



Manihiki Atoll black pearl farm census and mapping survey

*Ben Ponia, Tangi Napara, Martin Ellis & Ravengakore Tuteru
Ministry of Marine Resources, Rarotonga, Cook Islands ¹*

Abstract

Pearl farming in the Cook Islands is based on cultivating the black-lip pearl oyster and is presently centred at Manihiki Atoll. Cultured pearls are the nation's most valued export, officially worth NZ\$ 5 million in 1998 and accounting for 84 per cent of total exports. In view of the importance of this industry there is a need to ensure its sustainability. Two limiting factors affecting the capacity of Manihiki Lagoon for farming are: 1) the number of pearl shell should not exceed the natural levels of food production, and 2) the space or depth strata available for farming.

This survey has calculated the number of cultivated adult pearl shell at 1.5 million oysters. One quarter (24%) of the pearl shell is in pre-seeded conditioning phases while most (65%) are seeded. The total number of cultured adults has increased from 520,000 oysters in 1991 to 880,000 oysters in 1996. Similarly, the number of pearl shell per farm has increased. For instance in 1996 only five per cent of the farms recorded 20,000 to 50,000 oysters, at present this range is attributed to 20 per cent of the farms. In addition the percentage of farms exceeding 50,000 oysters has doubled from three to six per cent.

Approximately 1.1 million spat (pearl oyster juveniles) are being cultivated on spat collectors. However there is a disproportionate distribution of spat among the farms, with the majority of farms (93%) possessing less than 13,000 spat or no spat. The peak in spat population was recorded in 1996 when 3.5 million spat were estimated. It is suggested that the pearl farming industry should develop a spat collection niche in order to moderate future spat supply and prices.

This survey recorded 111 farms with a total of 690 culture lines and 424 spat collection lines. The total length of these farm lines is 160 kilometers. The farms cover seven square kilometres compared to 9 square kilometres reported at 164 farms in 1996. The reduction in pearl farms is attributed to the impact of Cyclone Martin in 1997. Presently, farm areas account for 30 per cent of the depth strata where pearl farming is feasible, i.e. the 10 to 30 meter depths.

It is estimated that the annual production from Manihiki is on the order of NZ\$ 12 million dollars or 250,000 pearls. Considering that the official statistics for export value in 1998 was only NZ\$ 5 million, it is thought that exports may be underreported by a factor of 50 per cent. The growth trend suggests that by the year 2003 there will be 2 million cultured adult shell and annual production of NZ\$ 18 million.

1. P.O. Box 85; Tel: (682) 28721; Fax: (682) 29721; E-mail: rar@mmr.gov.ck; Website: www.mmr.gov.ck

The ecological sustainability of the pearl industry has good prospects provided the whole lagoon is managed as one unit. This is logical given that the degradation of one farm will eventually affect all other farms. The proper use of the space for pearl farming, if done correctly, should allow for the forecast expansion to two million oysters without having to degrade the lagoon environment. Presently there is some frustration among pearl farmers because the allocation of farm areas is not properly managed. For example, some farmers are being forced to overstock oysters in their areas because they cannot expand farm boundaries. This is due to encroachment from neighbouring farms that are not properly utilising the space already available to them. In addition, new farmers or farmers who wish to relocate to a new area are often unsure of which areas in the lagoon are actually available.

This study has developed a computer package that incorporates a pearl farm census database linked to a geographical information system (GIS) and a bathymetric lagoon map. Such a tool could prove useful to ensure that the stocking density of pearl oysters and the allocation of pearl farm areas are managed in accordance with the food and space capacity of the lagoon.

Introduction

Manihiki Atoll in the northern Cook Islands is renowned for its abundant stocks of black-lip pearl oysters. Historically the oysters were harvested for their mother-of-pearl shell but since the mid-1980s the pearl shell has been cultivated for its black pearl instead. Manihiki Atoll is the center of production for pearls produced in the Cook Islands accounting for about 90 per cent of the total output. The only other lagoon where significant pearl farming occurs is at Penrhyn (Tongareva) Atoll.

The stocking of mature oysters in close proximity at farms is thought to enhance the chances of breeding. This may explain the large cohorts of juvenile (spat) retrieved on artificial collectors in recent years. As a result, there has been a rise in farm production. For example, the annual value of exports in the three years from 1996 to 1998 has increased from NZ\$ 1.5 million to NZ\$ 3 million and NZ\$ 5 million, respectively. Presently, pearls are the Cook Islands' most valuable export, accounting in 1998 for 84 per cent of total exports (MFEM 1999).

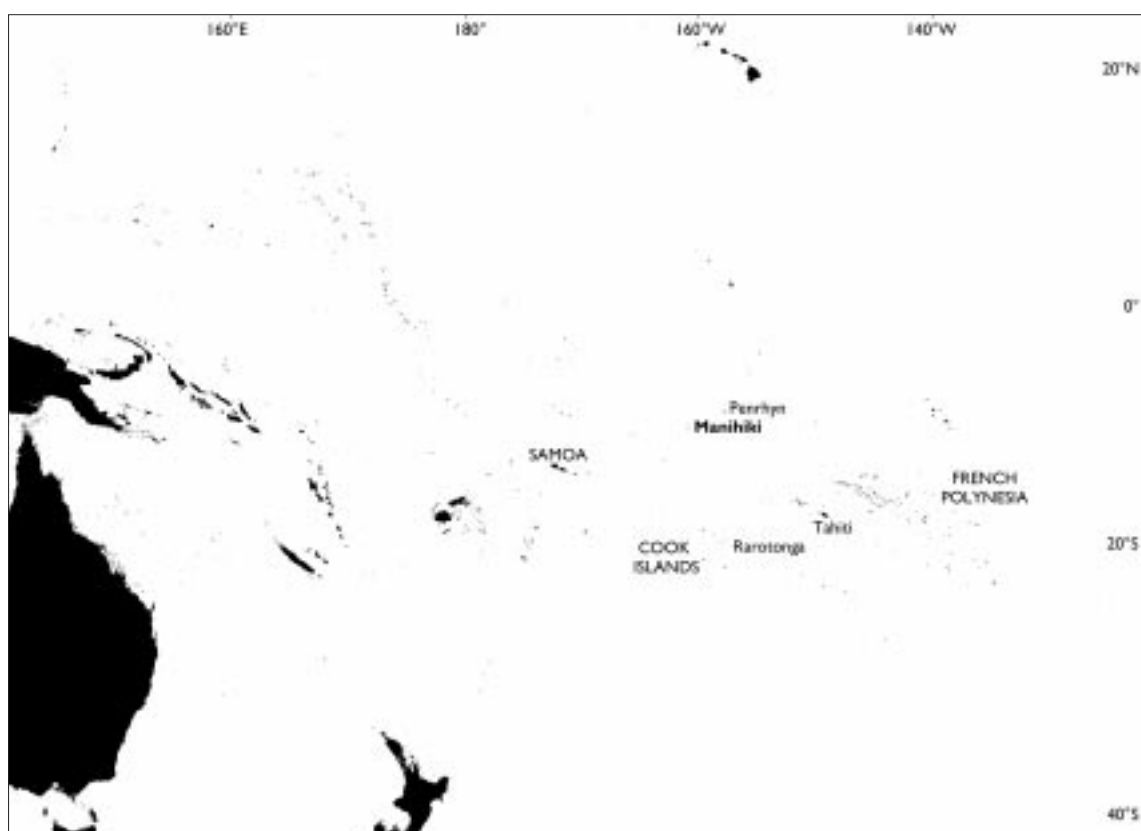


Figure 1. Location of Manihiki Atoll.

The black-lip pearl oyster (*Pteriidae*) retains many of its primitive strategies of survival. The surrounding seawater is constantly pumped through its gills in order to oxygenate the blood system. Simultaneously, suspended particulate matter in the water is filtered as food (or expelled as pseudofeces). Large volumes of water may be required for these purposes. Adult oysters have been shown to clear up to 20 liters per hour (Ponia 1996). The aggregation of oysters at a pearl farm can be likened to a large sieve that progressively removes oxygen and food from the water as it passes through the farm.

With a few exceptions, pearl farming on Manihiki is limited to the island's descendants. These farmers realise that the pearl industry has the potential to sustain economic opportunities for their future generations. There is also widespread awareness that virulent oyster diseases and poor pearl quality has resulted from poorly managed pearl farming industries in countries elsewhere. Therefore farmers accept that some management measures must be adopted to avoid these causal conditions.

Regulation of pearl farming is the responsibility of the local Government of Manihiki (known as the Island Council). In the past, farm licenses were issued periodically but since the disruption of Cyclone Martin in November 1997 this has not occurred. Nonetheless the Island Council has plans to re-introduce the license conditions. The responsibility of the national government agency, the Ministry of Marine Resources, is mostly for environmental monitoring. But it is believed that a more proactive approach may be to also utilise the Ministry's technical skills to support management initiatives where necessary.

The aim of this survey was to assess the number of pearl shells being cultured and the extent of pearl farm areas. Manihiki Atoll has a finite capacity to sustain the food requirements of cultured pearl shell and a limited amount of lagoon space for pearl farms. Information on the total number of pearl shells and areas occupied by farms is fundamental to managing the lagoon in a holistic manner.

A targeted output was a computer database to store and analyse the farm census data and a geographical information system (GIS) to map this information. Ultimately, this computer package could be routinely used by management authorities who possess basic computing skills.

Survey methodology

This survey essentially comprised two parts: 1) the census of pearl shells, and 2) the mapping of pearl farms. Field work occurred in April–May 1999.

The information from the pearl shell census was provided during visits to individual farmers. Farmers were asked to detail the number and category of adult pearl shells (i.e. first or second seeded, reject or conditioned). This was verified by field checks during farm visits. Also recorded were the number and sizes (i.e. length) of juvenile oysters (spat). Often the farmer did not have estimates of total spat counts so a spat assessment survey was conducted at the farm.

Proceeding the census of oyster stocks, farmers were asked to draw a layout of the farm lines, describing the length and type (culture line, spat collector line, etc) of farm lines. Additional data about the farm (e.g. farmer title, company name, and landmarks) were also recorded. On the basis of the farm layout, points were selected to represent the boundaries of the farm areas. Accompanied by the farmer, field staffs were directed to the exact location of these points and the coordinates recorded using a hand-held global positioning system (GPS). These coordinates were used to define the farm boundaries.

Data analysis

The pearl shell census information was stored in a Microsoft Access database. The database design incorporated numerous "drop-down" lists to properly categorise the data. Some preliminary analysis such as total number of adult oysters or total spat was inherently performed. More advanced analysis of the census results could be achieved by performing queries of the database. The farm boundary coordinates were also stored in the database.

The farm coordinates and pearl shell census were converted into GIS maps using MapInfo software. A link between the Access database and MapInfo GIS was established by custom writing a Visual Basic application. This software directed MapInfo to retrieve from the Access database the appropriate tables (farm boundaries and census query) and then convert the farm boundaries into spatial areas and also assign the census information to the farm area. Additional software was written that enabled simple thematic maps, such as farm areas, to be sorted according to the range of total adult oysters. Simply loading the application files and clicking the appropriate menu bar would initiate these applications.

Finally, three-dimensional maps of farms overlaid on the lagoon bathymetry of the Atoll were produced using Vertical Mapper software, an add-on application to MapInfo. Depth contours were recorded from a previous survey conducted by the South Pacific Applied GeoScience Commission, SOPAC (Solomon 1996).

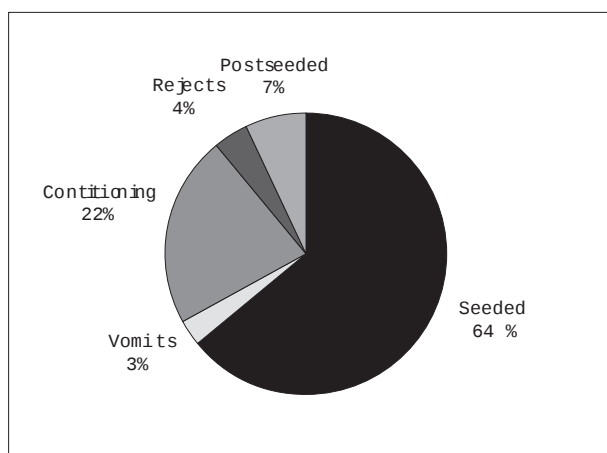


Figure 2. Categories of adult oysters cultured at pearl farms on Manihiki Atoll



Figure 3. Pearl farm areas on Manihiki Atoll.
Heavy lines demarcate the farm boundaries of the present survey. Light boundaries are the farm areas reported in 1996.

Results

The total number of adult pearl shell¹ reported by the census was 1.5 million oysters. About a quarter of the oysters (22%) were in pre-seeding phases (such as conditioning). The majority of oysters (64%) were seeded. Some oysters (7%) were in early post-seeded stages (i.e. are still in seeding catch bags) whereas four per cent of the oysters were unsuitable for seeding at the time ("rejects"). The smallest percentage of oysters (3%) were those that had expelled the pearl nucleus ("vomits") and will either be harvested for their meat or seeded for blister pearls (Figure 2).

The number of cultured spat was 1.1 million. The average number (and standard error) of spat counts per collector was 17.9 (0.3). A total of 47 farms and 267 spat collectors were sampled. The number of spat less than two inches length (i.e. generally less than one year old) and spat between two and four inches (between one and two years age) was about the same.

The number of cultured adult pearl shell has increased from 520,000 in 1991 to 1.1 million in 1996, to the present figure of 1.5 million (Table 1). The total number of spat has declined from 3.5 million in 1996 to the present amount of 1.5 million spat. The peak number of farms was reported in 1996 when 164 areas were identified compared to the present number of 111 farm areas (Figure 3).

The total area claimed by the 111 pearl farm areas was 7.73 square kilometers. This was less than the area reported in 1996 (9.02 km²). The total area of lagoon that can be utilised for farming (i.e. the depth between 10 to 30 meters), was estimated as 25.29 square kilometers.

Therefore, the farms presently account for about 30 per cent of the farmable lagoon area (refer to Figure 4 for a bathymetric map). The farms had a total of 690 individual farm lines and 424 spat lines. The total length of these cultured lines was 160 kilometers.

1. The term adult generally refers to oysters that are of "seedable age" (i.e. about two years) and to differentiate from the juvenile oysters that are still attached to spat collectors.

Table 1. Total number of cultured pearl shells

Year	Nos farm	Adults	Spats	Reference
1991	97	521,000	108,000	Tuara, 1991
1996*	164	880,000	3,500,000	LEMMP, 1997 (revised)
1999	111	1,525,000	1,078,000	This Report

* Note that subsequent analysis of the original 1996 figures by the author suggests these estimates may be overestimated. Shown are revised figures, the original estimate of adult oysters was 1,086,000 and spat was 8,000,000.

Table 2. Distribution of pearl farms according to number of cultured adult pearl oysters.

Year	1996		1999	
Nos of Oysters	Percentage of farms	Number of farms	Percentage of farms	Number of farms
No oyster count	50%	77	31%	34
<5,000	27%	41	23%	25
5,000–20,000	15%	23	22%	24
20,000–50,000	5%	8	19%	21
>50,000	3%	4	6%	7
Total	100%	153	100%	111

In comparison to the last survey conducted in 1996, the number of adult pearl shells per farm has increased. In 1996 about 80 per cent of the farms comprised less than 5,000 oysters or no none at all. Presently, farms in this range account for 54 per cent of the total number. In 1996, only five per cent of the farms had 20,000 to 50,000 oysters compared to about 20 per cent at present. Also there were four farms exceeding 50,000 oysters compared to seven farms recorded during the survey (Table 2).

There was a disproportionate distribution of spat among farms. Only two farms reported more than 150,000 spat. Eight farms had less than 150,000 spat but more than 36,000 spat. The remaining majority of farms (93%) had either less than 13,000 spat or no spat at all (Figure 5).

Discussion

This survey has demonstrated a desktop computer package that incorporates a pearl farm census database with links to a farm GIS and lagoon

bathymetry (Figure 6). This could be a useful management tool, especially with regard to the carrying capacity of the lagoon in terms of allocating space and assessing the number or density of cultured pearl shell.

The pearl culture industry at Manihiki Atoll rates as one of the Cook Islands' most important economic sectors. On the basis of 1.5 million adult pearl shell (this census) the annual production is estimated on the order of NZ\$ 12 million dollars, or 250,000 pearls. The present trend of growth suggests that by the year 2003 there will be two million cultured pearl shell and an annual production of NZ\$ 18 million dollars.

There is some discrepancy between production figures of this report and official export statistics, even taking into account the small proportion of pearls sold on the domestic market. The export figure for 1998 of NZ\$ 5 million suggests that there is gross underreporting of pearl exports on the order of 50 per cent or more.

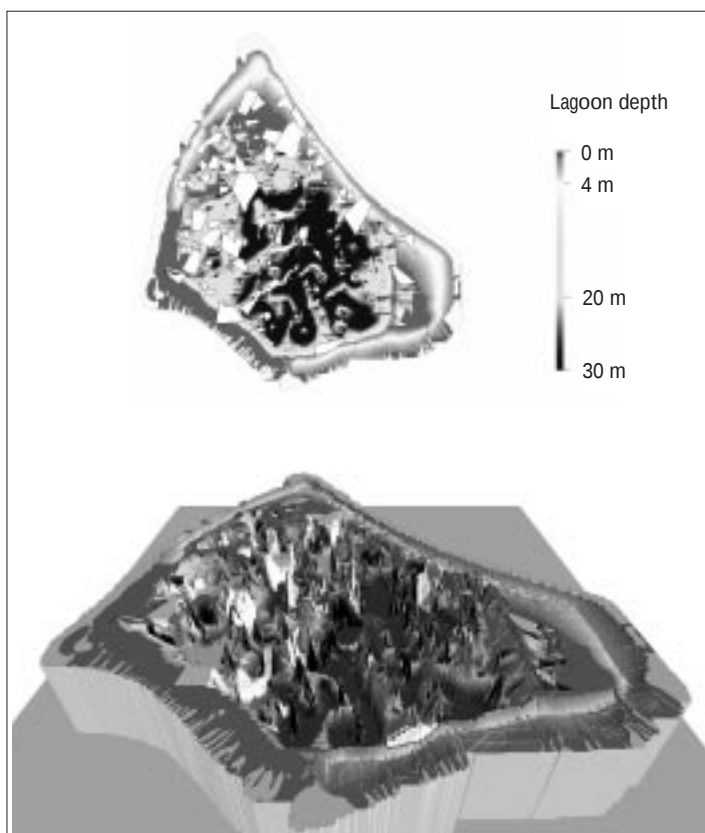


Figure 4. (Top) Lagoon bathymetry of Manihiki Atoll overlaid with pearl farms (white areas) mapped during this survey. (Bottom) The same view shown with a three-dimensional perspective.

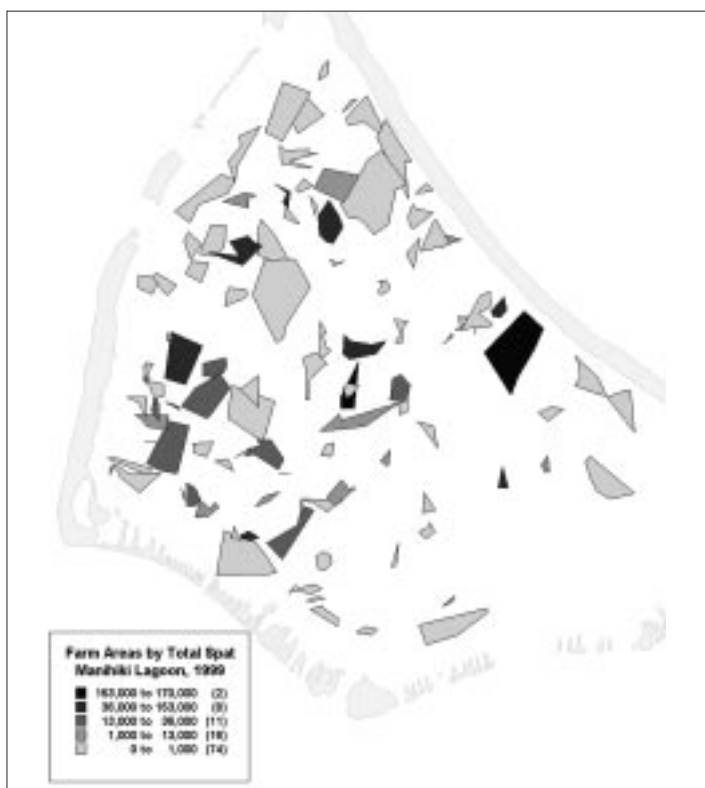


Figure 5. Number of spat at pearl farms on Manihiki Atoll

The ecological sustainability of the industry has good prospects provided lagoon-wide management measures are implemented within the immediate term. A priority is the tenure of farm leases to be allocated so that pearl shell are evenly distributed to ensure that overstocking, or “disease hotspots” do not occur. Many farmers expressed frustration at being forced to overstock their farm area because of neighboring farmers who have increased their boundaries without fully utilising the area already available. This raises the challenge of establishing a system of allocating farm boundaries that can be readily referenced and distributed on a fair basis. An unpublished report by one of us (BP) has detailed plans to realign pearl farms according to a grid reference system.

In fact, since the last survey in 1996 there has been a reduction in the number of areas claimed as farms (164 versus 111 farms) and the amount of lagoon space utilised (9 km² versus 7 km²). This is probably a result of migration after Cyclone Martin. The current population of Manihiki Atoll is 468 persons (unpublished report, Ministry of Outer Islands Development, MOID) compared to 662 in the 1996. There may be a need to assess the implications of abandoned areas that are still claimed as pearl farms but are not actually being used.

Assuming space is properly managed in the lagoon then the portion of farmable strata occupied (30%) suggests that farming of two million pearl shells could be attained without density-dependent consequences on the health of the oyster. Many farms surveyed have culture lines placed about the spacing (>10 meters) suggested by modeling studies to allow adequate supply of food to the farm ecosystem (Ponia 1996). Also, a recent baseline survey of disease and pathogens in Manihiki concluded that, the present intensity of farming harbors low levels of pathogens amongst pearl oysters or other bivalve reservoirs of disease (Hine 1998). A responsible approach would be to establish checkpoints to assess pearl oyster and lagoon ecosystem health as the cultivated stock increases.

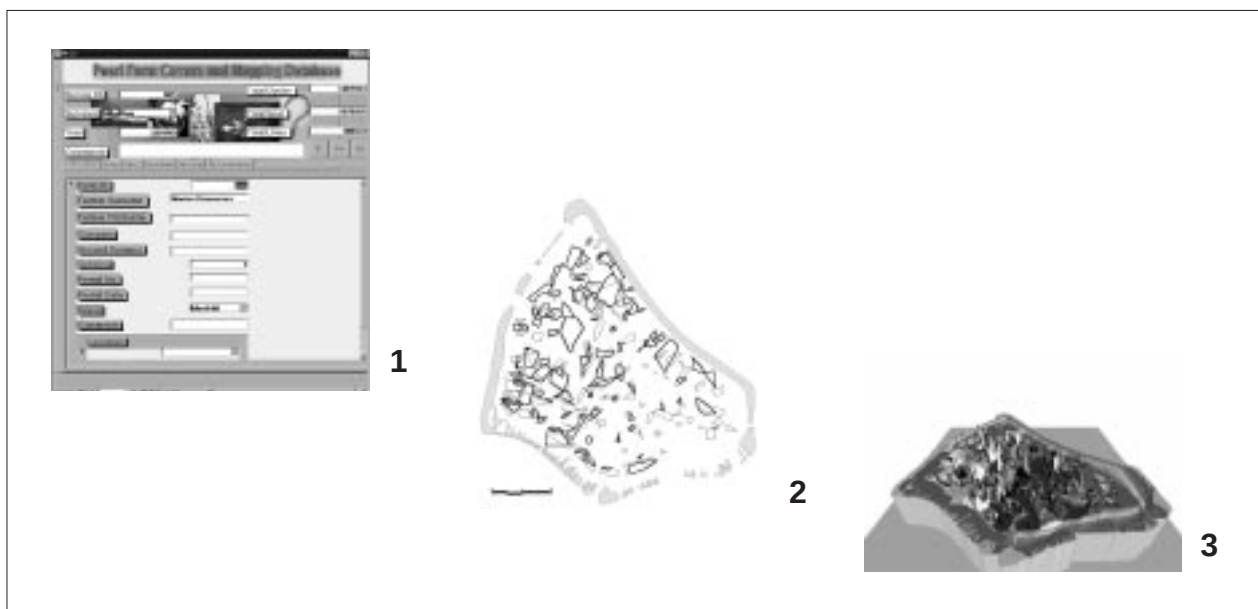


Figure 6. Computing management package developed from this survey. Elements include (1) a database, linked to (2) a GIS and (3) mapping software.

Oyster health and lagoon ecology aside, it is more difficult to predict density-dependent effects on the quality of the pearls produced. The growth trials conducted throughout the lagoon have reported reduced shell growth rates at highly stocked pearl farms compared to controls (MMR, unpublished data). It is possible that there may be some correlative impact of poor growth rates on pearl quality as farming levels intensify to the two million oysters mark.

Perhaps a concern to the development of the industry is the decline in the numbers of spat population. Projected growth figures of the industry assume availability of spat. Yet while many pearl farms have increased their number of cultivated adults this appears to have caused efforts to be diverted from spat collection. Several farmers whom have concentrated mostly on culturing adult oysters commented on the difficulty in securing adequate spat from other sources for ongoing operations. There is a need to develop a niche for farmers to concentrate on supplying spat. This may be important for the pearl farm industry in order to moderate future spat supply and spat prices.

Acknowledgements

We are grateful to Franck Martin and Les Allison of SOPAC, Fiji Islands, who assisted with the computing outputs of this survey. We would also like to acknowledge the support of the Manihiki Island Council, particularly the Mayor Hurricane Woonton and councilor responsible for marine affairs, Kora Kora. Finally the support of pearl

farmers who freely provided information and assistance when requested.

References

- Hine, M.P. 1998. A survey of the health of black-lip pearl oysters (*Pinctada margaritifera*) and other bivalves in the Cook Islands. Report prepared for the Ministry of Marine Resources, Cook Islands. National Institute of Water and Atmosphere (NIWA). New Zealand.
- LEMMP. 1997. Final report: Lagoon ecology monitoring and management project (LEMMP), Manihiki Lagoon, Cook Islands. Report Prepared by RDA International Inc. 166 p.
- MFEM. 1999. Cook Islands Quarterly Statistical Bulletin. June Quarter 1999. Statistics Office. Report to Ministry of Finance and Economic Management (MFEM). Cook Islands.
- Ponia, B.E. 1996. Feeding models and chlorophyll levels at black pearl farms in the Cook Islands: implications for management. M.Sc Thesis. James Cook University, Australia. 135 p.
- Solomon, S. 1996. Circulation studies in Manihiki Lagoon, Cook Islands. South Pacific Applied Geoscience Commission (SOPAC). Fiji. 68 p.
- Tuara, P. 1991. Pearl shell population count, Manihiki, Cook Islands. Report to the Ministry of Marine Resources, Cook Islands 31 p.

