A STUDY INTO THE PRODUCTION OF NUCLEI

FOR PEARL CULTURE USING

AUSTRALIAN MOTHER-OF-PEARL SHELL

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FISHERIES
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OBJECTIVES

This research program sought to compare the production of mother-of-pearl nuclei from *Pinctada maxima* shells of three different origins:

- punch shell from W.A. pearl oysters which had previously produced half pearls;
- shells from pearl oysters grown on a pearl farm in the Northern Territory; and
- shells from large wild pearl oysters from W.A.

NON-TECHNICAL SUMMARY

The cultured pearl industry in Australia relies on the supply of shell beads, or nuclei, as the base for cultured pearls. The nuclei currently used are made from the shell of freshwater mussels which are found in the United States and some parts of Asia. Many alternative materials have been tested for their suitability in the production of nuclei. Few materials have been found to be satisfactory for a variety of reasons. Previous research has shown that mother-of-pearl nuclei, made from the shell of *Pinctada maxima*, the pearl oyster used in the Western Australian pearl industry, can produce pearls which are indistinguishable in quality from those produced using freshwater muscle nuclei.

The supply and stability of the price of imported nuclei, particularly the larger nuclei used to reoperate pearl oysters at pearl harvest and which are used to produce the largest and most valuable pearls, has varied significantly over recent years. A reliable supply of large nuclei made from suitable material has been considered for some time to be of fundamental importance to the long-term future of the Western Australian Pearl industry.

This research program examined the viability of producing mother-of-pearl nuclei using the shell of the pearl oyster, *Pinctada maxima*. Nuclei were produced using shells of *Pinctada maxima* from three sources; large wild shell from the pearl oyster fishery near Broome, pearl shell which had been used to produce half pearls, and pearl shell from a farm in the Northern Territory.

All types of shells purchased for the production of nuclei were of variable quality, with only between 40 and 50 percent of shells being of adequate soundness to produce nuclei. The presence of boring sponge worms and bivalves made many of the shells unsuitable for nucleus production.

Both the number of cubes recovered from each shell and the production rate were directly proportional to shell quality. The wild shell produced almost twice as many cubes per kilogram of shell as the as the farm shells and the half pearl shells. The numbers of nuclei produced from cubes was significantly lower for those from the wild shell compared with those from the farm shell and the half pearl shell. Approximately 76 percent of wild shell cubes processed produced a nucleus, while approximately of 82 percent of cubes from the farm shell and the half pearl shell produced nuclei.

Although the wild shell was more expensive than the half pearl shell, the significantly higher cost of cube production from the half pearl shell more than outweighed its its initial cost-advantage. The relatively poor quality and high cost of farm shell made it commercially unattractive.

This project has demonstrated that it is technically and practically feasible to produce commercial quantities of nuclei from *Pinctada maxima* mother-of-pearl. The recovery of nuclei from wild shell is significantly higher and cheaper per unit than it is from either type of farm shell tested.

The Western Australian Pearl Industry has shown a significant interest in this project and a number of the companies assisted in various aspects of the research. The next step is for the industry to test the nuclei to prove to their own satisfaction that the nuclei produce pearls of a quality similar to, or better than those produced using the foreign alternatives.

KEY WORDS : Cultured pearls, nuclei, mother-of-pearl, *Pinctada maxima* .

1.0 BACKGROUND

The Australian Pearl Industry uses round beads, or nuclei, made almost exclusively from the shells of freshwater mussels, Family Unionidae, as the base on which a cultured pearl develops. The largest supply of the shells from the bivalve Family Unionidae comes from the United States, and more recently supplies have also been sourced from China and Vietnam. The American fisheries which produce the shells are under increasing pressure of exploitation and are also suffering from the effects of an invasion by a foreign shellfish (Zebra mussel) which is displacing the Unionids from their natural grounds. Pollution in some of the North American inland waters is also contributing to problems in the industry and many researchers and fishermen believe that the harvest levels of mussels must be reduced in the interests of conservation. A report on the Symposium on Conservation and Management of Freshwater Mussels describes the American freshwater mussel fishery and provides a clear view of the future of the fishery as it is held by those involved in it (L Joll, FWA, unpubl.), including the need for an early reduction in the harvest of the largest shells. The largest shells are required to produce the largest nuclei essential for second and subsequent pearl operations and any disruption to the supply of these nuclei will have a significant impact on the Australian pearl industry.

Many alternative materials for nucleus production have been tested in the past but few have produced satisfactory results. Nuclei made from the shell of the Australian pearl oyster, *Pinctada maxima* (also known as the silver-lip or gold-lip pearl oyster), have been tested extensively by the author and others and found to produce pearls of a similar quality to those produced using nuclei made from freshwater mussel shells. That work has been reported on by the author. Fisheries Western Australia and all members of the Pearl Producers Association have received copies of all relevant research reports.

Subsequent to these results, it was decided to further evaluate the viability of producing nuclei from *Pinctada maxima* which, if successful, could reduce the industry's reliance on imported shell nuclei.

The pearl oyster fishery in the Eighty Mile Beach and Broome regions produces approximately 627,000 pearl oysters annually for pearl culture. The pearl companies prefer pearl oysters below 170 mm dorso-ventral measurement (DVM) for pearl culture because the larger animals do not appear reliable in producing pearls of adequate quality. The rejection of pearl oysters over approximately 170 mm during fishing operations results in an accumulation of the larger animals in the fishing grounds which may be affecting the efficiency of divers fishing for culture-sized shells.

The Pearl Producers Association has previously discussed the issue of evaluating the production of mother-of-pearl nuclei from the silver-lip or gold-lip pearl oyster *Pinctada maxima*, but the matter has not received significant urgency of attention to date.

This project examined the commercial aspects of producing nuclei for pearl culture in Australia from Australian mother-of-pearl shell. The project originally sought to conduct a commercial viability assessment of the production of pearl nuclei from large wild mother-of-pearl shells. In response to some issues raised by the Western Australian Pearl Industry, the original proposal was expanded to compare the production of nuclei from mother-of-pearl shell of three different origins - large wild pearl oysters from the Western Australian pearl oyster fishery, the shells of pearl oysters which have produced half pearls, and pearl oyster shells from a pearl farm in the Northern Territory. An application to the National Seafood Centre (NSC) for financial assistance for part of the expanded project was successful. This document constitutes the final report for this National Seafood Centre Project.

2.0 NEED

This project sought to replace imported nuclei with a locally-produced alternative. There is no intention to export nuclei to foreign markets, the preference being to provide an exclusive nucleus product to the Western Australian Pearl industry.

The Western Australian Pearl industry will gain significant strategic advantage if this project succeeds. Success will ensure control of nuclei for pearl operations which is currently controlled by foreign nucleus producers.

No information is currently available on the production of nuclei from the Western Australian pearl oyster of different origins. This feasibility study needs to be done prior to the establishment of the commercial mother-of-pearl nucleus manufacture operation in Western Australia.

3.0 OBJECTIVES

This research program sought to compare the production of mother-of-pearl nuclei from *Pinctada maxima* shells of three different origins:

- punch shell from W.A. pearl oysters which had previously produced half pearls;
- shells from pearl oysters grown on a pearl farm in the Northern Territory; and
- shells from large wild pearl oysters from W.A.

4.0 METHODS

4.1 The Nucleus Production Process

The process of producing beads from solid shell of the silverlip pearl oyster began with the grading of the shells for suitability. The presence of worm, sponge or borer holes made a piece of mother-of-pearl unsuited for nucleus production (Plate 1). Provided that the shell was reasonably free of holes, the material also had to be thick enough to allow the production of a number of cubes of shell from which the nuclei are ground. A visual inspection or estimate of weight of a piece of shell was generally sufficient to determine its suitability for nucleus production.

Plate 1 Boring sponge and worms made the shell unsuited to nucleus production

Following grading, the shells were cut using a diamond-bladed saw. Cubes were cut from the thick section of the shell, with a need to cut cubes with minimum dimensions at least 2 mm greater than the size of nucleus sought. For the purposes of this project, a minimum nucleus size of 10 mm was set, acknowledging the relatively low value and ease of supply of nuclei smaller than 10 mm.

After cutting, the cubes were graded by size to facilitate easier processing in the first stage of the rounding process which involved the production of roughly-rounded blanks. This was achieved using a mill which turned the cubes between a silicon carbide wheel and a rubber plate, removing the corners and high points as the pieces of shell turned between the two surfaces.

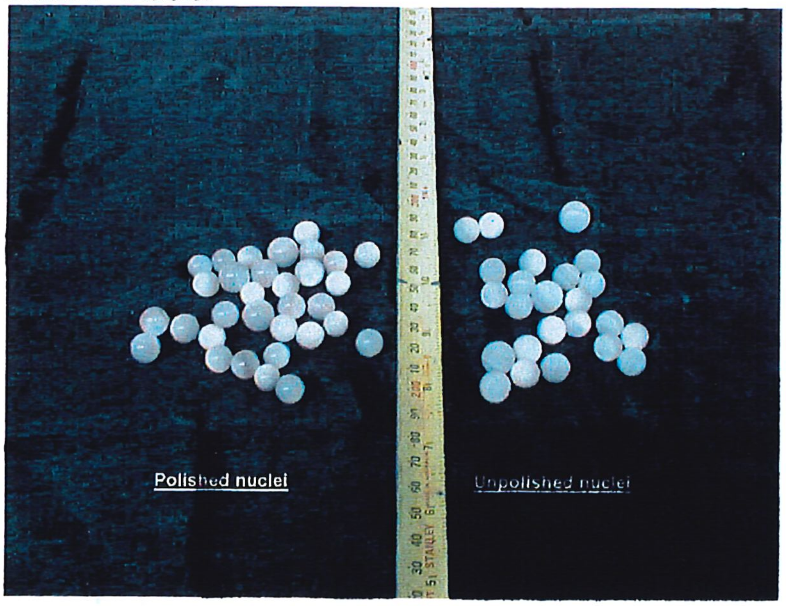
The second stage of the rounding process was performed using a lapidary machine designed to produce beads from semi-precious stone (Plate 2). A diamond-embedded grinding wheel, lubricated by water, was used in a semi-automatically operating machine to turn the roughly-rounded blanks of shell into spheres with an eccentricity in the region of +/- 0.03 mm (Plate 3).

The final stage of production was the polishing process which was designed to remove the deep scratches imparted by the diamonds in the grinding wheel. These scratches may retain foreign materials which are thought to contribute to the development of blemishes on the skins of cultured pearls. Fine abrasive compounds and organic acids were used to reduce the depth and width of the scratches, resulting in a high gloss finish on the surface of the nuclei.

The nuclei were then washed to remove any of the materials used during production process.

Plate 2 Nucleus machine

Plate 3 Nuclei



4.2 Sources of Shells

The shells of the silverlip pearl oyster from three sources were tested to compare the production of nuclei for pearl culture. Pearl oyster shells, which had been killed during pearl harvest, were obtained from Paspaley Pearls in Darwin at commercial rates. Punch shells, which had been used for the production of half pearls, were obtained from Broome Pearls Pty Ltd. Wild pearl oyster shells were fished under a Special Pearling Permit granted by Fisheries Western Australia; fishing was carried out by Arrow Pearling, Broome Pearls, and Maxima Pearls. The pearl oysters were taken from the wild pearl oyster fishery at the Lascepede Islands and the Eighty Mile Beach.

4.3 Grading and Assessment of Shells

All shells were packed into 200 litre drums, shipped to the Perth premises of SouthSea Nucleus Supplies and were initially graded for acceptability for nucleus production. The shells were evaluated in 200-litre drum lots, being convenient-sized samples for this part of the project. Shells with significant amounts of worm holes or boring sponge were considered unsuitable and were rejected.

The shells from the Lascepede Islands were determined early in the study to be generally thinner than those from the Eighty Mile Beach until they reached approximately 220 mm dorso-ventral measurement (DVM); consequently, those shells from the Lascepede Islands under 600 grams per piece were rejected as not being likely to produce commercially-viable numbers of cubes for rounding into nuclei. The shells from the Eighty Mile Beach were generally thicker than those from the Lascepede Islands and so the shells between 180 and 200 mm were accepted for nucleus production, provided that they were of adequate quality.

4.4 Processing Rate

The rate of cutting cubes from the shells was assessed using two operators on tile-cutting saws with diamond-embedded blades. The rate of production was determined from the numbers of cubes produced over three days by the two operators.

4.5 Production of Cubes

In order to produce data with sound statistical value, each shell-type was divided into seven replicates of 100 valves (half-shells). Each sample was kept separate while the production of cubes was carried out. As previously mentioned, this project sought to produce nuclei with a minimum size of approximately 10 mm so only cubes with minimum dimensions over approximately 12 mm were processed; the maximum size of nucleus achievable from a cube is at least 1.5 to 2.0 mm smaller than the smallest dimension of a cube due to the processes used to form a sphere out of a cube. Some nuclei smaller than 10.0 mm were produced during the project, but resulted from extended processing of larger nuclei which had failed to satisfy the roundness requirement at larger sizes earlier in the process.

4.6 Production of Nuclei

Following size-grading of cubes from each replicate into size-classes using a sieve, all of the cubes from all replicates of one shell-type were combined and processed into nuclei. The recoveries of nuclei of all sizes were then recorded for each shell-type.

4.7 Final Polishing and Grading

The nuclei went through several stages of polishing, all of the unpolished nuclei from each shell-type being combined for the polishing; the process was determined not to influence unevenly the acceptability of the nuclei between the different shell-types.

After completion of the final polishing stage, the quality of the nuclei was assessed with particular attention paid to roundness (measured with digital callipers) and surface flaws (assessed by microscopic examination of the nuclei). Samples of nuclei from other manufacturers were used as comparisons for the mother-of-pearl nuclei.

During the development phase of the polishing process, samples of nuclei were examined under an Environmental Scanning Electron Microscope (ESEM) at the University of Western Australia Centre for Microscopy. The examination sought to determine through X-ray analysis whether the cleaning process was removing the polishing compounds, recognising a commonly-held view that foreign particles on the surfaces of pearl nuclei contribute to the development of blemishes on the surfaces of cultured pearls.

The polishing process aims to remove the scratches from the surfaces of the nuclei using successively smaller-sizes of cutting and polishing compounds. Little published information was found on this subject but some commercial processes seek to achieve similar goals, although they are generally satisfied with a finish which has a significantly larger scratch-size.

5.0 RESULTS

5.1 Introduction

Pearl oyster shells of three origins were evaluated for their nucleus production potential during this research program; wild pearl oysters from the Lascepede Islands and the Eighty Mile Beach, half pearl punch shell from the M G Kailis Group of Companies (Broome Pearls), and ex-farm shells, both B Grade and C Grade, which had not been used for half pearl production, from Paspaley Pearls in Darwin, hereinafter called "farm shell".

The recoveries of useable product were recorded at the end of the major steps in the production process.

The discussion of the results is contained in Section 6.

5.2 Sources of Shells

The quality of the shells was recorded by 200 litre drum-lots, to provide an indication of the quality of material which could be expected from each shell-type. The average percentage "acceptable" for each shell-type and Standard Deviation are shown in Table 1.

Table 1 Grading of Shell for Suitability

Shell-type	% Acceptable (SD)
Wild	45.6 (12.1)
Punch shell	50.9 (22.0)
B Grade Farm shell	40.0 (4.1)
C Grade Farm shell	17.4 (6.6)

The Analysis of Variance (ANOVA) on the raw data showed no significant difference between the wild shell, the punch shell and the B Grade farm shell, (F=0.663). The C

Grade farm shell was not evaluated further due to the low percentage of shell of acceptable quality.

5.3 Processing Rate

The time taken to produce cubes was recorded over three days of production for each shell-type and averaged over the relevant period including all preparation and cleanup times. The rate of production of cubes from the three different shell-types is shown in Table 2.

Table 2 Rate of Cube Production

Shell-type	Cubes per person-hour
Punch shell	25
B Grade Farm shell	40
Wild Shell	60

5.4 Production of Cubes

The numbers of cubes produced per 100 shells (one valve = one shell) and per kilogram of mother-of-pearl was assessed. Only the "Acceptable" proportion from each of the batches of wild shell, punch shell and B Grade farm shells were assessed. The numbers of useable cubes (over 12 mm minimum dimension, or about 16 mm sieve size) per 100 valves and per kilogram of mother-of-pearl are shown for each shell-type in Table 3.

Table 3 Average Number of Cubes Produced per 100 Acceptable Valves

Shell-type	Mean weight of shell processed (gms)	Cube size 20 mm +	18 - 20 mm	16 - 18 mm	Average per 100 shell	Average cubes per kilo of shell
Wild shell	553	111.14 (95.9)	219.29 (43.3)	137.14 (101)	467.57	8.46
Punch shell	432	28.43 (8.7)	53.43 (18.1)	110.29 (19.1)	192.14	4.45
B Grade farm shell	575	43 (17.6)	96.1 (30.2)	109.9 (16.4)	249.00	4.33

N = 7 for each shell-type. Figures in brackets are standard deviations

5.5 Rough-rounding of Cubes

The rounding-off of the corners of the cubes was assessed and the time taken was not found to differ between shell-types. The process takes approximately 20 minutes for one batch of 70 cubes, with a recovery of approximately 85% across all shell-types.

5.6 Production of Nuclei

The recovery of nuclei from the bead-making machine was assessed to determine the attrition from the original number of cubes during the rounding phase. Table 4 shows the recovery relative to the numbers of cubes processed.

Table 4 Recovery of nuclei per cube of each shell-type

Shell-type	Cubes	Nuclei	% Recovery
Wild shell	3273	2506	76.57
Punch shell	1345	1107	82.30
B Grade farm shell	1743	1424	81.70

A pairwise t-test assessed the differences between the recoveries of nuclei from the cubes from different shell-types. The results are shown in Table 5.

Table 5 t-tests on recovery of nuclei from cubes by shell-type

Shell-type	t	Significance
Wild shell -punch shell	4.49	***
Wild shell - B Grade farm shell	4.33	***
Punch shell - B Grade farm shell	0.435	NS

Table 6 shows the recovery of nuclei of each size per 100 valves processed of each shell-type.

Table 6 Average recovery of nuclei per 100 valves processed of each shell-type

	SIZE mm														
Shell-type	15.5	15	14.5	14	13.5	13	12.5	12	11.5	11	10.5	10	9.5	9	Total
Wild shell			1.71			62.71		92.71	70.43		81.14	23.71	21.14	4.43	358.00
Punch shell	2.14		4.00		3.86	5.43		14.57	29.14		48.00	10.14	28.14	12.71	158.14
B grade farm shell				3.29	3.57		14.29	14.71	74.71	6.71	39.86	40.57	5.71		203.43

The cost of the raw material purchased to produce the nuclei from each shell-type was assessed. The results are shown in Table 7.

Table 7 Material costs of nuclei produced from 100 valves of each shell-type

Shell type	Shell cost $Aus *	Average weight (gms)	# nuclei per 100 valves	Value of scrap $Aus	Nett cost of mother-of-pearl nucleus $Aus
Wild shell	940.00	553	358.00	359.45	1.62
Punch shell	237.60	432	158.14	101.09	0.86
B grade farm shell	998.20	575	203.43	179.40	4.02

*The cost of wild shell was estimated at $17 per kilogram because that is an estimated cost of purchasing wild shell fished specifically for nucleus production, as opposed to catching large wild pearl oysters during culture shell fishing operations. The actual cost of the wild shells provided by Broome Pearls, Arrow Pearling and Maxima Pearls was considerably lower than this price, as a result of the commitment by those companies to assist in this project.

5.7 Final Polishing and Grading

The polishing process was found to require up to fifteen steps to achieve the fine quality finish sought by the Australian pearl industry. The process was not observed to cause a significant attrition in the numbers of nuclei; fewer than one percent of nuclei failed during the polishing and no differences were detected between the different shell-types. Some of nuclei were rejected following polishing, the process having high-lighted flaws in the surfaces of the nuclei which had occurred during the grinding process. These flaws were almost always able to be removed by a small amount of extra grinding.

6.0 DISCUSSION

6.1 Recovery of useable shell

The acceptability of the shell was based on adequate thickness and amount of sound shell for nucleus production. The assessment of the recovery of shells suited to nucleus production from the three different shell-types shows an apparent difference between the three shell-types. The large variances of the recoveries make the differences between the recoveries from the different shell-types not significant. A larger sample may result in some difference being detected. The presence of large amounts of boring sponge and worm holes made the assessment of C Grade farm shells unnecessary, hence the decision to assess the more expensive B Grade shells which showed a recovery rate of more than double that of the C Grade shell.

6.2 Processing Rate

The rate of cube production from whole shells showed a significant difference between the three shell-types. This is due mainly to the quality of the shells, including thickness, which allows the recovery of more nuclei per shell from the wild shell than was possible from the other shell-types; the number of cubes cut per 100 wild shells was almost double that of the B Grade farm shell and more than double that of the punch shells. This difference may change if the grading of the shells was more conservative, but such an approach would change other key financial performance parameters. It is also possible that increased familiarity with the cutting process during the project resulted in some of the improvement in cutting rate of the farm shells and wild shells.

6.3 Production of Cubes

Whilst the production of cubes is only an intermediate stage in the process of nucleus production, it is an important parameter in determining the viability of the process because it represents the most labour-and-material-expensive part of the entire process.

The production of cubes of all sizes per 100 shells processed was significantly higher in the wild shells than in the other shell-types, in particular in the two largest size-classes which have the capacity to produce the larger, more valuable nuclei. That difference was also reflected in the recovery of cubes per kilogram of shell processed in each shell-type, correcting for the difference in average weight between the three shell-types; the punch shell and farm shell were almost identical and the wild shell produced almost double the number of cubes of the other two shell-types per kilogram of shell.

6.4 Recovery of Nuclei from Cubes

The recovery of nuclei from cubes could be an important production parameter due to the cost of cutting shell, and the possibility that excessive losses in the transition from cubes to nuclei could impact significantly on the average cost of nuclei.

The recovery of nuclei from cubes of wild shell was approximately 5% lower than that from the punch shell and the farm shell. A t-Test showed that difference to be highly significant but the difference between the recovery rates for punch shell and farm shell was not significantly different. This difference between the wild shell and the other two shell-types may be due to the greater age of the wild shell compared with that of the punch shells and farm shells, which may make the shell slightly more inclined to fracture under the stresses of processing. Further testing may provide some more information on this issue.

6.5 Recovery of Nuclei from each Shell-type

The recovery of nuclei from each of the shell-types shows that the wild shell produces significantly more nuclei per shell than the other two shell-types (Table 6). Only production of nuclei from "acceptable" shell was evaluated; it was not considered appropriate to assess the recovery of nuclei from shells purchased due to the different qualities of shells purchased. The take of wild shells was quality-controlled in the field as far as possible but the suitability for nucleus production was not adequately determined until they were sorted and cutting began. The average quality of punch shell was higher than the other two shell-types because the shell which were graded as unsuitable on the first inspection were returned to the Broome Pearls at no cost. The farm shell were purchased after an initial inspection but without adequate knowledge of the specific quality required for nucleus production and in ignorance of the internal expression of surface defects in the shells, so the percentage of that shell which was suitable for nucleus production was lower than for the other two shell-types.

The recovery of nuclei from the different shell-types should improve with more stringent grading of shells prior to cutting. As previously discussed, the knowledge about shell quality gained during the project will allow some potentially-significant improvements to be made in a number of areas of production, including grading, cutting, and rounding-off in the nucleus machine.

6.6 Rate and cost of production

The labour costs of nucleus production has not been evaluated in this document because the cost of labour can vary quite markedly, depending on experience and availability of personnel. However, the production of cubes from shell gives an indication to the level of labour consumed in the most labour-intensive part of nucleus production.

The rough-rounding of cubes requires some supervision due to the propensity for the mother-of-pearl to split, causing disruption of the process and damage to other cubes in the same batch. The ability to process up to 80 cubes at a time makes the labour component relatively minor.

The production of spheres from roughly-rounded cubes is performed semi-automatically by the nucleus machine but requires some supervision. The production of a sphere from a roughly-rounded cube takes several passes through the nucleus machine, with this human supervision representing a cost, although significantly less than the preceding steps.

The polishing process is a lengthy process but one which requires only small amounts of supervision. Each stage of the process can handle several hundred nuclei with ease and that number is mainly limited by the size of the polishing device.

The cost of raw material will evidently have a significant impact on the commercial viability of making mother-of-pearl nuclei. The wild shells were provided at a relatively low cost by the three companies in the interests of assisting the project to proceed. That cost may not be sustainable in full commercial production unless special financial arrangements can be made and the estimates of material costs in Table 7 are a reasonable estimate of the cost of the commercial supply of wild shell.

It may be possible to maintain the lower costs of providing the shell if the pearl oysters are fished at the same time as pearl oysters are fished for pearl culture. If that is the case, the wild shells are very attractive as the source of mother-of-pearl for nucleus production. The current cost of the B Grade farm shell makes them unattractive for nucleus production unless they can be stringently graded prior to purchase. The use of punch shell, although the cheapest in raw material costs of the three shell-types tested, is less attractive than the wild shell due to the high costs of producing cubes from the whole shells. The recovery of some raw material costs through the sale of the scrap and unsuitable mother-of-pearl helps to offset the costs, but there is still a significant raw material cost per nucleus for all three shell-types.

7.0 BENEFITS

The longterm beneficiaries of commercialisation of this project should be the Australian pearl industry. That benefit will depend on the industry testing the nuclei to satisfy themselves that they produce pearls of a quality similar to that produced by the imported nuclei currently used. The benefits will include greater certainty of supply and price of the larger, more expensive, nuclei used in reoperations, and better control over quality of nuclei produced.

The conservation bodies in the United States will perceive a benefit from the commercialisation of this project due to the reduction in the level of exploitation of the freshwater mussels in that country.

8.0 CONCLUSIONS

This project has demonstrated that it is technically and practically feasible to produce commercial quantities of nuclei from *Pinctada maxima* mother-of-pearl. The recovery of nuclei from wild shell is significantly higher than it is from either type of farm shell tested.

Whilst the cost of producing the nuclei appears to allow such a product to compete with imported nuclei made from freshwater mussel shell, the commercial viability of such a project depends ultimately on the acceptability of the product to the market. That acceptability includes all aspects of the nuclei, including price, surface finish, size, consistency of shape, and consistency of supply.

The Western Australian Pearl Industry has shown a significant interest in this project and a number of the companies assisted in various aspects of the research. The next step is for the industry to test the nuclei to prove to their own satisfaction that the nuclei produce pearls of a quality similar to, or better than those produced using the foreign alternatives.

9.0 COMMERCIAL OPPORTUNITIES ARISING FROM THE PROJECT

This project has demonstrated that it is possible to produce quality nuclei for pearl culture from the shell of the Australian pearl oyster. The costs of production in Australia are high relative to those in many other parts of the world and as a result it is common for the most labor-intensive parts of the nucleus production process to be undertaken overseas. If this project is going to compete with both imported and locally-produced nuclei, it is likely that the cutting of the shells into cubes will have to be done offshore.

The sustainability of the wildstocks of large *Pinctada maxima* under increased exploitation, and the reliability of access to good-quality shell, are two major issues raised by this project. The study demonstrated that approximately nine nuclei can be recovered from the average acceptable wild pearl oyster. However, it is expected that, with selective grading of shells, significantly higher recovery rates should be possible, perhaps up to 15 nuclei per pearl oyster. At this higher rate, 6700 pearl oysters would produce approximately 100,000 nuclei of the larger sizes for reoperations, meeting a substantial proportion of the pearl industry's requirements. A survey of the wildstocks is currently planned by Fisheries Western Australia and is being funded by the FRDC. This survey will investigate the distribution and frequency of large pearl oysters with shells of adequate quality for nucleus production.

As previously identified, the pearl industry does not currently need an alternative supply of nuclei. However, it is considered to be in the best strategic interests of the industry to conduct evaluation trials on nuclei made from alternative materials so that, if and when the supplies of nuclei from traditional sources are compromised, a proven alternative can be adopted.

The final step in this project will be to approach industry members to test the mother-of-pearl nuclei and compare the pearls that they produce with those produced using conventional nuclei. No sales of nuclei have occurred to date and it now appears unlikely that significant sales will occur until industry companies are satisfied that the mother-of-pearl nuclei can be used without any technical or financial risk. This conservative view is understandable, so full commercialisation of this project is not considered likely for another three or four years.

10.0 ACKNOWLEDGEMENTS

This project was partly funded by the National Seafood Centre and the West Australian Fishing Industry Council Industry Development Unit. We are grateful to both NSC and the WAFIC IDU for their support of this project, and in particular we wish to thank Mr Ian Wells from the NSC and Mr Richard Stevens from WAFIC for their assistance in the acquisition of the grants.

The wild pearl oysters which were fished as part of this project were provided at very low costs by Broome Pearls Pty Ltd, Arrow Pearl Company Pty Ltd and Maxima Pearls Pty Ltd. We are particularly grateful to Steve and Penny Arrow, George Kailis and John Kelly, and David Jackson, as well as all of their respective fishing crews for their significant input and assistance in the acquisition of the wild shells. We also wish to thank the Paspaley Group for the provision of the farm shells used in the project.

The access to wild pearl oyster shells was granted by the Executive Director of Fisheries Western Australia, Mr Peter Rogers. We wish to thank Mr Rogers, and also Dr Jim Penn, Ms Heather Brayford and Mr Greg Findlay and other staff of Fisheries Western Australia for their valuable input and assistance during various stages of this project.

Two employees of SouthSea Nucleus Supplies, Mr Les and Mrs Kerry Imgrund carried out almost all of the routine processing of the shell. They also contributed significantly to the development of techniques and the collection of high quality data which allowed the results contained in this report to be analysed and presented with confidence.

APPENDIX 1

INTELLECTUAL PROPERTY

The key issue resolved in this project was that the commercial viability of nucleus production from mother-of-pearl shell in Western Australia hinges on the rate of recovery of nuclei per unit of shell purchased. The costs of production in Western Australia make the production of nuclei from ex-farm shells unattractive, but the production of nuclei from wild shell appears to be commercially viable.

APPENDIX 2

STAFF EMPLOYED ON THIS PROJECT

R J S Scoones	Principal Investigator
Mr L Imgrund	Technical Assistant
Mrs K Imgrund	Technical Assistant
Mr C O Kelly	Director
Mr S R McDonald	Director
Mr L G Dudfield	Director

Contract shell fishing services were provided by Broome Pearls Pty Ltd, Arrow Pearling Pty Ltd, and Maxima Pearling Pty Ltd.