for whole farm	
oxygen meter (2)	350
max-min thermometers (10)	100
secchi disc (2)	10
calipers (2), gauges, etc	100
balances (several ranges)	200
removable outlet screens (4)	400
holding containers	200
seine net	500
drop nets, scoop nets, weed samplers	200
punt	200
spinner feeder trailer unit	2,000
work truck	10,000
tractor	15,000
water mills ($4/ha^{-1}$)	40,000
	69,260

Water supply source*	
storage dam plus winter creek for pond topping up supply	62,500
Predator protection	
netting and fencing ponds with support structure	88,000
TOTAL	427,000
- Cost of Land	397,000
X1.71 for $,1986	680,000
+ Land Cost	710,000

* A complete account is given in Morrissy and House (1979) of the use and costs of various types of water sources - a complex subject.

No allowance was made by Morrissy and House (1979) for "special deductions in capital establishment costs for non-depreciable capital expenditure", "investment allowance" for new items of plant and machinery and certain farm improvements.

The model value of \$70,000 ha^{-1} is 1.71 times the 1979 costing (minus land which has remained unchanged in value). This factor over six years (to early 1986) represents an average inflation factor of 9% $year^{-1}$ based on the C.P.I. values over these years (W.A. Year Book 1985).

The present model value of \$70,000 ha^{-1} does not include a separate hatchery operation. Grow-out ponds are seeded

directly by release from females. In the 1979 feasibility study, costs were included for adjacent breeding stock pondage to support each hectare of grow-out ponds in this manner.

The model value may be taken as a maximum cost. However, experience has shown that inadequate funding, neglecting certain essential items (such as pond gravity outlets and efficient aeration) is a very unrealistic economy.

This capital cost is employed to calculate the return (%) on capital for a financial year of operation using a total farm income value (see below).

Comparisons of the standard capital cost of \$70,000 ha^{-1} for the 10 ha farm modelled, with independent projections are as follows:

(1) FACT (1986). \$40,000 ha^{-1} for a 5 ha farm (land, \$7 000 ha^{-1}); water supply, pond protection and aeration costs were unduly minimized.

(2) S. Bennison (pers. comm.) \$60 000 ha^{-1} for a 10.5 ha farm (minus land costs).

(3) W. Moore (pers. comm.) \$56 000 ha^{-1} for 2 ha of 0.12 ha ponds (minus land, and water supply source development costs).

(4) Villarreal (1986). \$54 000 ha^{-1} for a 5 ha farm (including land).

Operating costs

Cost of feeding and seeding (≡ breeding stock) are considered above and specified in the input separately to these, other, operating costs.

These costs are considered on the per hectare basis utilized by the model for the dynamics of grow-out of a year class cohort. Some aspects of operating costs, such as management staff salaries (for one manager and assistant) need to be placed on a realistic basis per hectare by definition of a total farm area (of ponds), which is taken as 10 ha.

The standard operating cost used in the model is \$600 ha^{-1} $month^{-1}$, i.e. corresponding approximately to an annual operating cost of \$7 100 ha^{-1}. This value was derived from costing predictions carried out by Morrissy and House (1979) adjusted as with previous capital costs for inflation by multiplying by 1.71. A cost breakdown by item is shown in Table 4.

Table 4 : Annual operating costs for 10 ha farm

		$	
Staff		1979	
Manager		20,000	
Assistant		10,000	
Contract labour		1,730	
		31,730	
Telephone, mail	)	500	
Advertising	)marketing	1,000	
Packaging	)	3,000	
Insurance		100	
Registration, licences		200	
Electricity (water mills, etc)		2,000	
Fuel, etc		3,000	
		9,800	
		Total	41,530
X1.71 for $,1986			71,020

Additional unaccounted for annual costs.

- Interest charges and loan repayments on establishment funds.
- Depreciation on capital items by prime cost or diminishing value methods ($3,000-3,500 $ha^{-1}yr^{-1}$)
- Costs of repair and maintenance (see depreciation).
- Land rates (on 20 ha).

The sensitivity of income is considered by increasing operating costs by 50%, (i.e. to $900 $ha^{-1}month^{-1}$) and 100% ($1,200) over the standard value, taken as a minimum because of some unaccounted for contentious items.

The model standard annual operating cost of $7,000 ha^{-1} for a 10 ha farm can be compared with the following independent estimates (minus seeding and feed costs).

(1) FACT (1986) \$4,300 ha^{-1} for a 5 ha farm (full-time staff \$35,000) with other costs minimized or absent (advertising, vehicle expenses).

(2) S. Bennison (pers. comm.) \$7 200 ha^{-1} for a 6 ha farm or \$5,900 ha^{-1} for a 10.5 ha farm.

(3) D. Holker (pers. comm.) \$15,000 ha^{-1} for a 10 ha farm (staff \$50,000).

(4) W. Moore (pers. comm.) \$10,500 ha^{-1*} for a 2 ha farm (staff \$18,200).

(5) Villarreal (1986). \$8,750 ha^{-1*} for a 5 ha farm (staff \$35,000).

(6) N. Moore (Aquafarm '86, Brisbane), \$5,170 ha^{-1} for a 6 ha farm ("labour", \$20,000).

*Unknown feed and seed costs included.

V ANALYSIS

The programme calculates for each month from seeding to twenty four months of grow-out the mean size and surviving density for a year-class cohort (Fig. 4 : example). The corresponding total biomass and the amount of biomass residing in marron greater than the minimum saleable size, of 40 g, is also calculated (Fig. 5).

The total value of the marron in the saleable part of the biomass is then calculated by month and the initial total seed cost and cumulative operating and feed costs are

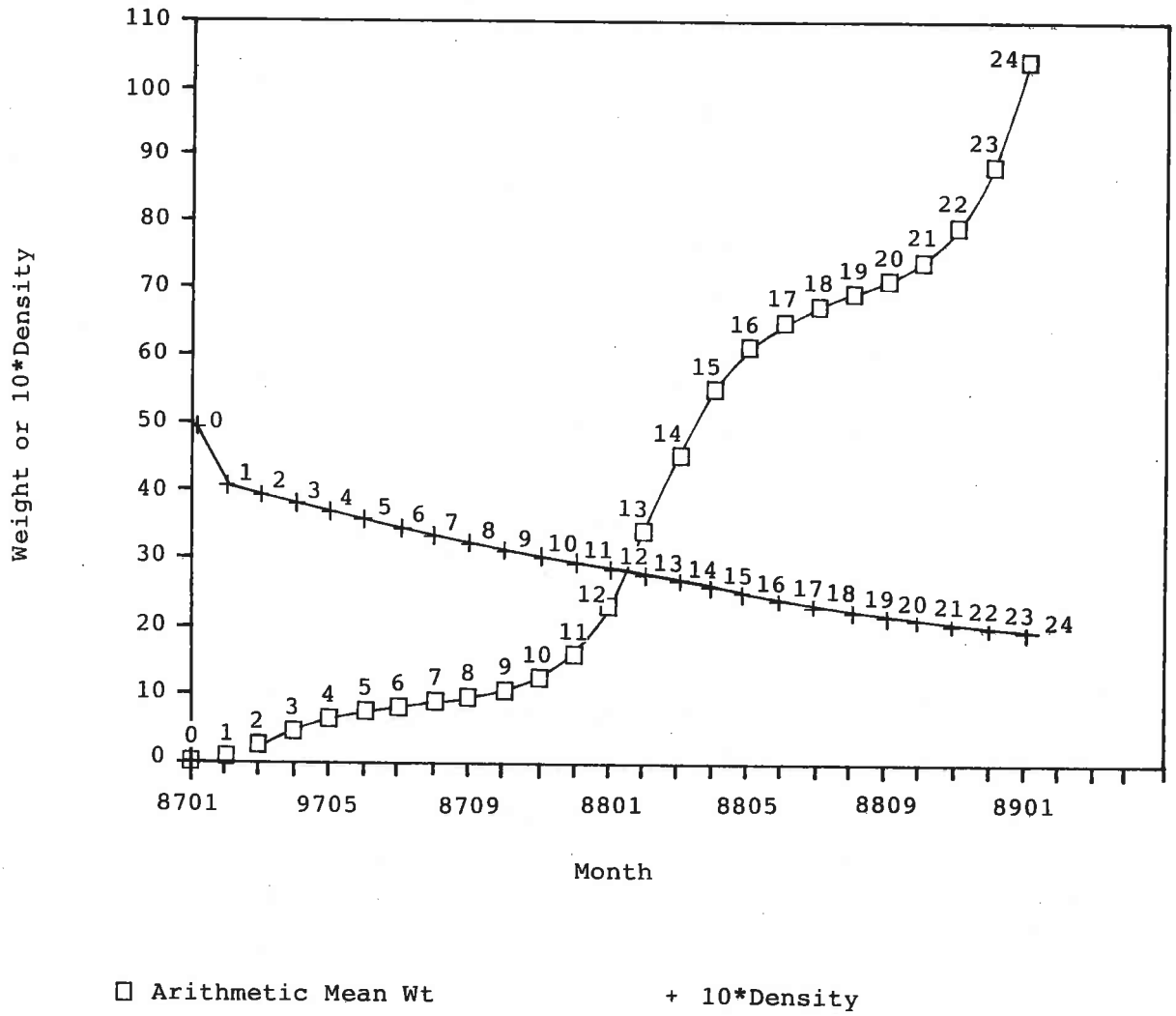


Fig. 4 Simulation output for mean weight and surviving density.

MARRON SIMULATION - RUN 6

Biomass and Biomass > Legal Size

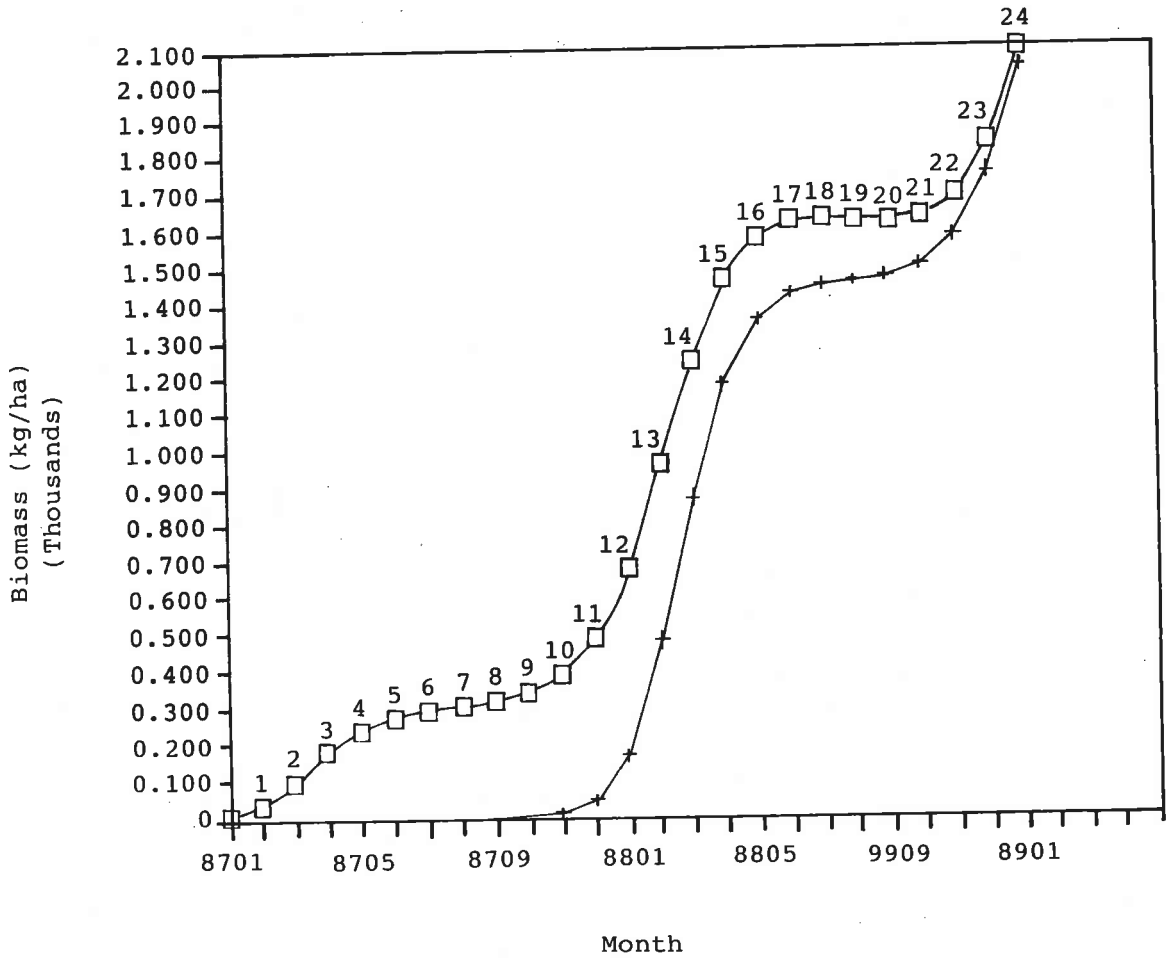


Fig. 5 Simulation output for total cohort biomass and the valued proportion of the biomass.

MARRON SIMULATION - RUN 6

Value of Harvest and Profit

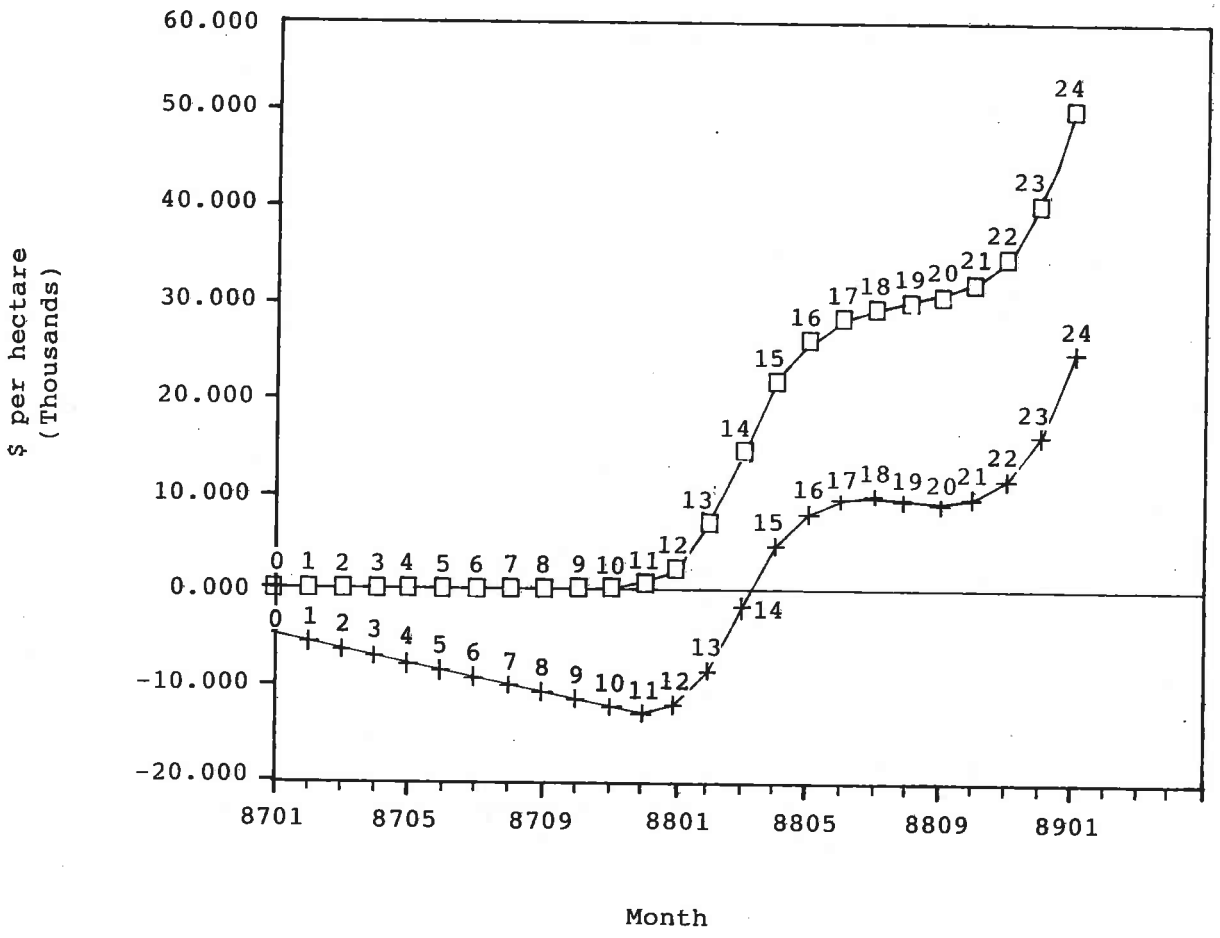


Fig. 6 Simulation output for value of the potential marron harvest and profit (income).

subtracted to give the monthly potential cohort (harvest) income, before tax (Fig. 6).

The above monthly biomasses and incomes which are most relevant, are those at sixteen-eighteen months of grow-out (called "peak" values) when increase in biomass slows and usually decreases through the second winter (at Pemberton) and those at twenty four months of grow-out ("final" values).

All the above analyses apply to a single cohort on a per hectare basis.

For the economics of the total farm operation of 10 ha, since the only cost-effective incomes occur over the second year of grow-out, half the total number of ponds (eg. 5 of 10 1ha ponds) are seeded in any one year and final harvest occurs two years later. In any one financial year, marron can be sold from only half (5) the ponds while operating costs accrue from all ten (10) ponds. The total farm income for a financial year for 10 ha of ponds is then the income value, e.g. the "final" value, for any one cohort multiplied by 5 (see Fig. 7 for an explanation).

Most of the analysis is concerned with system optimization, i.e. maximizing the return on harvest (Allen et al 1984), in terms of the growth/density relationship. Taking the optimum size/density combination from this analysis, seed, feed and operating costs are then varied (increased) separately (individual parameter perturbation, Livingston 1985), and in a "break-even" combination to determine the "sensitivity" of income values to possible higher costs.

VI RESULTS

Table 5 shows runs simulating Pemberton grow-out, with standard costs, over the empirical range of combinations

TABLE 5 : Pemberton, 2 year grow-out, mean size/density combinations, with standard costs*
MSS = minimum saleable size, g.

Run No.	Mean size g/ Density $-m^{-2}$ at 2 years from stocking	MSS g	Biomass kg ha^{-1} Peak (month)	> MSS %	Final (24 months)	> MSS %	Single Cohort \$ ha^{-1} Peak Income	Max^{m} Income	Annual Total Farm \$ (% return)
3	156/0.8	40	1232(16)	95.5	1248	97.3	+9727	+8356	+41780 (+6.0)
		120		42.6		74.1	-2495	+2266	+11330 (+1.6)
4	146/1.0	40	1353(17)	95.4	1460	97.6	+11401	+13638	+68190 (+9.7)
		120		41.7		71.4	- 2168	+ 5790	+28950 (+4.1)
5	123/1.5	40	1541(17)	91.9	1845	97.7	+11798	+21731	+108655 (+15.5)
		120		29.9		61.3	- 5255	+ 8391	+ 41955 (+ 6.0)
6	105/2.0	40	1634(18)	88.2	2100	96.8	+ 9594	+24988	+129940 (+17.8)
		120		22.5		50.6	- 8918	+ 6338	+ 31690 (+ 4.5)
7	88/2.5	40	1895(17)	79.1	2200	94.6	+ 3576	+17633	+ 88165 (+12.6)
		120		12.7		38.5	-16856	- 5174	- 25870 (- 3.7)
2/1	73/3.0	40	1797(17)	68.1	2190	90.5	- 3382	+11569	+ 57845 (+ 8.3)
		120		6.9		26.7	-20312	-13030	- 65150 (- 9.3)
8	60/3.5	40	1655(18)	57.1	2100	83.5	-10007	- 3395	+ 16975 (+ 2.4)
		120		3.7		16.6	-22990	-20065	-100325 (-14.3)
9	50/4.0	40	1529(18)	44.1	2000	74.5	-14981	- 4100	- 20500 (- 2.9)
		120		1.8		9.8	-24045	-24615	-123075 (-17.6)

* Seed cost, \$0.10 mar^{-1}; feed cost, \$0.30 kg^{-1}; operating cost \$600 ha^{-1}; capital cost, \$70,000 ha^{-1}

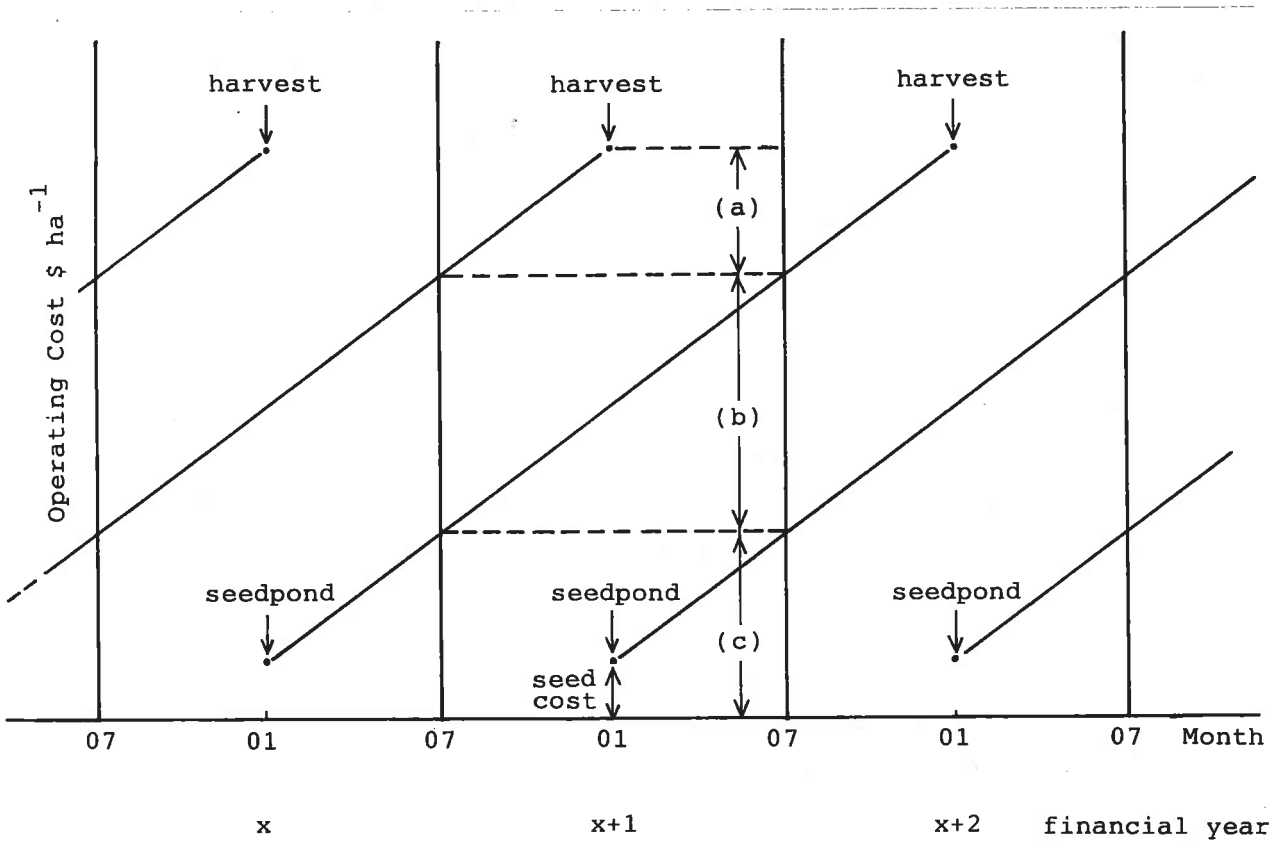


Fig. 7 Schematic for seeding 2 1ha ponds in alternate years for appraising total farm income (for 10 ha, 5 x a single cohort income at twenty four months of grow-out). The operating cost (or income) for two ponds seeded in successive years, over one financial year (x + 1) ie. (a) + (b) + (c), is equivalent to the total operating cost for a single pond/cohort from seeding to harvest over two years.

of two year mean size and density. Cohort biomass and income (ha^{-1}) are shown as "peak" and "final" values corresponding to sixteen-eighteen and twenty four months of grow-out, respectively. (Peak values refer to the start of the second early wintering period when biomass, i.e. growth slows, and usually declines slightly, over winter). Comparisons are also shown for the proportion (%) of the biomass exceeding, in individual sizes, a "minimum saleable size" (MSS) of either 120 g or 40 g and, hence, the corresponding incomes.

Biomass and its valued proportion are shown plotted against mean size/density combinations in Fig. 8. Because of the change in seeding density below 2.5 m^{-2} there is a discontinuity in the peak biomass curve. However, it is clear that the maximum biomass occurs at a two year mean size/density combination of 88 g/2.5 m^{-2}.

Since the valued proportion of the biomass increases towards lower densities, the maximum income occurs at a somewhat lower combination, i.e. at 105 g/2.0m^{-2} for final income (MSS = 40 g) (Fig. 9). In Figure 9 the discontinuity due to the change in seeding density is most apparent in this final income (a seed cost difference of \$5,000 ha^{-1}). For the maximum final income of \$25,000 ha^{-1}, with a MSS of 40 g, the return on establishment-capital costs is 17.8% (cf. 6.5% for MSS = 120 g - Run 5 and 6, Table 5). These simulations illustrate very clearly the distinct economic advantage of a MSS of 40 g over one of 120 g.

Return on capital, as an indicator of economic viability, in relation to total farm income or, more conveniently, cohort income can be judged from Fig. 10 which also permits rapid consideration of another establishment cost.

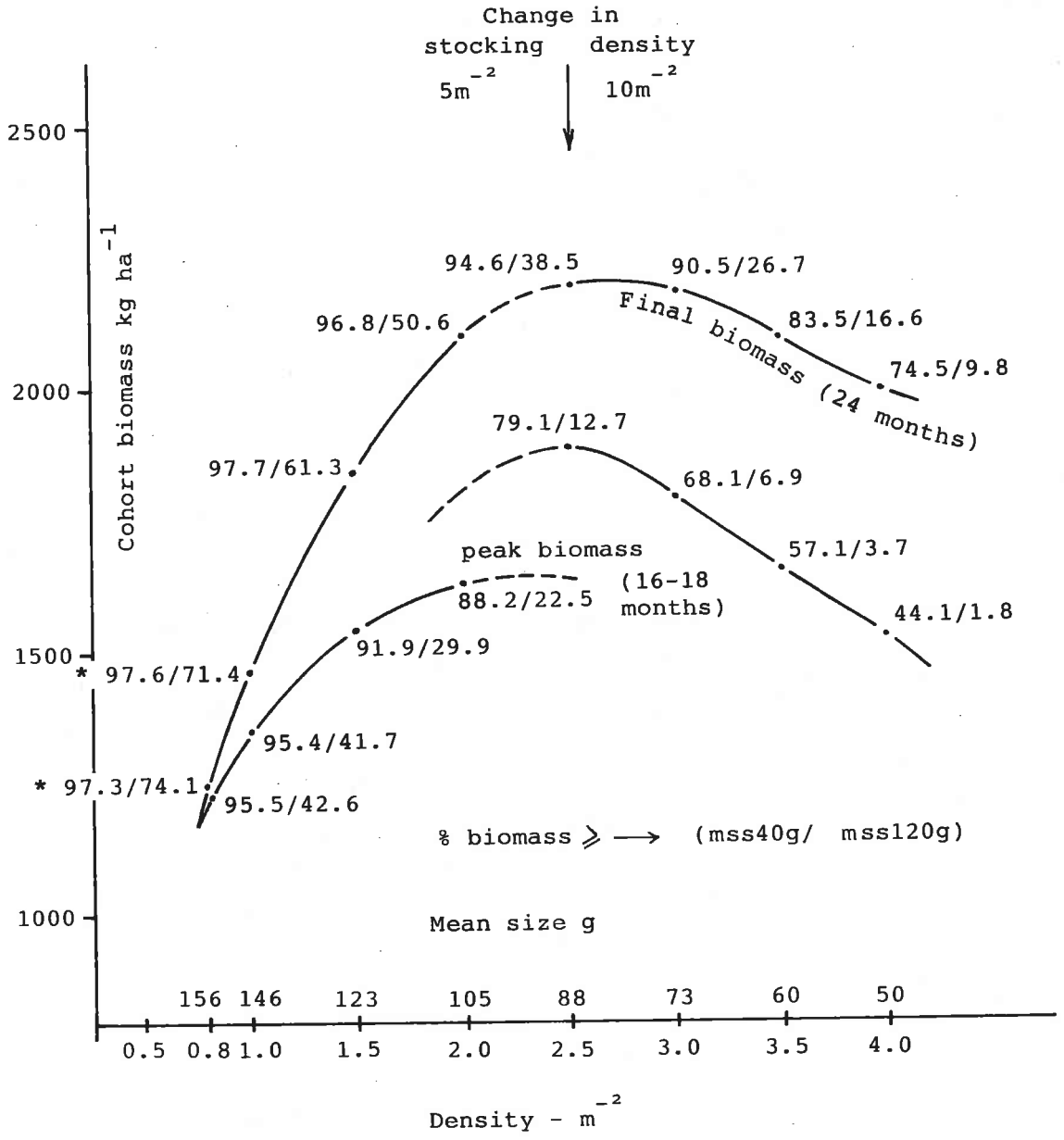


Fig. 8 Pemberton cohort biomass, kg/ha^{-1}, for combinations of two year mean size, g, and density, -m^{-2}; 0+ marron seeded on January 1st; MSS - minimum saleable size; * Computer overrun due to individuals exceeding 600 g; actual values approach 100%.

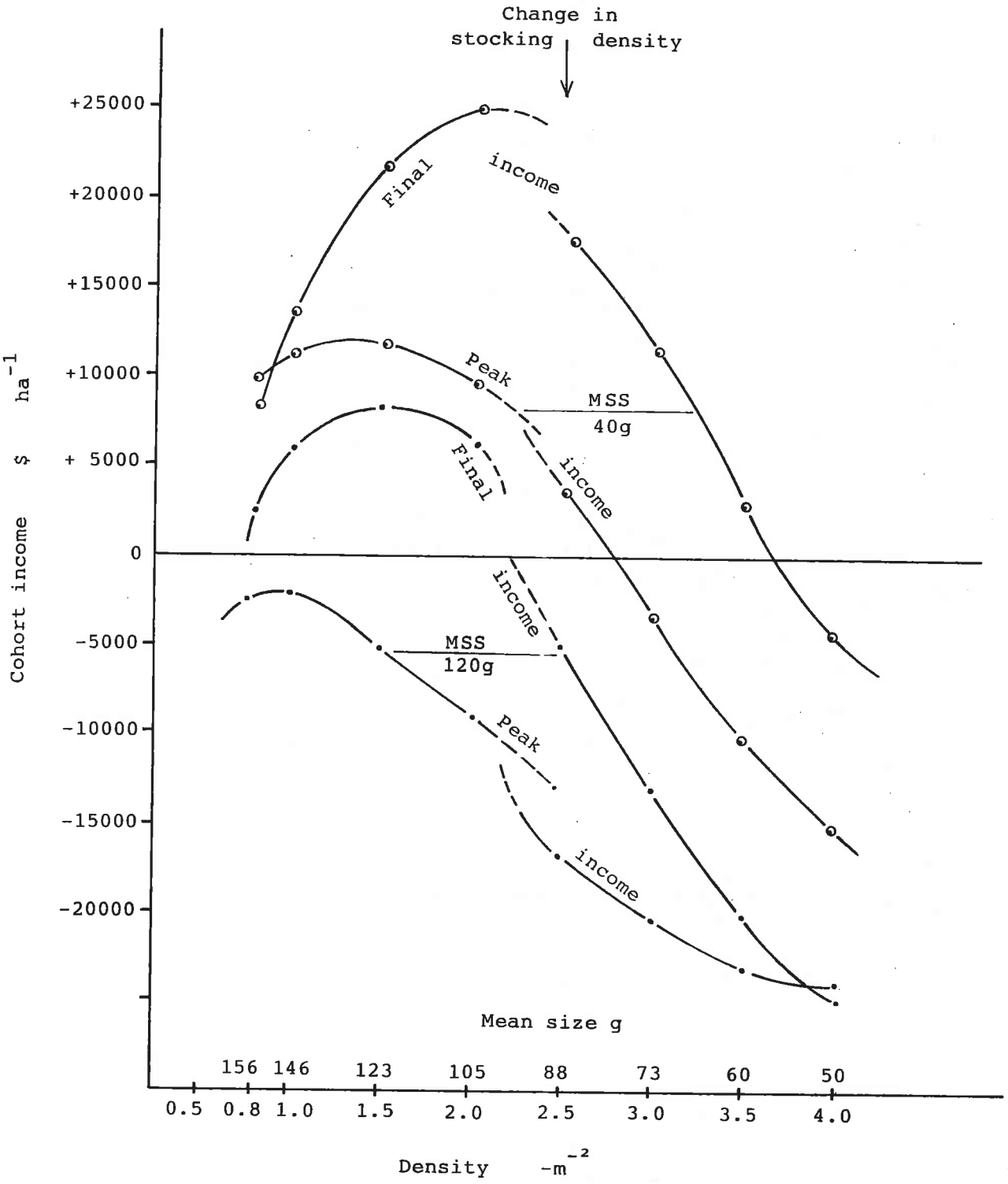


Fig. 9 Pemberton cohort incomes, $/ha^{-1}, for combinations of two year mean size, g, and density. -m^{-2}. MSS - minimum saleable size.

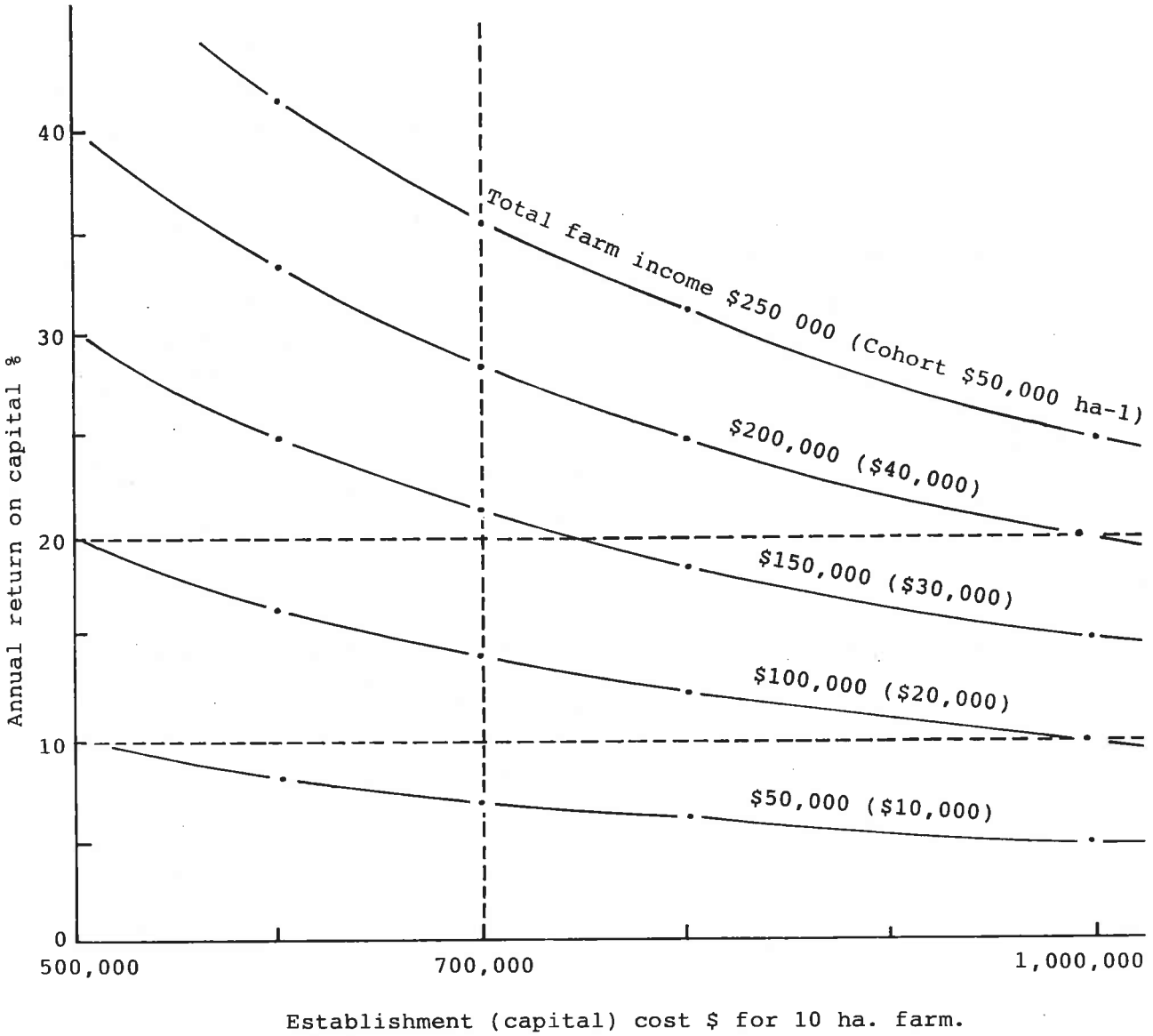


Fig. 10 Annual return (%) on total (10 ha) farm establishment capital cost at various levels of total farm annual (financial year) income. Equivalent cohort incomes for two year grow-out are shown in parentheses.

The Pemberton income simulations do emphasize the high level of pond management necessary to achieve economic viability, i.e. in ensuring densities in the range 1.5 - 2.5 m^{-2}.

The simulations also show the considerable difference in grow-out and harvesting scheduling necessary for marron by comparison with other farmed crustacea. In the latter cases, species typically show very fast growth rates early in life, mature early, are harvested in the range 20 to 60 g and maximum size, if achieved, is seldom in excess of 100 g as a species characteristic. In these cases (prawns, yabbies) grow-out to harvest from seeding is based upon an annual, or single growing season, schedule, sometimes with up to three crops per year.

Marron on the other hand are relatively slower growing early in life, mature in later years (at two and usually three years of age) but have a very large maximum size (2,000 g).

Consequently growth and increase in biomass accelerates to very high absolute levels during the second year of grow-out and most of the economic viability is achieved in the last few of twenty four months of grow-out. These characteristics can be seen in Figures 4 and 5, shown previously. Value of the marron first exceeds cumulative operating costs at twelve-fourteen months of grow-out at mean sizes of 50-60 g (Fig. 6, previously).

The effects on income and return on capital of various increases in operating costs over standard values are shown in Table 6 for the 105 g/2.0 m^{-2} Pemberton combination (run 6) with a MSS of 40 g. The combined influence of a 133% increase in food cost($0.70 kg^{-1}) a 300% increase in seed cost ($0.30 $marron^{-1}$) and a 50% increase in operating cost ($900 $ha^{-1}month^{-1}$) creates, approximately, a break-even operation.

TABLE 6: Cost increases over standard values for Pemberton, two year grow-out, mean size/density combination 105 g/2.0m^{-2}. Standard cost values are: food, \$0.30 kg^{-1}; seed, \$0.10 mar^{-1}; operating \$600 ha^{-1} month^{-1}; capital \$70,000 ha^{-1}. MSS = 40 g.

Run No.	Option	Single Cohort \$/ha^{-1} Peak Income	Single Cohort \$/ha^{-1} Final Income	Annual Total Farm \$ (% return)
6	Standard	+9594	+24988	+129940(+17.8)
10	Food \$0.70 kg^{-1}	+4211	+16976	+ 84880(+12.1)
11	Seed \$0.30 mar^{-1}	- 406	+14988	+ 74940(+10.7)
12	Operating \$900 month^{-1}	+4194	+17788	+ 88940(+12.7)
14	Operating \$1200 month^{-1}	-1206	+10588	+ 52940(+7.6)
15	Breakeven (10)+(11)+(12)	-11189	- 224	- 1120(-0.2)

The above simulations are based upon the standard Pemberton grow-out schedule of parental release and stocking of marron taken as January 1st, followed by two over-wintering periods and final harvesting in late December at twenty four months of age. The possible enhancement of economic viability by adopting an "early release" or a "nursery" schedule were simulated, based upon the optimum two year combination of 105 g/2.0 m^{-2} again. In effect these grow-out schedules eliminated one over-wintering period in the grow-out ponds and final harvesting occurs at the end of the second growing season near mid year. In each case there was only a slight, but insignificant increase in viability (Table 7). But not taken into account in costing are the increased hatchery costs of early release (by October 1st), if water temperatures need to be elevated, or the cost of nursery maintenance (at high density) for nine months.

Finally, an attempt was made to simulate grow-out at a warmer locality, than Pemberton, where growth-rate would be higher (Table 8). The mean size/density combination predicted for such a locality by Morrissy (1979), i.e. 111 g/2.9 m^{-2} at two years of grow-out, increased the annual return on capital to 34.8% (run 18). This increase can be compared with either of Pemberton runs 2 (8.3%, 73 g/3.0 m^{-2}) or 6 (maximum of 17.8%, 105 g/2.0m^{-2}).

The problem with this simulation, as explained earlier, is the survival assumption implicit in the different growth/density relationship for the warmer locality. An attempt was made in further simulations to bound this problem by considering a 50% increase in mean size for the optimum Pemberton combination i.e. run 19 compared with run 6 (Table 8)

Run 19, assuming that survival is only density dependent, 150 g/2.0 m^{-2}, shows a return on capital of 39.5%. At

Pemberton a mean size of 150 g is combined with a lower density of 0.9 m^{-2}, showing only a 7.8% return (run 20).

A more realistic simulation of the influence of both density and growth dependent survival, using the Pemberton mean size/density relationship was produced by shortening grow-out time from twenty four to eighteen months for the 105 g/2.0 m^{-2} combination, to accelerate growth rate. This run (No. 25) showed a 21.8% (cf 17.8%, run 6) return on capital.

TABLE 7 : Early release/stocking and nursery options.

Run No.	Option	Mean size g/$_2$Density -m at 2 years from stocking	MSS g	Final mean size g	Final density -m^{-2}	Biomass kg ha^{-1} Final (month)	%> MSS	Single Cohort $ ha^{-1} Final Income	Annual Total Farm $ (% return)
16	Early release and stocking on 1st October	105/2.0	40	94.2	2.27	2134 (20)*	95.6	+25739	+128695 (+18.4)
6	Release and stocking on 1st January	105/2.0	40	105	2.0	2100 (24)*	96.8	+24988	+129940 (+17.8)
17	Release on 1st January; nursery until stocking on 1st October	105/2.0	40	95.9	2.27	2172 (20)*	95.9	+26024	+130120 (+18.6)

*Run 16 age of marron = 20 months; one over-wintering period in grow-out ponds) two full growing
6 age of marron = 24 months; two over-wintering period in grow-out ponds) seasons in grow-out ponds.
17 age of marron = 30 months; one over-wintering period in grow-out ponds)

TABLE 8: Extrapolations for a faster growth rate with a longer growing season at a warmer locality than Pemberton.

Run No.	Option	Mean size g/ Density $-m^{-2}$ at 2 years from stocking	MSS g	Biomass kg ha^{-1}				Single Cohort $ ha^{-1}		Annual Total Farm $ (% return)
				Peak (month)	> MSS (%)	Final (24 months)	> MSS (%)	Peak Income	Max^{m} Income	
18	Predicted mean size/ density from Morrissy (1979)	111/2.9	40	2616(18)	89.3	3219	97.2	+23627	+48742	+243710 (+34.8)
2	Pemberton density comparison	73/3.0	40	1797(17)	68.1	2190	90.5	- 3382	+11569	+ 57845 (+8.3)
19	Pemberton 2 year mean size + ≅ 50%	150/2.0	40	2237(18)	95.4	3000	97.5	+30532	+55236	+276180 (+39.5)
6	Pemberton density comparison	105/2.0	40	1634(18)	88.2	2100	96.8	+ 9594	+24988	+124940 (+17.8)
20	Pemberton mean size comparison	150/0.9	40	1186(18)	95.4	1350	97.5	+ 6859	+10881	+ 54405 (+7.8
25	Pemberton minus 6 months grow-ing time	105/2.0	40	1634(12)	88.2	2100 (18 months)	96.8	+15272	+30559	+152795 (+21.8)

VII CONCLUSIONS

(i) The present minimum legal size of 76 mm carapace length(≅ 120 g) for farmed marron as food excludes from sale a significant proportion of any harvest taken up to two years of semi-intensive pond grow-out.

(ii) A size of 40 g (≅ 52 mm carapace length), based upon potential market acceptance, would permit sale of more than 95% of most harvests.

(iii) With a minimum sale size of 40 g for harvests from a final grow-out density range of 1.5 - 2.5 m^{-2}, the % return on capital can be in the range 10-20% for the Pemberton research locality and can be expected to be somewhat higher at warmer localities, recommended for marron farming.

(iv) Successful development of a semi-intensive marron farming venture is clearly dependent upon a very large establishment/capital investment in suitable facilities, a medium term start-up period, and specialist management skills. As a consequence, this level of aquaculture, in contrast to the less demanding extensive form, cannot be viewed, and should not be encouraged at the present time, as suitable for a broadly based industry, i.e. with many participants. Adoption of a lower minimum legal size for sale of farmed marron should be confined to particular ventures showing suitable commitment, as a necessary concession.

(v) While the present analysis clearly shows that a lower size limit provides a major incentive for investment, at present lacking for

semi-intensive marron farming, the practical basis for investment in a large pond development is unknown. The empirical data bases for the cohort dynamics employed to develop the projections in this paper on a per hectare basis for a 10 ha farm are derived from the space-limited facilities of a few very small (by commercial standards) research ponds at Pemberton, i.e. ponds of 0.01 ha. It is considered that the configuration characteristics of these small ponds are unlikely to yield the same favourable cohort dynamics or be manageable at the same high level if they are scaled up to a commercial size (eg 2000 m^{-2}). Considerable research needs to be carried out to establish the optimum configuration of large ponds to overcome this present disincentive for semi-intensive farming. At the same time experience needs to be developed and demonstrated on construction methods and practical management for large operating ponds. The latter aspect is extremely important because of the very low level of fish farming experience in this country.

VIII REFERENCES

Allen, P.G., L.W. Botsford, A.M. Schuur, and W.E. Johnston, (1984). Bioeconomics of aquaculture. Dev. Aquacult. Fish. Sci. 13, 1-351.

Cloern, J.E. and F.J. Nichols. 1978. A von Bertalanfy growth model with a seasonally varying coefficient. J. Fish. Res. Board Can. 35, 1479-82.

FACT. 1986. Economics of commercial marron farming. Freshwater Australian Traders Newsletter No. 14. 9th February, 1986.

Livingston, P.A. (1985). An ecosystem model evaluation : The importance of fish food habits data. Marine Fish. Rev. 47, 9-12.

Mills, B.J. and P.I. McCloud. 1983. Effects of stocking and feeding rates on experimental pond production of the crayfish Cherax destructor Clark (Decapoda: Parastacidae). Aquaculture. 34, 51-72.

Morrissy, N.M. 1974. The ecology of marron Cherax tenuimanus (Smith) introduced into some farm dams near Boscabel in the Great Southern area of the Wheatbelt Region of Western Australia. Fish. Res. Bull. West. Aust. 12, 1-55.

Morrissy, N.M. 1976a. Aquaculture of marron. Part 1. Site selection and the potential of marron for aquaculture. Fish. Res. Bull. West. Aust. 17, Part 1, 1-27.

Morrissy, N.M. 1976b.Aquaculture of marron. Part 2. Breeding and early rearing. Fish. Res. Bull. West. Aust. 17, Part 2, 1-32.

Morrissy, N.M. and R.R. House. 1979. Economic feasibility of intensive outdoor pond culture of freshwater crayfish in Australia. (Held in Fisheries Dept. Library, WAMRL).

Morrissy, N.M. 1979. Experimental pond production of marron, Cherax tenuimanus (Decapoda: Parastacidae). Aquaculture. 16, 319-44.

Morrissy, N.M. 1980. Production of marron in W.A. farm dams. Fish. Res. Bull. West. Aust. 24, 1-80.

Morrissy, N.M. 1984. Assessment of artificial feeds for battery culture of a freshwater crayfish, marron Cherax tenuimanus (Decapoda: Parastacidae). Dept. Fish. Wildl. West. Aust. Rept. 63, 1-24.

Pardy, C.R., W.L. Griffin, M.A. Johns, and A.L. Lawrence. (1983). A preliminary economic analysis of stocking strategies for penaeid shrimp culture. J. World. Maric. Soc. 14, 49-63.

Villarreal, H. (1986). Economics of marron farming in Queensland. Freshwater Aquaculture Association Newsletter. 2 (1), 7-8.

Western Australian Year Book. 1985. No. 23-1985. Aust. Bureau of Statistics, W.A. Office.

IX APPENDIX - Length-weight (L-W) relationships

(i) The Fisheries Act prescribes size measurement of marron in terms of a particular form of carapace length (CL) measurement (there are several), the rostrum carapace length (RCL). The latter is measured from the tip of the rostrum along a mid dorsal line to the posterior edge of the carapace. For research purposes a more accurate carapace length is measured, the eye-orbit carapace length (OCL). The latter is measured from the posterior carapace edge of the orbit laterally to the posterior lateral edge (notch) of the carapace.
RCL ≡ 1.39 OCL.

Note: total length of marron from the tip of the rostrum to the edge of the tail or telson is approximately twice the RCL.

All carapace lengths are measured by means of a caliper, or by a similar fixed gauge, in the case of the present Legal Minimum Size Limit given by the Fisheries Act as 76 mm RCL (= 54.5 mm OCL).

(ii) Except for total length, it is difficult, even with long experience, to think of actual sizes of crayfish in terms of carapace lengths. For carapace lengths, measurements given in centimetres are more easily related to an actual crayfish than ones given as millimetres. Moreover the aquaculture industry deals in weights of individuals and crops for management and sale.

(iii) Individual weights corresponding to carapace lengths are calculated from length-weight (L-W) equations established previously by measuring the lengths and weights of a large sample of individual crayfish. A statistical equation is then derived using a log-log transformation to permit linear

regression of weight on length. It is important to understand that any L-W equation cannot yield by calculation the actual weight of particular crayfish from its carapace length. The equation will only estimate the average weight of crayfish of that length although statistical limits can be given for the average or mean estimate. Because of natural variation in the body weight of individual crayfish of a given carapace length, the average weight calculated as corresponding to the Legal Minimum Size Limit of 76 mm RCL, has no validity legally in terms of the Fisheries Act.

(iv) The L-W equation currently employed for marron is based upon a large sample of all sizes from early 0+ year olds to marron well in excess of the legal size. However, L-W equations because of the log-log transformation, are very sensitive to the distribution of sizes in the sample and recalculation with additional data can be expected to yield a, slightly, different equation. Also measurement of carapace length of very small 0+ group marron necessitates use of microscopic rather than caliper measurement. The former involves a parallax error, while the latter gives a carapace compression error. So, for the very small 0+ group, the microscopic measurement is converted to a caliper one by extrapolation to smaller sizes using a relationship established for the two types of measurement.

The equation relating w, g, to OCL, cm, based upon only 1+ year old and larger marron which has been used is;

$$w = 0.9268\ OCL^{2.867} \quad (n=228)$$

For an OCL of 54.5 mm (≡ 76 mm RCL) the mean weight given by this equation is 120 g.

The equation, currently employed, incorporating 0+ year old marron is;

$$w = 0.9361\ OCL^{2.838}$$

Because of the peculiar nature of log-log equations the inclusion of small 0+ year old marron tends to lower the fitted linear equation for larger sizes and the weight corresponding to the minimum legal size is 115 g.

(v) Table 1 shows equivalent weights, OCL and RCL based upon the second L-W equation above.

Table 1: Equivalent weights; rostrum and eye-orbit carapace lengths

w g	OCL mm	RCL mm
2	13.1	18.2
5	18.0	25.0
10	23.0	32.0
15	26.6	37.0
20	29.4	40.9
30	33.9	47.1
40	37.6	52.3
50	40.6	56.4
60	43.3	60.2
70	45.7	63.5
80	47.9	66.6
90	50.0	69.5
100	51.9	72.1
110	53.6	74.5
120	55.3	76.9

The Review Committee in considering a possible reduction in or abolition of the Legal Minimum Size Limit for the marron industry will need to make judgements in terms of crayfish weight. However, while it would be ideal to frame such a legislation in terms of a weight definition, for legal contest it will be necessary to use carapace length. Carapace length can be measured to better than 1 mm and a standardised fixed gauge easily provided. The precision of weight measurement is greatly related to instrument cost, particularly in field situations, and acceptable accuracy by balance type standardisation and calibration would be very difficult to achieve in practice.

17 APPENDIX 2

PROPOSED POLICY GUIDELINES FOR CONTROLLING THE IMPORT OF FISH INTO WESTERN AUSTRALIA FROM INTERSTATE

CONTENTS PAGE NUMBER

1. BACKGROUND

Approximately 700,000 live fish (mainly freshwater) are imported into Western Australia each year essentially for the hobbyist aquarium trade. Approximately 95% of those imports are from overseas. The Australian Department of Primary Industry, Animal Health and Quarantine Service provides the necessary quarantine control to ensure that only permitted species are imported and that each consignment of live fish are sourced from a certified overseas supplier and undergo quarantine procedures at registered fish quarantine establishments to minimise the risk of disease introduction. Within Western Australia, the field quarantine service is provided by the Agriculture Department on behalf of the Australian Department of Primary Industry. There are seven registered fish quarantine establishments within Western Australia.

The remaining live fish imports coming into Western Australia are sourced from interstate aquarium fish breeders and farm fish hatcheries.

Between seventy and one hundred consignments of live fish are imported into Western Australia from interstate each year. The majority of these consignments consist of goldfish although an increasing quantity comprises the species silver perch, golden perch and murray cod for stocking farm dams.

The Fisheries Act requires that any person importing fish into Western Australia must obtain a permit from the Director of Fisheries providing the specific approval to do so and the conditions for release of such fish.

In practise however, because much of the trade in the past has been for the aquarium home market trade and the volume of fish coming into Western Australia has been at a low level, the monitoring of the interstate trade in

live fish by the Fisheries Department had been of a low priority and ineffectual.

The recent interest in importing live fish for stocking farm dams and the growth of investment anticipated in all areas of aquaculture has caused a re-appraisal of priorities. The subject of disease isolation and minimising of risks becomes more important as 'live fish' become an increasing part of the trade in food fish. Clearly from a 'disease' risk viewpoint there exists an immediate requirement to adopt sensible quarantine arrangements where fish are imported from the eastern states. In preparing the proposed policy guidelines for minimising associated disease introduction risks from the interstate flow of live fish into Western Australia, it is desirable for reasons of costs that quarantine procedures replicate where practical, the same quarantine procedures administered by the Agriculture Department. In this way the need for additional man power and resources to undertake the day to day quarantine procedures could be kept to the absolute minimum.

In essence, this would require the day to day operation of quarantine procedures to be undertaken by the Animal Quarantine branch of the Agriculture Department, while the policy aspects remained with the Fisheries Department.

The guidelines for quarantine also need to be sufficiently flexible to allow the Fisheries Department through the Minister for Fisheries, to take account of unusual quarantine arrangements that would be necessary for different species of fish which may be imported for fish farming purposes. The guidelines also need to be sufficient to provide for their enforcement and to cover the requirement for the reporting of 'disease outbreaks' on licensed fish farms in Western Australia.

The review committee, in supporting the proposed guidelines controlling the import of fish from interstate, accepted there may be other manpower arrangements which could equally provide for the administration of fish quarantine procedures. The addition of this responsibility to that of the Animal Quarantine Branch of the Agriculture Department was likely to be the most efficient, as it minimised duplication of an existing function.

2. DISEASE RISKS

The review committee does not have specific expertise on fish diseases or their detection.

In attempting to identify whether a case existed for the control of live fish imports from interstate within Western Australia, the following points were relevant to quarantine and disease testing of fish and shellfish. Much of this information came from experts in the field of fish disease diagnosis.

2.1 Major disease pathogens of concern to Australian importers.

Bacteria:
- Yersinia ruckeri
- Aeromonas salmonicida
- Pasteurella piscicida
- Haemophilus piscium
- Lactobacillis piscicola
- Streptococcus spp
- Mycobacteria spp
- Vibrio spp
- Renibacterium salmoninarum
- Aeromonas hydrophila

Viruses:
- Infectious Pancreatic Necrosis
- Infectious Haematepoietic Necrosis
- Viral hamorrhagic septicaemia

Spring viraemia of carp
Rosy Barb agent
Herpes viruses.

2.2 Quarantining and Health Certification

Precedents have been, and are currently being, established for quarantine and health certificates for fish and shellfish prior or following inter-state movements to protect existing or future industries from disease. Tasmania currently requires intensive health certification on broodstock populations of Atlantic salmon prior to importation of live eggs and is proposing certification of freedom from goldfish ulcer disease prior to importation of goldfish. Queensland currently employs a system of quarantine and health examination on marine prawns following importation from the Northern Territory.

One recommendation of the Standing Committee on Agriculture Workshop on Fish Diseases, May 1985, was: "The Workshop recognizes the need for adequate health certification for interstate movement of live fish, crustaceans and molluscs within Australia, and recommends a system of health certification be instituted by each State or Territory". This recommendation was supported by delegates in view of the need to protect industries on a State by State basis from disease.

2.3 Disease Identification

While the disease status of salmonid and non-salmonid Australian fish species is relatively well documented, but nevertheless incomplete, less than adequate information is available on the indigenous diseases of crustaceans and molluscs.

Previously undescribed diseases may exist which could be transmitted by interstate movements. The Fish Diseases Reference Laboratory at Benalla is in fact diagnosing previously undescribed pathogens in association with intensive production of fish and shellfish and from outbreaks of disease in wild populations. For example, the amoeba-like protozoan in salmonids in Tasmania, the iridoviral disease of redfin perch in Victoria and a baculoviral-like inclusion in penaeid prawns in Queensland have all been described in the last year. Other recognized pathogens appear restricted to certain geographical locations. For example goldfish ulcer disease is endemic in Victoria and New South Wales, and Yersinia ruckeri, the cause of enteric redmouth of salmonids, is present in certain hatcheries in Victoria and New South Wales.

There is thus a very good case to initiate quarantine of fish and shellfish from eastern Australia based on the distribution of existing diseases and on the likelihood of undescribed diseases being transmitted by interstate movements.

2.4 Ornamental Fish

In regard to ornamental fish, concern continues to be expressed at the risk of introducing major exotic diseases into Australia in latently infected, clinically normal fish. Exotic pathogens affecting ornamental fish are well documented and include: Infectious pancreatic necrosis virus in goldfish (Carassius auratus), discus fish (Symphysodon discus), carp (Cyprinis carpio) and danio (Brachydanio rerio); Yersinia ruckeri bacteria type 1 in goldfish (C. auratus); Aeromonas salmonicida bacteria in goldfish (C.

auratus); Edwardsiella tarda in tetra (Hyphessobrycon sp.) and fighting fish (Betta splendens); Edwardsiella ictaluri in danio (Danio devario), knife fish (Eigemannia virescens) and rosy barbs (Puntius conchonius); and proliferative kidney disease in goldfish (C. auratus).

All these agents are potentially serious pathogens of salmonid and/or non-salmonid fishes including murray cod and golden and silver perch. It is noteworthy that crustaceans and molluscs are specifically excluded from importation primarily on the basis of their disease-carrying potential.

2.5 Movement of Infected Fish Between States

An incongruous situation exists with regard to legislation, at least in some States, to control fish diseases. The situation exists whereby a disease if detected in fish during quarantine will result in total destruction of that shipment, under the Commonwealth Quarantine Act. Once released from quarantine, however, there is in some States, inadequate legislation to eradicate or destroy diseased fish or to control their movements . This is the current situation with goldfish ulcer disease in Victoria and believed to be in New South Wales. There is thus limited control, if any, on the movement of infected fish between States.

2.6 Disease Free Broodstock

The potential to establish a viable domestic and export industry based on culture of ornamental fish in tropical or subtropical regions is considerable. An estimated $4-5 million is spent on imported ornamental fish each year. Establishment

and maintenance of disease free broodstock is fundamental to a successful industry in these specimens. The same set of arguments apply to fish farming ventures producing fish for the edible food market.

2.7 Crayfish Plague Fungus

Crayfish plague fungus is one of the few primary pathogens resulting in 100% mortalities. This disease has devastated freshwater crayfish in Europe and North America and has recently been reported in Britain. If introduced to Australia the fungus would devastate freshwater crustaceans here in a similar manner, as Australian species are susceptible to it. It would be foolhardy in the extreme not to adopt strict quarantine measures against live freshwater crayfish or their uncooked products, to protect native Western Australian species and the developing marron aquaculture industry.

2.8 Developing a System of Quarantine for Western Australia

In developing a system of quarantine for Western Australia it needs to be recognized that the system should not be inflexible and should allow for introduction of new genetic material if required, but under strict control.

A system based on the relative risk posed by individual fish or shellfish species to be imported may be practical:

a) Total prohibition of those species known to be infected with serious diseases.

This is largely hypothetical at present as we believe Australia is free of most major diseases of fish and shellfish, but would apply, for example, if diseases such as infectious pancreatic necrosis, bacterial kidney disease, or crayfish plague, were diagnosed in the eastern states. It should apply at present to the marine molluscan disease QX in oysters (Saccostrea commercialis) and possibly to fish with redspot or ulcer disease from the eastern states.

b) Importation of "high risk" species subject to health certification.

Generally, protocols for certification need to be developed for the species in question, based on a knowledge of diseases carried by that species.

Examples appropriate to Australia would include the following:

(i) Freedom from salmonid and goldfish ulcer disease (Aeromonas salmonicida), infectious pancreatic necrosis (Yersinia ruckeri) and proliferative kidney disease in goldfish.

(ii) Freedom from viral diseases, bacterial kidney disease, (Yersinia ruckeri), including whirling disease in salmonids.

(iii) Freedom from crayfish plague fungus, (Aphanomyces astaci), (Thelohania),

Aerococcus viridans (Gaffkaemia) and viral diseases in crustaceans.

(iv) Freedom from epizootic haematopoietic necrosis virus in redfin perch (Perca fluviatilis).

(v) Freedom from known diseases described in individual species of imported ornamental fish, e.g. infectious pancreatic necrosis in discus fish.

Certification may be done on the broodstock population at the point of export, or on subsamples of imported fish or shellfish held in quarantine. Certification procedures have a statistical basis which are designed to ascertain prevalence of infection within certain confidence limits.

c) Importation of fish not known to be affected by exotic or other diseases may be treated in a manner similar to ornamental fish derived from overseas. Constant monitoring and laboratory examinations should be conducted on fish showing inordinately high mortality rates.

In all cases of imported fish, it is recommended that treatment for external parasites be conducted as these are usually readily removed and can be serious pathogens in high numbers. This would effectively eliminate the introduction of new ectoparasites into the Western Australian environment.

In considering all these points, the review committee was conscious of the need to develop a reasonable framework for quarantine control associated with live fish imports into Western Australia.

The guidelines proposed provide a sensible, flexible basis towards establishing a better control on the movement of live fish into Western Australia and reducing associated disease risks.

In addition they provide an ability to prevent the introduction of species through interstate movements of live fish, having the potential to cause ecological problems if accidentally released into Western Australia's rivers or streams.

3. GUIDELINES FOR CONTROLLING INTERSTATE IMPORTS

3.1 Quarantine Arrangements

All fish imported into Western Australia from the eastern states to be required to undergo the same quarantine controls as currently apply for imported fish from overseas sources, except as provided by specific exemptions.

3.2 Measures Required for Fish Quarantine

All live fish entering Western Australia will be ordered into Quarantine and will not be released from Quarantine until they have fulfilled all Quarantine requirements to the satisfaction of the Inspecting Officer. For the purposes of definition, 'fish' shall include all "live" fish, crustacean and molluscs, including the ovum or sperm thereof.

Measures required for Fish Quarantine are as follows:-

(a) Imported fish may not be moved from the airport except to a place approved and licenced as a fish quarantine premises, and may not be removed from those premises without the approval of a Quarantine Officer.

(b) Imported fish delivered by road or rail transport, shall be delivered by direct consignment to a registered live fish quarantine establishment.

(c) On arrival the fish will be transferred by net to new water and the imported water will be either passed into an approved water heating unit or held in a storage tank until disinfected with an approved chemical under quarantine supervision. Any water effluent from the premises during the quarantine period is to be disposed of via either of the manners described above. If using a water heating unit, it must be kept running at all times and any malfunction is to be reported to a Quarantine Officer.

(d) Imported bags are to be sterilised in an approved disinfectant or destroyed by incineration.

(e) Each tank is to be fitted with a record chart which is to be kept up to date at all times. The chart must show the tank number, the number of species of fish, the name and address of the exporter, the date of arrival and the consignment number, and must list any treatments given and any sickness or deaths observed. The card is to be handed to a Quarantine Officer at the end of quarantine.

(f) All dead fish must be removed as soon as possible and placed in the freezer in a separate numbered plastic bag for each tank. Any unusually high mortalities or diseases must be reported to a quarantine officer immediately.

(g) Tanks must be kept clean at all times. They must be free of gravel, sand or shell grit and only sterilizable materials (eg plastic) may be contained in the tank.

(h) Access to the premises must be available to Quarantine Officers during normal business hours. The licensee must state the times when the premises will be attended.

(i) The licensee will ensure that no fish leave the premises under any circumstances without quarantine approval.

(j) On completion of quarantine, fish are to be transferred by net into clean water.

(k) After use, all nets to be sterilised in the quarantine premises by dipping into water containing not less than 10 ppm of Chlorine (at least 0.1g HTH/litre).

(l) After each use, tanks are to be treated with 0.1g HTH/litre for 12 hours. The water may then be disposed of directly into a town sewerage system however if no sewerage system is available, water must be heat treated.

(m) The premises must be maintained to the degree of sanitation required by the Chief Quarantine Officer.

(n) Entrance to the premises is restricted to the owner, his nominated employees and Quarantine Officers, or other persons approved by a Quarantine Officer.

(o) Tropical fish and Goldfish may not be released from quarantine within 14 days of arrival and where necessary they will be held in quarantine for longer periods for treatment or will be destroyed.

(p) Marine fish are exempted from requirements for fish quarantine (pro tem).

(q) Fish imported from interstate and held in quarantine within a quarantine premises cannot be held in the same room at the same time as exotic fish imported from outside Australia, undergoing quarantine.

3.3 Premises for the Quarantine of Live Fish

The quarantine establishments shall be the same premises as those registered and approved under Section 46A of the Commonwealth Quarantine Act.

3.4 Permitted Species for Import

Aquarium fish

(i) Any species of freshwater fish permitted for importation under Schedule 6 part 2 Division 1 to the Wildlife Protection (Regulation of Exports and Imports) Act 1982.

(ii) Any species of marine fish permitted importation under Schedule 6 part 2 Division 2 to the Wildlife Protection (Regulation of Exports and Imports) Act 1982.

(iii) Any native fish (not including invertebrates) or exotic fish bred within Australia, which the Western Australian Pet Industry and Aquarium Association is able to identify as being of minimal disease or ecological risk.

(Further consultation will need to take place between experts on fish diseases, the aquarium industry, fisheries biologists and the Fisheries Department, towards defining those species which may or may not be imported from interstate).

Farm Fish

(b) Farm Fish (interstate sourced only)

Golden perch
Silver perch
Murray Cod

Other species of farm fish (as approved by the Minister for Fisheries)

3.5 Other Quarantine Policy Requirements

(a) The Minister for Fisheries to be given the power to vary the List of live fish permitted for interstate import under (a) and (b) above.

(b) The Minister for Fisheries to be provided with discretionary powers to approve imports of other farm fish and to vary or add to quarantine requirements. This will allow tests to be undertaken so as to isolate disease factors or to seek certification of 'diseased free' fish stock from the supplier, before exporting to Western

Australia and quarantine to be undertaken under specified conditions on a fish farm.

(c) To make it an offence to release any aquarium fish into any brook, stream, pond, lake, river, estuary, ocean, dam, waterway, or body of water other than an aquarium unless authorized to do so by a permit. (This requirement to apply to all Aquarium fish under 3.4).

(d) To make it an offence to import any species of fish other than those specified in the permitted species import schedules.

(e) To make it a requirement for any person seeking to import live fish from interstate, to obtain a permit from the Director of Fisheries before entry into Western Australia. (Note this is already covered by Section 39C(f) of the Fisheries Act 1905). (This legislation needs to be clarified in relation to aquarium fish and the permitted import species schedules).

(f) The person submitting an application for a permit to import fish to be required to detail, as a condition of permit, the date of expected delivery, and transport arrangements for the live fish consignment into Western Australia.

(g) To make it a requirement for any person granted a permit to import fish from interstate, to immediately deliver the fish to a registered quarantine establishment for quarantine purposes.

(h) The Director of Fisheries be required to issue a notification of each permit issued to the Senior Inspector of Animal Quarantine.

(i) The Director of Fisheries, in relation to the release of farm fish into farmers dams, to have the power to specify those areas of the State where releases of specific fish species may be permitted for use by the farmer as a source of edible food for on-farm consumption.

(j) The Senior Inspector of Animal Quarantine to be provided the authority, after conducting an initial inspection of a consignment of fish imported from another State, to order the immediate release of such fish where a quarantine certificate has already been issued by another Australian registered quarantine establishment.

(k) The Senior Inspector of Animal Quarantine to be provided the authority, after conducting an initial inspection of a consignment of fish imported from another State, to order the release of such fish where a 'disease free' certification has been issued for the fish farming establishment supplying the fish. The certification would need to be issued by a body such as the Australian Fish Health Reference Laboratory or some other independent agency having special skills in fish disease detection.

(l) Where exemptions are provided for under 3.5(j) and 3.5(k) for early release of imported fish, the fish are to be transferred to clean water by net and the imported water treated as per quarantine procedures.

(m) Post quarantine release of fish to be undertaken by the fish buyer in accordance with the conditions of permit issued by the Fisheries Department. Enforcement of these arrangements to be undertaken by the Fisheries Enforcement Branch of the Fisheries Department.

(n) The Fisheries Enforcement Branch to investigate and enforce breaches concerning interstate traded live fish.

(o) Every licenced fish farmer to be required by law, to notify the Fisheries Department of disease outbreaks of any fish held.

3.6 Anticipated Costs of Quarantine Procedures

The level of interstate import of live fish into Western Australia is low. On average between 2-3 consignments of live fish arrive in Western Australia from interstate each week.

The current facilities and staffing of the animal quarantine branch of the Agricultural Department is considered adequate to provide the quarantine service without large incremental costs.

This aspect would need further discussion between the Fisheries Department and the Department of Agriculture. The necessary legislative power largely exists within the regulation making powers of the Fisheries Act.

3.7 The Availability of Expert Advice on Fish Diseases

The major fish diseases reference centre in Australia is that of the Australian Fish Health Reference Laboratory in Victoria. Every encouragement needs to be provided for the development of a Western Australian based fish diseases referral identification service to meet the requirements of the aquarium trade and those of aquaculture. The development of these skills within Western Australia is an important requirement for the further development of commercial fish hatcheries, grow-out facilities

and the certification of disease free status of live fish exports albeit from food fish aquaculture or the aquarium trade.

The skills for these services need not necessarily fall within the public service but could easily be attached to Universities, Technical Colleges or commercial medical/agricultural services.

Such a disease referral service has recently been encouraged by the Fisheries Research Branch in co-operation with the WAIT School of Medical Technology which already has histopathological/bacterialogical facilities and expertise. Experience in the field of fish diseases needs to be encouraged by appropriate funding of investigations-projects on identifiable problem areas.

3.8 Education

Should Government decide to proceed with quarantine proposals outlined, their introduction needs to be accompanied with an appropriate education campaign aimed at the principal importers of live fish.

18 APPENDIX 3

EXISTING INTERIM REQUIREMENTS FOR LICENSING OF FRESHWATER CRAYFISH FISH FARMS

1. Minimum development requirements for the granting of a new fish farm licence for freshwater crayfish (marron, yabbies, koonacs, etc.) are as follows:-

(a) Hatchery

Existence of a hatchery facility for controlled production of young-of-the year (0+) marron for sale as a live product for seeding purposes only. Breeding stock for the hatchery must be established and may not have been captured (under a Recreational Fishing Licence) from the wild, but must either have been purchased from a licensed marron farmer (proof of purchase is necessary) or bred up to current numbers on the property. Licence renewal is conditional upon proof of annual production of a minimum of 50,000 0+ year old marron, or satisfactory reasons for the contrary.

(b) Grow-out

(Currently grow-out entails culture of marron to a minimum carapace length of 76 mm for marketing.) Existence is required of a minimum surface area of ponds of 0.5 ha at the time of application. Existing farm dams will not be accepted as ponds which should be purpose-built for the venture. Provision of readily drainable ponds is a condition of licensing for the purpose of verification of stocks at the discretion of the Director. Readily drainable ponds are those with

built-in bottom outlet sumps, outlet "monks", or similar outlets for release of water by draining. Proposed draining by means of pumping or siphoning does not conform to this requirement. Additionally, a breeding stock and hatchery facility must be established which is capable of supplying 0+ year old crayfish for seeding the pond area, at a density of 10/sq m or proof of purchase of such a quantity of 0+ year old crayfish from a licensed hatchery must be supplied.

2. A licence for a fish farm venture will not be granted on the basis of an application detailing only a proposal for development. That is, prior to the establishment of a hatchery and/or ponds as specified in 1 above. However, approval in principle of the proposed fish farm may be granted for prospective fish farmers for commercial reasons subject to eventually satisfying the above licensing criteria. Developers should note that no limitation exists on the number of fish farm licences for freshwater crayfish, nor by the nature of fish farming is any such limitation envisaged as necessary as a future licensing policy.

3. Besides adherence to the type and minimal development requirements of production facilities specified in 1 above, developers should note that successful application for licensing in due course also requires satisfactory proof of approvals from local, health, and water authorities.

19 APPENDIX 4

PROPOSED GUIDELINES FOR LICENSING FRESHWATER FISH FARMINING DEVELOPMENTS IN SOUTH WEST WESTERN AUSTRALIA

CONTENTS PAGE NUMBER

1. MARRON

1.1 Semi Intensive Fish Farming

1.1.1 Sale of Undersize Marron for Food To Licensed Processors (Eg. Restaurants)

A restricted number of development licences to be issued over the next five years. Up to ten licences would be issued to investors having the necessary financial, technical and management capacity to undertake the development sought. The development licences to be issued in accordance with proposals submitted to Government. The minimum total area of ponds as a pilot development to be 2.5 hectares, each pond to be not more than 0.5 hectares and to be gravity self drainable. The developers would need to provide a programme outlining their capacity to establish a minimum level of marron broodstock to undertake the development sought and mechanisms for product marketing, ensuring the orderly marketing of marron of all sizes. A programme and time schedule of development would also need to be specified. (Refer recommendations 11-14).

A fish farm licence would not be granted until submissions for the issue of development licences have been invited, considered, allocated and initial capital works towards establishing ponds undertaken. Approval in principle for development to be granted following determination of successful applicants for development licences.

1.1.2 Sale of Undersize Marron from Existing Licensed Fish Farm/Tourist Facility.

Licensed fish farmers having a fish farm/tourist establishment with a joint restaurant/meal serve facility, to be allowed to sell under the authority of a processors licence, undersize marron for consumption by the public on the premises. (Recommendation 28).

1.1.3 Sale of Undersize Marron for "Stocking" Purposes (6 gm) and/or the Production of Legal Size Marron

(a) Minimum development requirements for the granting of a new fish farm licence as follows:-

(i) Hatchery

Existence of a hatchery facility for controlled production of young-of-the-year (0+) marron for sale as a live product for seeding purposes only. Breeding stock for the hatchery must be established and may not have been captured (under a recreational fishing licence) from the wild, but must either have been purchased from a licensed marron farmer (proof of purchase is necessary) or bred up to current numbers on the property or purchased from an approved source. Licence renewal is conditional upon proof of annual production of a minimum of 50,000 0+ year old marron, or satisfactory reasons for the contrary.

(ii) Grow-out

(Currently grow-out entails culture of marron to a minimum carapace length of 76 mm for marketing). Existence is required of a minimum surface area of all ponds of 0.5 ha at the time of application. Existing farm dams will not be accepted as ponds, which should be purpose-built for the venture. Provision of readily drainable ponds is a condition of licensing for the purpose of verification of stocks at the discretion of the Director. (The maximum drainage period of any pond for inspection purposes should not exceed ten hours). Readily drainable ponds are those with built-in bottom outlet sumps, outlet "monks", or similar outlets for release of water by draining. Proposed draining by means of pumping or siphoning does not conform to this requirement. Additionally, a breeding stock and hatchery facility must be established which is capable of supplying 0+ year old marron for seeding the pond area at a suitable density or proof of purchase of such a quantity of 0+ year old marron from a licensed hatchery must be supplied.

(b) A licence for a fish farm venture will not be granted on the basis of an application detailing only a proposal for development. That is, prior to the establishment of a hatchery and/or ponds as specified above. However, approval in principle of the proposed fish farm may be granted for prospective fish farmers for commercial reasons subject to eventually satisfying the

above criteria. Developers should note that no limitation exists on the number of fish farm licences for size marron, nor by the nature of fish farming is any such limitation envisaged as necessary as a future licensing policy.

(c) Besides adherence to the type and minimal development requirements of production facilities specified above, developers should note that successful application for licensing in due course also requires satisfactory proof of approvals as relevant from local government, health authority and the Western Australian Water Authority. (Recommendation 15).

1.2 Permit Sales of Marron From Private Impounded Waters on Private Property

The committee highlighted the need for supplies of valuable broodstock to be available to licensed marron farmers as the current and expected scarcity of supplies, was identified as a major obstacle to the development of a viable marron aquaculture industry in Western Australia. Initially therefore permits to sell legal size marron from private impounded waters will only be granted for the purpose of supplying licensed or developing marron farms with broodstock. This sytem of permits would be reviewed annually to ensure it could be adequately policed, and once the initial demands of marron farmers for broodstock were satisfied, the system to be evaluated to determine if it should be expanded to allow permit holders to supply size marron for food consumption through licensed processing establishments (see Recommendation 17).

A permit for the sale of size marron to be issued to the property owner where;

(a) Total area of impounded water exceeds 2.5 hectares.

(b) Sampling by the Fisheries Department has been undertaken to determine expected yields.

(c) The cost of sampling to be met by the property owner.

(d) The area of water does not include any river or stream or body of water forming part of or indirectly contributing to, the public sport fishery on marron.

A single annual permit that will expire on a common date of 30 April each year, will be issued to each property owner following the receipt of an application and a determination of expected production of size marron through inspection sampling. The permit will define the name of the registered buyer, the selling period and the total quantity to be sold. The buyer will also have to keep records of the permit holder from whom the marron were purchased. (Recommendations 16-18).

1.3 Commercial Harvesting of Koonacs and Yabbies

A restricted number of commercial fishing licences to be issued to persons interested in the commercial fishing of farmer's dams on private property east of the Albany Highway.

Yabby fish farming will not be permitted west of the Albany Highway. (Recommendations 19 and 20).

1.4 Trout (Current Policy)

A fish farm licence will be issued to any fish farmer seeking to farm trout.

The issue of a licence will be dependent upon approvals from the Western Australian Water Authority for water usage and effluent disposal. (Recommendation 21).

1.5 Aquarium Fish and Plants (Current Policy)

A fish farm licence will be issued to any fish farmer seeking to breed aquarium fish (excluding aquarium tanks) within ponds subject to the following requirements:-

(i) Each species of fish to be bred to be separately considered and approved by the Director of Fisheries.

(ii) Must not have any aquatic plants that are "declared plants" under the Agriculture and Related Resources Protection Act.

(iii) Ponds not to be constructed on any creek, stream, river or flood plain thereof.

(iv) Effluent to be disposed of through a sump without any direct drainage into a creek or stream, river or storm water drain.

(v) The ponds to be adequately bunted against loss of fish through damage caused by storm rain run-off.

(vi) The premises to be accredited free of snails that are an intermediate host for

the live stock disease liver fluke, by the Agriculture Protection Board.
(Recommenation 22).

1.6 Other Species

To be considered on a case by case basis.

Note
A farm fish licence will not be issued unless appropriate approvals have been issued by the Western Australian Water Authority encompassing water usage and effluent disposal.

APPENDIX 5

List of Persons and Organisations providing Written Submissions

S Abbott
Technical Officer
Department of Agriculture
JERRAMUNGUP 6337

R Brown
Lot 6 Iron Road
STONEVILLE 6554

Burns Farming Pty Ltd
Inc. Treen Brook Downs Trout Farm
PEMBERTON 6260

C H Industries
Box 75
KATANNING 6317

J Cuthbertson
67 Ullapool Road
MOUNT PLEASANT 6153

Denmoore Marron Farms
7 Noble Street
KEWDALE 6105

B L de Russet
Meerup Road
NORTHCLIFFE 6262

Freshwater Lobsters of Collie
Arcadia Farm
RMB 274
WELLINGTON MILLS 6236

P R & S J Goldring
P O Box 41
PEMBERTON 6260

Greenbushes Fish Farm
P O Box 31
GREENBUSHES 6254

P Hainge
P O Box 13
WAROONA 6215

K E & S G Jackson
Mt View Marron Farm
P O Box 40
PEMBERTON 6260

Marron Brook Farm & Pottery
Hawke Road
PEMBERTON 6260

Marron Growers Association of Western Australia (Inc)
G P O Box T1818
PERTH 6001

C W Quin
c/- Quin Spencer Argo
P O Box 7330
Cloisters Square
PERTH 6000

E A Riley
17 Bucktin Street
COLLIE 6225

Shire of Augusta-Margaret River
P O Box 61
MARGARET RIVER 6285

Shire of Collie
Throssell Street
COLLIE 6225

Shire of Manjimup
P O Box 1
MANJIMUP 6258

Shire of Northam
55 Fitzgerald Street
NORTHAM 6401

Shire of Serpentine-Jarrahdale
6 Paterson Street
MUNDIJONG 6202

G C Stockwell
Valley Ponds Trout Fishery
Gull Rock Road
Lower Kalgan
Via ALBANY 6330

T B S Pastoral Co.
Weir Road
BASKERVILLE 6056

Western Australian Tourism Commission
G P O Box X2261
PERTH 6001