REPORT TO FISHING INDUSTRY RESEARCH COMMITTEE

RESEARCH AND DEVELOPMENT OF HATCHERY AND NURSERY CULTURE OF THE PEARL OYSTER PINCTADA MAXIMA.

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RESEARCH AND DEVELOPMENT OF HATCHERY AND NURSERY CULTURE OF THE PEARL OYSTER PINCTADA.MAXIMA.

1. INTRODUCTION

There has been recent revitalisation of the West Australian pearl culture industry to a stage where annual production is now worth about $40 million.

Mortalities of pearl shell transported to the culture farms and concerns regarding the state of pearl oyster stocks stimulated a series of research projects which have been funded largely from the Fishing Industry Research Trust Account (Table 1).

This year, funds were sought for two projects, in hatchery and nursery culture and on developing on-growing techniques and disease prevention husbandry (Table 2)

Despite work over a number of years, the hatchery and nursery project has not led to establishment of artificial propogation even on a research scale. Accordingly, I was requested by the Fishing Industry Research Committee to:

1. Re-examine the justification for further funding;
2. Investigate work done to date;
3. Examine current and proposed research strategies including facilities and operations;
4. Make conclusions and recommendations aimed at enhancing the prospects of future success given project justification.

Most effort was devoted to the hatchery/nursery proposal but because the on-growing/disease prevention proposal is related, both projects are considered.

With the above aims, I considered background papers and travelled to Western Australia to complete investigations and prepared a confidential report (Appendix 1)

This report is presented to the Fishing Industry Research Committee by Dr Trevor G Dix, Aquaculture Development Services Pty Ltd, RSD 1646, Grove, Tasmania 7106. Trevor G Dix does not accept responsibility for any loss or damage caused by unauthorised use of the report. In the time available, conclusions have often been based on discussion rather than written information but the author has used his best endeavours to ensure that findings are based on accurate sources.

2. JUSTIFICATION APPRAISAL

Pearling has a long history in tropical Australia with the major species Pinctada maxima being exploited initially for natural pearls and mother of pearl (MOP). More recently (from the 1960s) the species has been collected from natural beds and cultivated on pearl farms for culture of round and half pearls (mabes).

Australian pearl culture has centred on the Torres Straits and Broome although it is in Western Australia that the industry has shown strong recent growth with increasing participation by Australian ventures.

The Western Australian pearl culture industry yields product worth approximately $40 million annually, ranking second or third amongst the State's fisheries.

In terms related to value alone there is clear justification for research projects on pearl oysters certainly within a State context but with potential value elsewhere in tropical Australia.

The question then is, what topics should research address and specifically, does work in the field of artificial propogation warrant priority? Further, is research proposed in FIRTA appplications 87/81 and 87/82 justified and capable of achieving its objectives?

Culture of pearls in cultivated pearl oysters is the most economically important sector of the pearling industry in Western Australia. Shellstock for culture is derived entirely from natural populations of Pinctada maxima, particularly young stock just above the legal minimum size of 120 mm (fished populations are thought to be ages 2-4 years)

Quotas currently limit annual gathering of culture pearl oysters to approximately 360 000, almost all taken from patches within the 80 Mile Beach area south of Broome. Researchers consider that current annual harvests are sustainable (N Hall Pers. comm) although detailed assessments are unavailable. This indicates a clear need for work in stock assessment, particularly as current management measures are soon to be reviewed.

An exclusive reliance on natural shellstock from populations of unknown status must place an industry with major investment in pearl culture at some economic risk, the extent of risk being exacerbated if the industry increases production. On this ground alone there is justification for research and development work on artificial propogation.

In addition, the cost of gathering shell by hookah diving and achieving transfer of pearl oysters to farms for cultivation is high - industry sources suggest as much as $12 each includng shares for divers, dinghy boys, skippers, crew plus other operating outlays. When this cost is contrasted with the cost of production of other artificially cultivated bivalve species there again is clear justification for work on artificial propogation of Pinctada maxima.

My findings (see Sections 3 and 5 of this report) suggest further that work proposed in Project 87/82 is justified and is capable of achieving its objectives and that work may serve to provide the essential knowledge base for industry development in the field.

Aside from the above, mortalitites of shell collected for cultivation have been both a constraint and an added cost to industry. Previous FIRTA work (80/13) appears to have been a catalyst to industry in developing practices to reduce mortality. Mortalities or at least a reduced pre-operative lack of vitality appear to still occur. This provides justification for continuing investigations as partly envisaged in the project 87/81.

3. INVESTIGATION FINDINGS

The perspective aquaculture projects must be viewed as a series of segments within the overall cultivation and culture process which is:

1. Broodstock collection, housing and conditioning;
2. Spawning induction and fertilisation;
3. Larval rearing;
4. Settlement and early nursery culture (to 1-2mm size)
5. Nursery culture to about 10mm
6. Intermediate culture to about 50mm
7. On-growing culture to 120mm
8. Pearl culture and cultivation

Clearly segments 1-7 aim to replace or supplement the collection of naturally occurring pearl oyster.

Three only "good spawnings" have been achieved in projects since 1982/83. In the current season (1986/87) no significant spawning was achieved despite numerous attempts. The overall result, in part related to early work not being conducted at Broome, highlights the need for priority work in the first segment, broodstock conditioning.

Larval growth and survival results have been poor and no larvae have been set as spat. Whilst this relates largely to a lack of viable gametes, results reflect a variety of larval management shortfalls including food species, overstocking and water treatment practices.

Lack of larvae has in turn precluded work on early nursery culture and other segments of the investigation.

In short, apart from spawning induction, insignificant real progress except for a broadening of experience base, has been achieved in artificial propogation.

Project Management

A number of instances highlight sub-optimal project management including:

- a clear lack of effective co-operation and co-ordination between senior researchers in the programmes, arising partly from the lack of aquaculture experience of the one who was given senior status in the mid term of projects;

- delays in establishment of the Broome hatchery. These resulted in no effective work at Broome during the vital 1985/86 breeding season. Work in its lieu at Perth was ineffective;

- lack of clear, targeted goal setting by researchers

- insufficient external input on state-of-the-art hatchery technology;

- inadequate attention to early broodstock management in 1986/87.

Hatchery Design

The Perth hatchery, is remote from Broome. It was established amidst a general purpose aquarium facility which led to inevitable compromises in the pearl oyster project

The Broome hatchery was established with constraints on space and floor loading. In addition the plumbing system is complex with a multitude of valves, many pumps and filters and a number of (dissimilar) metal components. Very limited provision was made for the care of newly set spat in a nursery.

Whilst it is argued that over design was necessary in the plumbing because of poor water quality (particularly in spring tides) this is a moot point.

These aside a very effective algal production facility has been designed and this should cater for hatchery needs in the envisaged programme (see below).

Hatchery Operation

Lack of significant quantities of eggs at Broome has meant that larval and spat rearing facilities have not been evaluated to any degree.

The (few) larval growth curves indicate that stocking density, feeding and water treatment protocols all require re-appraisal (R Rose reached a related conclusion after a recent visit to Japan).

It has been stated that the hatchery was designed as a "high density low volume" operation. This is only partly so and whilst a "low density high volume" system is less demanding in operating requirements, the Broome system has not been tried in either mode.

Natural Problems

Management, design and operation aside there are inherent difficulties in the project, some in part related to working in a remote area, others to the animal itself - particularly as it appears to be a seasonal spawner which in some years may not spawn (this is not proven but possible).

Intensive zoo- and phyto- fouling creates problems for natural spat collectors and early on-growing of pearl oysters. This will dictate novel solutions to a range of problems.

4. RECOMMENDATIONS

Hatchery and nursery operations for 1986/87 should have a clear project goal - production of 100 000 10mm spat for extended nursery and intermediate on-growing assessments. This goal shapes broodstock and food requirements, minor hatchery design changes, larval and nursery operations. A higher goal should not be sought although this will not preclude experimental work with additional larvae. It does preclude any "additional" or outside studies (eg on water quality) by hatchery staff, in fact any work not related directly to segments 1-6 (see above).

Project Management

Responsibilities of the senior investigators have been divided in the research projects 87/81 and 87/82.

The projects are, however, related as one proposes to nursery culture the spat raised in the other. The senior researcher in aquaculture should have clear and absolute day-to-day responsibility for that project and should not, unless related directly to hatchery and nursery operations, perform functions in the second project (indeed as the second project depends so heavily on the hatchery work there is a need to have added personnel input to the hatchery work during the busy breeding season).

As with the hatchery project there is a need for goal orientated, planned research in on-growing and mortality studies. This project may well accommodate (with other Department assistance) an important role in fisheries assessment of natural stocksalthough effective nursery and on-growing work will be demanding.

Day-to-day project management aside there should be:

- regular (informal but searching) review of all work
- a possible input of expert help during the coming breeding season
- a critical overview of the projects early in 1988.

Work in Aquaculture Segments

Broodstock (Appendix 2)

500 broodstock are to be established on longline in Roebuck Bay in June. These must be well maintained and assessed regularly.

Small trials with intensive conditioning are to be initiated immediately at the hatchery. Extensive collections may be necessary later in the year.

This winter all existing gonad histological samples should be processed and analysed.

Larvae (Appendix 2)

Batches are to be raised at modest densities with experimental comparison of different feeding and water treatment strategies.

Settling and Early Nursery Care (Appendix 2)

Four 750l tanks (on hand) and 3 upwell units are to be established along the north-west side of the hatchery.

The tanks will require 900mm cylinders and be capable of operation in recirculation and flow through modes and as upwells. Screens on each cylinder should be exchangeable to allow both settling and on-growing (some setting will be done on artificial substrates in the larval tanks)

Early On-Growing

Systems are to be resolved and tested but Japanese style pearl nets should be on hand for initial work - these will require frequent attention.

Larger stock may be placed on prepared rubble bottom possibly fenced to exclude predators.

Early trials should be possible with small numbers of natural spat.

System Modification and Operation

The metallic "bucket" screen housing should be replaced together with stainless steel pipework. Recoating of the pressure sand filter is required.

Operators may be required to bypass all filters except the sand filter and 20 micron screen for larval and early set work.

5. SUMMARY OF KEY POINTS, CONCLUSIONS AND RECOMMENDATIONS

Project Justification

Collection and transport of young pearl oysters to the pearl farms is expensive - in fact the silver lip pearl oyster must be one of the most expensive aquaculture shellfish.

Whilst there is some reassurance that current fishing of natural beds can be sustained, our knowledge is insufficient to make clear predictions. Given that pearl markets can accommodate increased Pinctada maxima supplies (which will be derived not only from Australia) managers may be uneasy about increasing the natural catch for culture purposes.

> There is thus good justification for artificial propogation, research and development on both economic and stock management bases.

The private sector has made a number of attempts to develop artificial propogation over the years and most attempts have failed (it is said that one company has achieved recent success in Indonesia). Lack of development may be a measure of the difficulty of the work or of a complex of other factors including economic priorities etc.

> The present FIRTA project 87/82 has the potential to provide the necessary knowledge base to serve as a springboard for industry development of economic artificial propogation.

Project Perspective

The aquaculture project must be viewed as a series of segments within the overall culture and cultivation process, viz:

1. Broodstock collection, housing and conditioning;
2. Spawning induction;
3. Larval rearing
4. Settlement and early nursery culture (to 1-2mm)
5. Nursery culture to 10mm
6. Intermediate culture to 50+mm
7. On-growing culture to 120mm
8. Pearl culture operations

The project to date has centred on the first three segments.

> Although considerable experience and background information has been gained, to date work has not achieved any major objectives in any segment, except spawning induction, despite considerable expenditure of FIRTA and State funds.

Findings and Recommendations

Research in the FIRTA projects developed through a training phase (in Tasmania), operation of a research hatchery at Perth to now, establishment of a small hatchery at Broome.

During this period there has been considerable development in bivalve hatchery technology with a range of species throughout the world.

Lack of progress with the FIRTA project to date has many causes including:

- poor project management - with results such as missing the 1985/86 spawning season at Broome, a lack of effective co-operation between senior researchers in pearl oysters, and no clear quantified goal setting;
- design defficiencies in the hatchery facilities and insufficient appreciation of the logistic difficulties of attempting to hatchery rear pearl oysters in Perth;
- some operational defficiencies in the hatchery
- inherent difficulties within the species and environment, particularly in broodstock collection, housing and conditioning.

The above should not be construed to imply that existing hatchery staff have not devoted their efforts to the project - the work has inherent difficulties which demand a clear, goal orientated and dynamic approach.

The number of stock which may be required by industry is, in the context of other bivalve culture operations, quite small and there is good reason to suggest that the hatchery segment can be developed during the 1986/87 breeding season.

> A programme strategy should be developed to produce 100 000 10mm spat in the hatchery this season. These spat should be used for research in nursery and on-growing segments and also provided to those in industry who are interested. The latter may stimulate innovation in what is likely to be the most difficult part of propogation.

[This modest horizon should not preclude production of additional larval as a means of adding to the experience base or provision of additional spat for nursery and on-growing experiments]

Achievement of the 1987/88 objective will demand:

- intensified high priority efforts with broodstock (additional temporary assistance will be required at least for the period September - February);
- minor modifications to the hatchery and to existing larval management protocols including water management and feeding strategies;
- establishment of modest nursery facilities within the hatchery;
- trial of nursery then on-growing strategies in the field;

- a dedicated, goal orientated effort by hatchery staff with avoidance of any peripheral research activities such as water quality monitoring etc. This will involve also effective integration of hatchery and on-growing work.

- regular and critical review on a monthly then day to day basis during spawning season. Such reviews should concern the Department and the trust account administrators who will need to reassess the project in early 1988.

APPENDIX I

WORK PROGRAMME, T G DIX

Sunday	2 May -	Review of background literature, travel to Perth.
Monday	4 May	Further literature, interviews R Dybdahl, N Morrisey and N Hall (Waterman)
Tuesday	5 May	Travel to Broome, interviews Dr Arnold, R Rose and S Baker. Inspection, analysis of hatchery.
Wednesday	6 May	Inspection pearl oyster farm Deep Point, interview Toshi Fuji and Snowy Cambden. Further discussions re programme.
Thursday	7 May	Further analysis of hatchery, report draft, travel to Perth.
Friday	8 May	Meeting B K Bowen, report preparation.
Saturday	9 May	Finalisation, travel to Hobart.

APPENDIX 2

CHECKLISTS

Broodstock

2 x longlines with shell subsurface and near bottom in Roebuck Bay per R Rose drawings.
Additional stock on bottom
Early replacement of sick stock essential
Visual scoring of gonad condition
Regular cleaning of stock (pressure cleaner required plus part time labour.

Evaluation of system for temperature manipulation, experimental at first then pilot scale (at least 25 female stock).

Evaluation of all existing gonad samples

Collections from fishing grounds or farms if required.

Larvae and Setting

Batch divided into 2 x 2 tanks, two to have 20 micron water, water change and feeding strategy per instruction (Dix), latter to have 1 micron water.

In tank settling on plastic plates with glass coating plus miniframes of mesh.

Setting in nursery on 250 mesh screens with above substrata.

Nursery

Operated as a combination recirculating flow through spray system (Onga FP1, 2 of) then as a flow through upwell system. Added food initially. Screens for cylinders 250, 500 and 1 000 micron.

TABLE 1

SUMMARY OF FIRTA FUNDING ON WA PEARL OYSTERS

Project: (FIRTA 82/85) Studies of the artificial propogation of pearl oyster seed.

Year	Funding
1982/83	$58 264
1983/84	103 087
1984/85	103 818
Subtotal	$265 169

Project: (FIRTA 85/58) Enhancing the availability of pearl oysters for pearl cultivation in Western Australia.

Year	Funding	
1985/86	$159 459	
1986/87	173 609	
Subtotal	$333 068	TOTAL $598 237

Note: In addition to the above, discussion with D. Arnold suggest that State contributions from the State Fisheries Research and Development Fund could exceed $150 000 from the years 1985/86: 1986/87 FIRTA expenditure to be finalised.

Project: (FIRTA 80/13) A study into the cause of mortality in the cultured pearl industry in Western Australia.

1980/81	$38 518
1981/82	43 933
1982/83	47 977
TOTAL	$130 428

TABLE 2

SUMMARY OF FUNDS REQUESTED FOR CURRENT WA PEARL OYSTER RESEARCH

Project: (FIRTA 87/82) Research and Development of hatchery and nursery culture for the pearl oyster Pinctada maxima.

Year	Funding
1987/88	$133 699
1988/89	126 773
Total	$260 469

Project: (FIRTA 87/81) Developing on-growing techniques and disease prevention husbandry of pearl oysters in Western Australia.

Year	Funding
1987/88	$96 523
1988/89	$99 631
Total	$196 154

TOTAL $456 623