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**PROJECT DEVELOPMENT ASSESSMENT :  
PACIFIC ISLAND PEARL OYSTER RESOURCE  
DEVELOPMENT : PROJECT 9131#**

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## **1. INTRODUCTION**

### **1.1 The Project**

The ACIAR Fisheries Program is considering a project proposal aimed at investigating the development of the pearl oyster resources in the South Pacific. The collaborating institutions in Australia developing the proposal are James Cook University (JCU); Queensland Department of Primary Industry (QDPI/OVL); Queensland University of Technology (QUT); and in the South Pacific, the Ministry of Marine Resources, Cook Islands; Ministry of Natural Resources Development, Kiribati and the South Pacific Commission (SPC), Noumea.

### **1.2 Project Objectives**

The production of cultured pearl shell and pearls has become an expanding industry in the South Pacific region. These activities are seen by many countries as an appropriate development industry for remote island communities where the products are non-perishable, high-value, easily transportable and labour-intensive. While many atoll lagoons are able to support pearl oyster production, previous periods of overexploitation have reduced wild stocks to unsustainable levels to support the commercial production. As such, stocks need to be re-established or supplemented from wild and cultured stocks in other regions for the development of the industry to occur.

To assist the development of the cultured pearl oyster industry in countries of the South Pacific region, an investigation into a wide range of activities associated with mother-of-pearl shell and cultured black pearl production is proposed. The objectives of the proposal as indicated in the Phase 2 document are:

- (i) To assess the natural stocks and spatfall (newly-settled juveniles) of blacklip pearl oysters in the atoll lagoons of selected Pacific Island countries.
- (ii) To develop a low-technology method for hatchery culture and select a suitable method for nursery culture.
- (iii) To identify the diseases etc of blacklip pearl oysters and recommend appropriate prevention and control measures.
- (iv) To improve the yields of gem-quality and average-quality pearls through better bead insertion and oyster management practices.
- (v) To describe the genetic resources of blacklip pearl oysters in selected Pacific Island countries.

The details of the proposed research are contained in the Phase 2 project documentation and are not repeated in detail here. It can be noted the objectives are, in general, quite broad and encompass a wide range of activities associated with all aspects of pearl production. As such, the technical impacts of the research are not clearly apparent. Subsequent discussions with scientists

involved with the proposal identified several potential impacts of the research. These are discussed in more detail in section 2.

The remainder of the paper is devoted to, firstly, outlining the current status of pearl and pearl shell production in the countries of interest, and secondly, describing the framework and assumptions used to estimate the potential benefits from the proposed research. Finally, the results of the analysis are discussed and the sensitivity of these results to variations in selected parameters is assessed.

### **1.3 Blacklip Pearl and Mother-of-Pearl Shell Production and Exports**

The two primary countries in the South Pacific involved with the proposed research are Cook Islands and Kiribati. The Cook Islands have already adopted the technology to produce pearls while Kiribati is yet to produce commercial quantities of pearl shell, this being the first stage of developing a capacity to produce pearls.

The majority of world pearl and mother-of-pearl shell production is exported, primarily to Japan which accounts for over 90% of imports in the first instance. While information is readily available for imports of pearls to Japan, world production information is generally not. Japan, while being the major purchaser of pearls, is also the major producer in the world, culturing 71.6 tonnes of pearls in 1988 (out of world production of approximately 90 tonnes). Table 1 lists production and value of production for cultured freshwater and saltwater pearls in Japan from 1980 to 1988.

The Pacific island countries, including Australia, contributed 60% of imports to Japan by value but only 6% by weight in 1988. The value of imports increased to 69% in 1989 while the contribution of weight remained steady. Of all the pearls, the majority are from goldlip oysters but production from blacklip oysters is increasing. Table 2 lists pearl imports to Japan by country of origin for 1988 and 1989.

The first stage of developing a pearl industry is establishing a large self-sustaining population of pearl oyster shell. This is the primary aim of the research in Kiribati. 'Natural stocks are often enhanced through collection and aggregation by divers and/or by the use of spat collectors' (McElroy 1990). Suspended culture techniques are used to enhance growth and survival and are a proven technique for blacklip oysters in the Pacific. Pearl oyster cultivation to this first stage yields valuable shell, primarily used to make natural buttons, but also for inlay work in furniture.

Fishery data from FAO (1991) indicates pearl oyster shell production of 390 tonnes in 1988, the main producers being Australia, Japan and Fiji. However, Philipson (1988) indicates approximately 6,000 tonnes of MOP shell is harvested annually worldwide, of which 1,500 tonnes comes from the Pacific region and PNG. This includes production from both goldlip and blacklip pearl oysters. Philipson (1988) lists Philippines, Indonesia and Cook Islands as the major shell exporters and Japan and Korea the primary importers. From this, it is apparent that there is an element of inconsistency between the various sources of production, export and import information.

With the focus of the research on production of pearls and shell in Cook Islands and Kiribati, it is necessary to have information on the domestic production of these commodities. However, this is not currently available for these countries. Information is available on pearl and shell exports for the

Cook Islands while no information is available for Kiribati. As the majority, if not all, pearl and shell production is exported, then it is reasonable to assume

**Table 1.** Production of pearls in Japan

Year	Freshwater Pearls mt	Saltwater Pearls mt	TOTAL mt	Value \$USm
1980	6.3	42.0	48.3	223
1981	6.0	46.0	52.0	248
1982	6.1	52.0	58.1	208
1983	6.0	58.0	64.0	266
1984	6.0	64.0	70.0	289
1985	4.0	62.0	66.0	251
1986	2.4	67.0	69.4	323
1987	2.2	66.0	68.2	361
1988	1.6	70.0	71.6	482

Source: McElroy (1990)

**Table 2.** Pearl imports to Japan from country of origin

Country	1988				1989			
	kg	%	\$US '000	\$/kg	kg	%	\$US '000	\$/kg
<u>South Pacific</u>								
Australia	1,072	4.6	45,687	42,618	1,231	4.3	70,063	56,916
French Polynesia	314	1.3	25,116	79,987	505	1.8	41,084	81,354
New Caledonia	21	0.1	1,799	85,667	6	0.0	485	80,833
Tonga	1	0.0	161	161,000	-	0.0	-	-
Cook Islands	-	0.0	-	-	21	0.1	799	38,048
TOTAL	1,424	6.1	74,265	52,152	1,769	6.2	112,424	63,552
<u>Others</u>								
Indonesia	341	1.5	8,566	25,120	517	1.8	11,764	22,754
Hong Kong	9,414	40.1	11,377	1,209	14,766	52.1	11,510	779
USA	208	0.9	9,113	43,813	702	2.5	9,711	13,833
China	10,200	43.5	8,327	816	8,031	28.3	5,904	735
Philippines	82	0.3	5,150	62,805	107	0.4	3,986	37,252
India	274	1.2	2,424	8,847	340	1.2	2,588	7,612
Taiwan	988	4.2	429	434	1,811	6.4	1,137	628
TOTAL	23,450	100.0	123,501	5,627	28,363	100.0	162,284	5,722

Source: McElroy (1990)

export data is a close approximation of the current level of domestic supply. Exports of pearls and shell for the Cook Islands are listed in Table 3. For the purpose of the analysis, it is necessary to estimate the potential production for Kiribati resulting from the research since no commercial quantities are currently produced. This procedure is discussed in section 2 with the framework and the assumptions for the analysis.

The two developing countries collaborating in the project are considered small in population and size of GNP, not only by world standards, but also in relation to other South Pacific countries. While controlling large areas of marine resources, other natural resources such as land are scarce. This is reflected in the low GNP, which at current prices in 1988, was \$A39 million for the Cook Islands and \$A51 million for Kiribati (AIDAB 1990). With a population of approximately 20,000 for Cook Islands and 70,000 for Kiribati, GNP per capita was \$A1,773 and \$A729 respectively. The GNP per capita for Kiribati is one of the lowest for any country in the Pacific region.

## **2. FRAMEWORK AND ASSUMPTIONS FOR BASE CASE**

### **2.1 Economic Surplus Framework**

A simple economic surplus framework is used for the analysis. This assumes a linear demand and supply curve where the research results in technology that lowers the costs of production, shifting the supply curve down and to the right. It is assumed the supply shift is parallel and demand is static. Benefits of the research are measured by the change in economic surplus.

### **2.2 Application of Framework to Pearl Oyster Research**

Discussions with scientists involved with the proposal assisted in identifying two areas of potential impacts as a result of the new technology. These have been summarised in the following:

- (i) The improved availability of juveniles and oysters for culture through stock aggregation to improve spawning and spat collection. Techniques are also developed to enhance population building of the wild stocks. For areas where wild stocks have been overexploited or lagoon conditions are not conducive to spawning or spatfall, the impact of this research would be noted in reduced costs for obtaining juveniles for culture.
- (ii) Improving the yield by increasing the number of shells harvested. This is achieved through an impact on the method of production through improving the surgical implanting techniques that reduce the mortality of the oyster and/or rejection of the bead.
- (iii) Improving the yield through increasing the harvested shell:pearl conversion ratio ie increasing the number of pearls obtained per harvested oyster achieved through improved information on the genetic stock, disease and disease control, and improved husbandry and cultural techniques.

**Table 3.** Exports of pearls and pearl shell from Cook Islands

Year	Pearl kg	Shell kg
1985	1.0	13,973
1986	-	74,041
1987	-	107,088
1988	-	50,227
1989	26.0	71,404
1990	84.0	43,496
1991	40.3	-

Source: Ministry of Marine Resources, Cook Islands

The assumed impacts of the research have different effects in each country. For Kiribati, improving the access to juveniles for culture has a significant effect through removing a major constraint and allowing the culture of shells to become viable. Previously, the cost of obtaining stocks to culture restricted the development of the industry whereas it is assumed the research results in reducing the cost of obtaining juveniles to culture. The initial impact for Kiribati would be for production to become viable under pre-research production techniques with the improved access to juveniles. Additionally, new producers in Kiribati would also gain the benefits from improving the culture techniques as indicated in (ii) and (iii).

For the Cook Islands where the technology for producing pearls has already been adopted, the research resulting in the impacts of potential yield increases described in (ii) and (iii) is more significant to production. These different cases result in different cost impacts and subsequently, different research benefits to be estimated for each country.

The impacts of the research on the costs of producing pearls in each country are described in detail in the next section.

### **2.3 Cost Analysis and Assumptions**

A critical component in estimating the potential research benefits is determining the impact of the new technologies on the cost structure for producing pearls and pearl shell. Unlike crops and many livestock enterprises where costs and returns occur in the same period, pearl production is more like tree crops and forestry activities where there is a cost stream over time. It is necessary to compound the cost stream to present costs in current dollar terms. In addition, there are various combinations of activities that can occur, from spat collection, ongrowing to pearl production. For this analysis, it is assumed that the pearl farming activities include ongrowing and pearl culture, and that this process takes a period of five years. A summary of the activities that occur over this period is listed in Table 4.

With these annual activities as a guide, a cost analysis for pearl production without the research is estimated based on the following assumptions.

- (i) The cost analysis is estimated for 1000 shell units, these being the initial number of juvenile shells cultured.
- (ii) Activities are divided into ongrowing and pearl culture. It is assumed that juveniles are purchased from other sources.
- (iii) Ongrowing costs include the initial purchase of juvenile oysters for \$1.00 each for Cook Islands producers, \$1.50 per juvenile shell for materials such as wire ropes to hang the oysters and \$1.50 per juvenile shell for labour and operating costs for annual maintenance (e.g. shell cleaning). Potential Kiribati producers would be faced with a cost of obtaining juveniles to culture of \$3.00 per shell. This reflects the current scarcity of suitable oysters and the extra effort required to obtain oysters to culture. These costs are calculated for the initial 1000 juvenile shells purchased. The oyster purchase costs and material costs occur in Year 1 while the ongoing maintenance costs occur in Year 1 and 2.



**Table 4.** Pearl production activities

Year	Activity	Output
1	<b>ONGROWING</b>	
	Juvenile purchase	
	Juvenile rearing	
2	Juvenile rearing	
3	<b>PEARL CULTURE</b>	
	Mother shell preparation	
	Nuclei insertion	
	Pre-culture (inspection of nuclei)	Sale of dead/rejected shell
4	Main culture	
5	Main culture	
	Harvest	Pearls Shell

- (iv) The pearl culture activities occur in Year 3 when the oyster has reached a sufficient size. Preparation and grafting/implanting activities occur on all shells. It is assumed there are no losses over the two-year growing out phase and 1000 shells are prepared and implanted.
- (v) Preparation prior to implanting involves a total cost of \$2.00 per shell.
- (vi) Implanting of the nuclei bead involves a cost of \$1.50 for the bead and mantle material for each shell and \$3.50 for the technician completing the implanting operation. All shells are implanted.
- (vii) As a result of the implanting operation, losses occur. It is assumed that losses from mortality or rejection total 55% (mortality 20% and rejection 35%). The remaining 450 shells are cultured until harvest in Year 5.
- (viii) It is assumed the shells lost as a result of the implanting operation are sold as mother-of-pearl shell in Year 3 where these shells weigh 250 grams each. While it is noted this is not necessarily the case where oysters rejecting beads are normally re-implanted, the assumption is a simplifying one for the purpose of the analysis.
- (ix) The surviving implanted shells require maintenance until harvesting (ie shell cleaning), costing \$1.00 per shell. The number of shells this applies to is 450 for years 3, 4 and 5.
- (x) These shells are harvested in Year 5, costing \$1.00 per shell.
- (xi) Of the harvested shells, it is assumed that 20% contain pearls, of which 5% are of gem quality and 15% consist of other pearls of saleable quality. With 450 harvested shells, the number of pearls harvested totals 90.
- (xii) The average weight for each pearl is assumed to be 2 grams, where total pearl production without research is 0.18 kg for the initial 1000 juveniles cultured.
- (xiii) The remaining mother-of-pearl shell from the harvested shells is sold in Year 5. It is assumed the shells have grown further to weigh 350 grams each. Total shell production is 295 kg, consisting of 137 kg of mother-of-pearl shell in Year 3 and 158 kg in Year 5.
- (xiv) Price per kg of pearl is assumed to be \$A75,000, and \$A10.00 per kg of pearl shell.
- (xv) The cost allocation assumption is based on output of shell in Year 3 and 5 as the proxy indicator of the implicit allocation of resources between shell and pearl components of production.

Tables 5 and 6 indicate the resulting production costs for pearl prior to the research for Cook Islands and Kiribati respectively. From this, the impacts of the research on the costs are determined. The following production and cost alterations are assumed to occur where the Cook Islands and Kiribati have the same after-research production costs.



## (4) UNIT COSTS

Per Kg Shell	: SHELL	295 kg	\$12.72
Per Kg Pearl	: PEARL	0.18kg	\$71,294

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Per Kg Shell	: SHELL	295 kg	\$16.71
Per Kg Pearl	: PEARL	0.18kg	\$78,784

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- (i) the cost for juvenile oysters for Kiribati falls from \$3.00 per oyster to \$1.00 per oyster. Stock aggregation and population enhancement techniques are assumed to make juvenile oysters more available.
- (ii) The implanting cost increases 50% from \$3.50 to \$5.25. While the time taken to complete the implanting operation increases, the labour unit costs significantly decrease as foreign technicians are replaced by domestically-trained technicians.
- (iii) The proposed new implanting technique requires additional inputs such as chemicals (ie anaesthetic, disinfectant) and disposable materials (ie sutures, needles, syringes). The additional cost for these inputs is \$2.00 per oyster.
- (iv) The new implanting techniques and improved information on the oyster are assumed to reduce the bead rejection/mortality of the shell after implanting and increase the number of pearls per harvested oyster. Rejection/mortality drops from 55% to a total loss of 30% resulting in a larger number of oysters being harvested, while the number of saleable pearls increases from 15% of harvested oysters to 30% (where the number of harvested oysters has increased).
- (v) As a result of the new innovations, production for the 1000 shell units used for the analysis increased to 0.42 kg of pearls (from 210 pearls) and 320 kg of shell.

The cost adjustments with the research are presented in Table 7 and are applicable to both Cook Islands and Kiribati.

#### **2.4 Joint Products and Cost Allocation**

Costs are allocated based on the weight ratio of shell sales in Year 3 and Year 5 where the emphasis in the first two years is on shell production and the later years on cultured pearl production. The emphasis in the first years alters with the technology as more shells survive and are available for pearl production, justifying the reduced allocation of costs to shell production in the first two years. Table 5 to 7 indicate the allocation of costs between pearl and shell for each year.

#### **2.5 Production and Estimation of Potential Production**

For Cook Islands, exports of pearls and MOP shell are used as an indicator of production without research. For pearls, exports averaged 50.1 kg annually for the period 1989-91. Assuming a pearl weight of 2 grams per pearl, this indicates approximately 25,000 pearls were exported annually. With 20% of harvested oysters producing saleable pearls, this required approximately 125,000 oysters to be harvested annually. Passfield (1992) indicates 600,000 shells are being farmed in the Cook Islands. Given a 5-year production cycle, this equates to an annual harvest of 120,000 shells which is close to the estimate indicated by the assumed number of pearls sold.

The research is expected to overcome current production constraints and reduce costs sufficiently for production to be viable at current prices. As such, it is necessary to estimate the level of production that is expected to occur. Since no production is currently recorded



## (4) UNIT COSTS

Per Kg Shell	: SHELL	320 kg	\$6.38
Per Kg Pearl	: PEARL	0.42kg	\$47,148

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for Kiribati, this is crucial for the analysis of potential benefits. Additionally, it is assumed production in Cook Islands will expand from the one atoll (Manahiki) currently being used to culture oysters.

To estimate potential production, the number of additional atolls available were listed. Their suitability to oyster culture was determined and the atolls were classified as 'good', 'medium' or 'poor'. This was based on a number of characteristics such as the availability of food and the water interchange characteristics of the lagoon. The atolls classed as 'good' were determined to have a culturing capacity of 100,000 oysters, of which 20,000 were harvested annually. Four atolls in Kiribati and two in the Cook Islands were assumed to be in this category. The medium-type atoll was considered to be less productive and could only support approximately 25,000 oysters to be cultured. With 13 atolls in Kiribati considered to be in this category, the total number of shells cultivated was assumed to be 325,000, of which 65,000 were harvested annually.

Potential production of pearls was estimated at 58 kg for Kiribati and 24 kg for Cook Islands. This is in addition to the 50.1 kg currently cultured in the Cook Islands. Shell production was assumed to total 36,250 kg for Kiribati. Shell production for the Cook Islands was estimated at 15,000 kg in addition to the 55,000 kg already produced.

## **2.6 Cost of Research**

The project proposal indicated the estimated total cost of the research from all institutions would be \$A1.8 million. Of this, \$A932,926 would be provided from ACIAR funds while the collaborating institutions (including the developing country institutions) would contribute \$A866,189. The project is expected to be completed in 3 years.

## **2.7 Other Parameters**

### **2.7.1 Supply and demand elasticities**

With a production period of 5 years for pearls and 2-3 years for shell, supply is considered to be relatively inelastic. An estimate of 0.4 has been used in the analysis. With production contributing a small proportion of total world production of cultured pearl oysters, demand elasticity is assumed to be relatively elastic. An estimate of -1.5 is used.

### **2.7.2 Ceiling level of adoption and adoption pattern**

Adoption of the new technology by the current producers is assumed to commence in the Cook Islands in Year 9 which is 6 years after the proposed completion of the research. Adoption takes four years to reach the ceiling level of adoption, which was estimated at 70%. The adoption pattern is as follows: 20% in the first year of adoption (ie Year 9), 40% in the second, 60% in the third and 70% in the fourth.

The commencement of adoption is staggered for other production areas, depending on the capacity of the production environment and the current status of the industry in the country. For example, adoption in currently-producing areas of the Cook Islands commences in Year 9 while other

potential areas commence two years later in Year 11. On the other hand, in Kiribati where there is no commercial production, initial adoption in the more favourable production areas commences in Year 11 while the less suitable areas are a year later.

### 2.7.3 Price

Pearls are a high-value commodity. The price of pearls used in the analysis is \$A75,000 per kg. This is based on a weighted average of the average price received by South Pacific countries (including Australia) for 1988 and 1989. With pearls weighing approximately 2 grams each, this is equivalent to approximately \$A150 per pearl (or \$A75 per gram).

Mother-of-pearl shell is primarily used for buttons, and to a lesser extent, as inlay in furniture. The price currently received by the producer is \$A10 per kg. This is equivalent to \$A2.50 for the 250 gram shells and \$A3.50 for the 350 gram shells.

### 2.7.4 Compound rate and discount rate

With pearl and shell production, costs and income items occur over a 5-year period. With the cost benefit analysis, it is necessary to express the costs and income items in constant year dollar terms. This requires cost and income items to be compounded into the current year dollar terms. The compound rate used for this purpose is 6%.

A key issue in cost benefit analysis is how to express future cost and benefit streams in current values. The common practice is to discount future values by an appropriate discount rate. While numerous factors affect the rate selected, to maintain a consistency, the benchmark discount rate recommended by the Department of Finance for cost benefits analyses conducted by government organisations is used. The benchmark discount rate recommended is 8% and is the discount rate used in this analysis.

## 3. RESULTS OF THE BASE CASE ASSESSMENT

### 3.1 Estimation of Annual Benefits

Annual benefits resulting from the research are estimated using the following formula:

$$AB = kQ_{so} + \frac{e_d e_s k^2 Q}{2P(e_s + e_d)}$$

where:

$AB$  is the annual benefits

$k$  is the unit cost reduction

$Q_{so}$  is the quantity supplied before research



$e_d$	is the price elasticity of demand
$e_s$	is the price elasticity of supply
$P$	is the price before research

Before the annual benefits can be estimated, it is necessary to calculate the unit cost reduction,  $k$ , resulting from the research.

Tables 5 and 6 indicate the 'without' research cost analysis for pearl and shell production. Costs occur over 5 years and are compounded to current dollars. The allocation of costs between pearl and shell production for each year is indicated at the bottom of the table by the cost allocation row. This shows total costs in current dollars of \$A16,584 per 1000 juveniles cultured in Year 1 for Cook Islands and \$A19,109 for Kiribati. Given the cost allocations assumed, the resulting unit cost per kilogram of pearl is \$A71,294 for Cook Islands and \$A78,784 for Kiribati. With a price of \$A75,000 per kilogram for pearls, the estimated unit production costs for Kiribati exceed the unit price, confirming the current situation with no commercial production. The unit cost per kilogram of shell is \$A12.72 for Cook Islands and \$A16.71 for Kiribati.

With research, there is a reduction in the post-implanting mortality/rejection and an increase in the number of saleable pearls. Table 7 indicates the cost impacts resulting from the research which are applicable to both Cook Islands and Kiribati. While based on 1000 juvenile shells being initially cultured, a greater number of shells are harvested. The major changes to costs include a 50% increase in the cost of the implanting operation and the added expense of chemicals and materials for this operation. Note that this cost increase is applicable to all 1000 shells implanted. In addition, with the number of shells surviving the implanting operation, a greater number of shells reach harvesting in Year 5, adding to the post-implanting labour, operating and harvesting costs. The resulting total costs for the 1000 juvenile shells cultured in current dollar terms is \$A21,811. In addition, with the changing emphasis to pearl production, the shift of resources to pearl production is noted in a change in the cost allocation assumptions. The unit cost of production with research is \$A47,148 per kilogram of pearl and \$A6.38 per kilogram of shell.

The resulting unit cost reduction from the research for Cook Islands is \$A24,146 per kg of pearl. As the unit cost of production for pearls in Kiribati before the research is greater than price, it is necessary to take account of the difference exceeding the price when calculating the unit cost reduction. The subsequent unit cost reduction for pearls is \$A27,852.

As the unit cost per kilogram of shell for both countries exceeds the assumed price, the estimated unit cost reduction for shell in both countries takes account of the shell price. This results in an estimated unit cost reduction of \$A3.62 per kilogram of shell.

Given the assumptions relating to production ( $Q$ ), the adoption patterns and ceiling levels for each production area and the unit cost reduction estimates ( $k$ ) for pearl and shell, the annual benefits to Cook Islands from the research totals \$A1,503,790. Over 87% of the benefits are from the research impacts on costs allocated to pearl production. For Kiribati, the estimated benefits are

based totally on estimated production levels assumed to occur as a result of the research. At the ceiling level of adoption, the annual benefits total \$A1,294,214, of which 93% is attributable to the reduction of costs allocated to pearl production.

While meat is a by-product of pearl and shell production, no estimate is made of any benefits attributed to this aspect of the production process.

### **3.2 Flow of Benefits and Costs**

Table 8 presents the flow of research costs and benefits for each production environment in the Cook Islands and Kiribati after taking account of the adoption pattern and ceiling level of adoption. Costs occur during the first three years while the benefit flows commence in Year 9 in the Cook Islands, followed by a staggered adoption by the other regions. The net benefit flow peaks in Year 15, amounting to an annual benefit of \$A2,798,006.

### **3.3 Net Present Value of Benefits and Internal Rate of Return**

The net present value (NPV) is the value of a future stream of net benefits in current dollar terms for a given discount rate. The discount rate used in this analysis is 8%, resulting in a positive NPV of \$A10.4 million from the estimated benefit stream for the proposed research.

The internal rate of return (IRR) is the discount rate that results in the project having a zero net present value. Generally, project selection using this criterion suggests if the IRR is greater than the interest rate, the project is acceptable. The analysis indicates an IRR of 24%.

It is important to highlight the fact that the estimates for NPV and IRR are based on potential production for new regions. More critically, the estimated benefits for Kiribati are based solely on estimates of the potential production. If the potential production does not eventuate for Kiribati, the resulting IRR would be 17% and the NPV of research benefits would total \$A3.53 million. The benefits accruing to Kiribati would be zero. It is critical to obtain evidence to support the estimates of potential production in these countries.

To identify how robust the estimates used in the analysis are, it is necessary to assess the sensitivity of the NPV and IRR to variations in selected parameters considered to have an important impact on the results. A summary of the results of the sensitivity analysis is reported in section 4.

## **4. SENSITIVITY OF RESULTS**

### **4.1 Cost Allocation**

With the joint product nature of pearl production, it is ideal to allocate costs between pearl, shell and meat production. This is further complicated by the 5-year production cycle. With limited information, costs are assumed to be allocated according to the production of pearl shell at different stages of the 5-year production cycle. It is important to assess the impact of changes in

this assumption which reflects the emphasis between pearl and shell production at particular stages in the production cycle. The allocation of costs to meat production is

**Table 8.** Flow of benefits and costs

Year	Costs		Adoption Cook Is	Gross Benefits				Adoption Kiribati	Gross Benefits				Net Benefits
	ACIAR	Other		Cook Is (current)		Cook Is. (good)			Kiribati (good)		Kiribati (medium)		
				Shell (\$)	Pearl (\$)	Shell (\$)	Pearl (\$)		Shell (\$)	Pearl (\$)	Shell (\$)	Pearl (\$)	
1	288,407	298,522	0	0	0	0	0	0	0	0	0	0	(586,929)
2	341,582	298,692	0	0	0	0	0	0	0	0	0	0	(640,274)
3	302,937	268,975	0	0	0	0	0	0	0	0	0	0	(571,912)
4			0	0	0	0	0	0	0	0	0	0	0
5			0	0	0	0	0	0	0	0	0	0	0
6			0	0	0	0	0	0	0	0	0	0	0
7			0	0	0	0	0	0	0	0	0	0	0
8			0	0	0	0	0	0	0	0	0	0	0
9			0.2	42,129	254,248	0	0	0	0	0	0	0	296,378
10			0.4	84,259	508,496	0	0	0	0	0	0	0	592,755
11			0.6	126,388	762,745	11,481	121,796	0.2	15,308	188,706	0	0	1,226,424
12			0.7	147,453	889,869	22,962	243,591	0.4	30,616	377,412	12,438	153,324	1,877,665
13			0.7	147,453	889,869	34,443	365,387	0.6	45,924	566,118	24,876	306,647	2,380,718
14			0.7	147,453	889,869	40,184	426,284	0.7	53,578	660,471	37,314	459,971	2,715,125
15			0.7	147,453	889,869	40,184	426,284	0.7	53,578	660,471	43,532	536,633	2,798,006
16			0.7	147,453	889,869	40,184	426,284	0.7	53,578	660,471	43,532	536,633	2,798,006
17			0.7	147,453	889,869	40,184	426,284	0.7	53,578	660,471	43,532	536,633	2,798,006
18			0.7	147,453	889,869	40,184	426,284	0.7	53,578	660,471	43,532	536,633	2,798,006
19			0.7	147,453	889,869	40,184	426,284	0.7	53,578	660,471	43,532	536,633	2,798,006
20			0.7	147,453	889,869	40,184	426,284	0.7	53,578	660,471	43,532	536,633	2,798,006
21			0.7	147,453	889,869	40,184	426,284	0.7	53,578	660,471	43,532	536,633	2,798,006
22			0.7	147,453	889,869	40,184	426,284	0.7	53,578	660,471	43,532	536,633	2,798,006
23			0.7	147,453	889,869	40,184	426,284	0.7	53,578	660,471	43,532	536,633	2,798,006
24			0.7	147,453	889,869	40,184	426,284	0.7	53,578	660,471	43,532	536,633	2,798,006
25			0.7	147,453	889,869	40,184	426,284	0.7	53,578	660,471	43,532	536,633	2,798,006
26			0.7	147,453	889,869	40,184	426,284	0.7	53,578	660,471	43,532	536,633	2,798,006
27			0.7	147,453	889,869	40,184	426,284	0.7	53,578	660,471	43,532	536,633	2,798,006

28	0.7	147,453	889,869	40,184	426,284	0.7	53,578	660,471	43,532	536,633	2,798,006
29	0.7	147,453	889,869	40,184	426,284	0.7	53,578	660,471	43,532	536,633	2,798,006
30	0.7	147,453	889,869	40,184	426,284	0.7	53,578	660,471	43,532	536,633	2,798,006

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assumed to be zero for the analysis.

#### **4.2 Mortality/Rejection and Pearl Production**

Two important potential impacts the research aims to achieve are to reduce the loss of shells as a result of the implanting procedure and increase the number bearing saleable pearls. The base case analysis assumes a combined reduction of mortality/rejection of 45% and an increase in the number of saleable pearls harvested by 50%, resulting in an IRR of 24% and NPV of \$A10.4 million. Table 9 indicates different combinations of the two parameters, suggesting a degree of sensitivity in the results if the research does not achieve the assumed impacts. If only a 20% decrease/increase in mortality/rejection and number of pearls is achieved, IRR falls to 9% and NPV declines significantly to just \$A400,000. This is based on the assumption that implanting costs also increase 50%. However, if they significantly increase, the effect of not achieving the desirable impact is more noticeable as indicated by the sensitivity analysis presented in Table 10. This uses an implant cost of \$A10.50 per shell. The sensitivity that results is due to the fact that all shells need to be implanted and if fewer pearls and shell are produced, then the initial costs have to be borne over a smaller amount of output. This results in a lower unit cost reduction, and more likely, a unit cost increase as Table 10 indicates. This highlights the importance of achieving the desired impacts on these parameters for the viability of the research as well as the significance of the implanting costs.

#### **4.3 Lag to Adoption**

An important parameter influencing the viability of projects is the lag period to adoption. The sensitivity analysis of this shows that extending the period to adoption has detrimental effects on the criterion used to assess the worth of the proposal. The analysis shows that, for each extension of the lag period by two years, the IRR falls approximately 3 percentage points. Currently, it is assumed benefits accrue from Year 9, where this is staggered for each country and region. This may be optimistic given the long production period for pearls, and, to a lesser extent, pearl shell.

#### **4.4 Ceiling Level of Adoption**

Another uncertain parameter that influences the viability of the proposed project is the ceiling level of adoption. Reducing the ceiling level of adoption results in the IRR falling. For example, if the adoption ceiling falls to 30% of producers the IRR drops to 17%. The combined effects of a lower adoption ceiling and an extension of the lag period should also be assessed considering the optimistic estimates for these parameters currently used.

#### **4.5 Comment on Overall Sensitivity**

The parameters the research are focused on, namely the level of mortality/rejection after the implant operation and the number of saleable pearls (through genetic improvement, culture techniques and disease control etc), are those that show the greatest sensitivity to variation. If the suggested research impacts are not achieved, the level of benefits using the current base case assumptions is likely to be significantly reduced. It is also necessary to highlight the underlying impact of the

implanting costs to the sensitivity of the analysis, especially where all shells bear this cost but the output this is spread across is potentially highly variable.

**Table 9.** Sensitivity to changes in both mortality/rejection and pearl production (Based on implant cost of \$5.25/shell)

IRR		Decrease in Mortality/Rejection				
		10%	20%	30%	40%	50%
Increase in Pearl Production	10%	-	-	9	14	17
	20%	-	9	15	18	20
	30%	9	15	18	20	22
	40%	14	18	20	22	23
	50%	17	20	22	23	25

  

NPV (\$m)		Decrease in Mortality/Rejection				
		10%	20%	30%	40%	50%
Increase in Pearl Production	10%	-	-2.1	0.15	2.1	3.9
	20%	-2.1	0.4	2.5	4.4	6.1
	30%	0.2	2.5	4.6	6.4	7.9
	40%	2.1	4.4	6.3	8.1	9.6
	50%	3.9	6.0	7.9	9.6	11.0

  

Unit Cost Reduction (pearl) Cook Islands		Decrease in Mortality/Rejection				
		10%	20%	30%	40%	50%
Increase in Pearl Production	10%	-	-3580	1118	5085	8486
	20%	-2532	2660	6966	10603	13720
	30%	3147	7939	11914	15271	18149
	40%	8014	12465	16156	19273	21945
	50%	12233	16387	19832	22741	25235

**Table 10.** Sensitivity to changes in both mortality/rejection and pearl production (Based on implant cost of \$10.50/shell)

IRR		Decrease in Mortality/Rejection				
		10%	20%	30%	40%	50%
Increase in Pearl Production	10%	-	-	-	-	-
	20%	-	-	-	-	3
	30%	-	-	-	5	13
	40%	-	-	4	13	17
	50%	-	-	12	16	19

  

NPV (\$m)		Decrease in Mortality/Rejection				
		10%	20%	30%	40%	50%
Increase in Pearl Production	10%	-	-	-	-	-
	20%	-	-	-	-	-
	30%	-	-	-	-0.6	1.5
	40%	-	-	-0.7	1.5	3.4
	50%	-	-	1.2	3.4	5.2

  

Unit Cost Reduction (pearl) Cook Islands		Decrease in Mortality/Rejection				
		10%	20%	30%	40%	50%
Increase in Pearl Production	10%	-35792	-27500	-20000	-	-
	20%	-26868	-	-	-	-3231
	30%	-19317	-12318	-6531	-1660	2502
	40%	-12845	-	-972	3551	7416
	50%	-7235	-1170	3846	8067	11674

## 5. OTHER POINTS TO NOTE

When considering the proposal and the subsequent analysis, the following points should be noted.

- Spillover of benefits to other similar environments in other countries, ie other lagoons with potential pearl production capacity, have not been included, potentially underestimating the benefits. This is noted in particular with production of other types of pearls using similar techniques.
- With the slow development of skills in implanting using non-Japanese labour, the adoption of techniques requiring skilled labour would have to be investigated. This may impact on the ceiling level of adoption, the lag period but more importantly, the cost of implanting currently assumed. Any problems relating to the training of labour and acquiring of sufficient implanting skills would add to the lag period and reduce the ceiling level of adoption, thus reducing the IRR and NPV of the proposal. Additionally, if domestic technicians cannot be trained, the labour costs attributed to implanting would rise and have detrimental impacts on the analysis.
- The broad nature of the project's objectives raises questions of whether a three-year project is sufficient to investigate all the issues. This is compounded further by the production cycle for pearls being up to 5 years.
- The issue of public versus private research needs to be considered given the 'monopoly' Japanese technicians have on certain aspects of the production and marketing process. This is only slowly being removed.
- Finally, it should be highlighted that the increase in production of shell and pearl for the countries is valued at over \$A2.0 million for Cook Islands and \$A4.8 million for Kiribati. This suggests an increase in GNP of 5-10% for these countries through the impacts of one research project, where there is a degree of uncertainty in relation to the feasibility of such a large rise in GNP.

## 6. CONCLUDING COMMENTS

The analysis has shown the proposal to potentially result in a reasonable return for the proposed investment of funds. However, caution is necessary in interpreting the results which are for a given set of assumptions. Some of these impacts are based on judgements made by the scientists and should be treated as 'best guesstimates' at this stage. The sensitivity analysis has shown that the project becomes less attractive for small changes in certain parameters, in particular the mortality/rejection and number of saleable pearl assumptions. The importance of achieving the impacts assumed in the analysis cannot be understated.

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