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PEARL OYSTER

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INFORMATION BULLETIN

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Note from the editor

This issue follows hard on the heels of the last. Well, maybe. We were wanting to move to a twice-yearly publication schedule, if for no other reason than to avoid all the complaints from overworked postmen and crazed readers about the hefty weight of the last issue. Some ungracious souls compared it to sending an encyclopaedia by mail. Thank you. Do you read your encyclopaedias, shelve them, or use them as doorstops?

But point taken; we want to be more of a bulletin than a tome. We will therefore try to adhere to a couple of deadlines for incoming articles and clippings—30 June and 31 December of each year. I will do my best to hurry them over to Noumea shortly thereafter. There can often be backlogs on the SPC pressline (Regional Technical Fisheries Meetings, other Information Bulletins and such can swamp them for months), but the capable production folk there will get them to your doorstep as soon as possible.

So this issue strives to be not dour documentation, but ground-breaking news, dispatches from the front. And we do bring both great news, and news of great tragedy. The bad news first: by now most of you have probably heard of the disastrous cyclone (hurricane, typhoon) which hit Manihiki in early November 1997. Both villages on the atoll were devastated, all of the pearl-farm structures above the water in the lagoon were destroyed, and almost twenty lives were lost (9 confirmed, about 10 still missing, presumed dead). The island has been largely evacuated, as there is simply no means of accommodating and feeding the 400-odd folk.

Cyclone Martin's winds weren't particularly strong: 80–100 knot gusts. Most of the damage was incurred by the storm-surge tidal waves which pushed over the island, and lifted the lagoon height to where all of the **kaoa** (islets inside the lagoon upon which most of the farm structures were built) were swamped.

Inside this issue

Most of the pearl-farm lines below the water still appear to be intact, but it will be some time before this jewel in the centre of the Cooks' pearling crown is gleaming again.

The issue of long-term impacts to the lagoon is drawing some differing prognoses. Some like to think that the highly-enclosed lagoon has needed a 'good flushing', but others have pointed out that the waves, rather than flushing the lagoon out, flushed everything else in: diesel, detergents and all.

Miles Anderson, with RDA International, recently completed an ADB-funded year-long intensive study of Manihiki lagoon's hydrology and ecology, to improve the scientific basis of pearl-industry management decisions. Some of the preliminary results are presented in an article here in this issue. As well as addressing some of the more pressing issues of pearl-farming sustainability and limits to growth, this study has also provided a comprehensive baseline of the lagoon before Martin's passage: its hydrology, benthic community and pearl-oyster stocks.

There would now seem to be a unique opportunity to use this baseline to assess the impacts of the 'flushing', and to track the recovery of this lagoon. Such information could help guide mitigation measures on other cyclone-prone atolls (at the least, we should all be more aware of the need for cyclone shelters, and emergency procedures), or help shape future disaster response and clean-up efforts when (not 'if') other pearl-farming lagoons are similarly hit.

And now to the good news: the future for hatchery-stocked pearl farming has looked a little brighter over the last six months, with some significant increases in production from three separate projects. Masahiro Ito, formerly with the ACIAR pearl project, took a consultancy with Roko Island Pearl Farm in Cape York, Queensland, late last year. He produced several sizeable batches of spat using basic techniques and equipment.

Dr Rick Braley, who has been providing guidance and training to the Tongareva Marine Research Centre, and the pearl oyster hatchery, over the last year or so, has cranked up his team to full-steam ahead, providing Penrhyn with the spat they need for farm expansion.

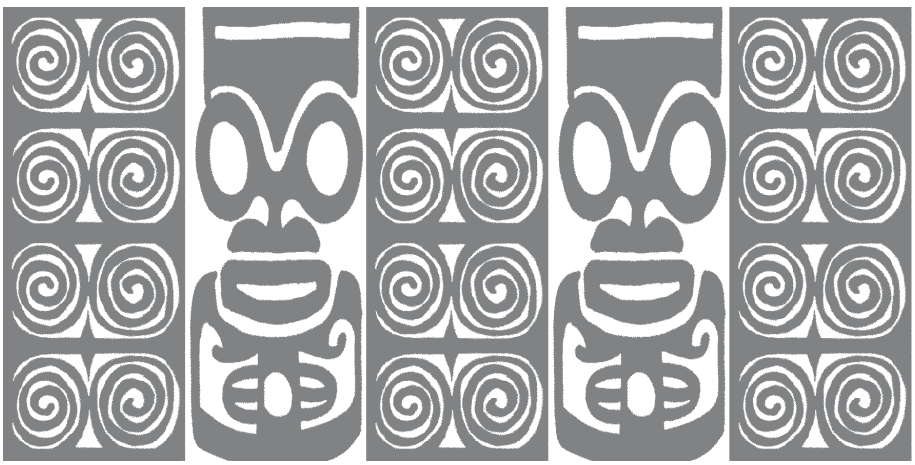
Black Pearls, Inc. also had good success with a temporary hatchery set-up in Majuro, Marshall Islands, which now accelerates the Majuro farm towards a full-scale commercial footing, and opens up expansion opportunities.

Each of these operations yielded significant spat-per-run tallies of six figures, from fairly low capital and operating costs. Both *P. maxima* and *P. margaritifera* were represented. Inside this POIB we have articles on each of these milestones, giving more details on the rearing systems and the post-set approaches.

I also clamber up into my pulpit again for yet another couple of opinion pieces. I indulge in some podium-thumping on the significance of the pearl culture industry to the region (compared with, say, tuna). And I ruminate quietly on the future role of regional co-operation in this impending expansion (contrasted with, for example, tuna!).

Good reading, good pearling!

Neil A. Sims



RESEARCH NOTES AND REPORTS

Commercial spat production of *Pinctada maxima* at Roko Island hatchery, North-East Australia, with *in vitro* fertilisation technique

by Masahiro Ito [1]

Introduction

Most silverlip pearl oyster farms in the Torres Strait are on the verge of collapse and closure because of a shortage of supply of mother-of-pearl (MOP). This shortage is attributed to a poor resource-management strategy, and ignorance by both the public and private sectors. Aquatech Oceania, contributing to a sustainable development of fisheries resources, provided a consultancy service to Roko Pearls in the Torres Strait, NE Australia. We designed a low-cost pearl oyster hatchery system for the silverlip pearl oyster (*Pinctada maxima*) and conducted hatchery staff training during March to June 1997. Our aims were:

1) to develop skilled hatchery technicians through short-term, on-the-job training,

2) to produce a commercially viable number of high quality spat (at least 100 000 two-mm spat per larval run) during the off-peak spawning season (April – September) in this region, and

3) to attain year-round mass production from an inexpensive hatchery system with a minimum number of technicians. During the off-peak spawning season, we successfully produced 200 000 spat from a single larval run with artificially matured ova and activated sperm. Being able to supply spat year-round to the pearl farms is a major breakthrough for the *P. maxima* pearling industry, particularly in the Torres Strait.

Materials and methods

All the broodstock were held in pearl nets, suspended from a surface longline system. They were transferred to a raceway tank before hatchery operation. Donor oysters were washed thoroughly. The gonads were cut off from male and female oysters and kept separately in glass beakers with UV-sterilised and filtered seawater until the gametes were stripped for artificial maturation and activation procedure. Gametes of both sexes were usually immature, so-called 'spent' during this time of year. The solution containing immobile sperms was either stored in the refrigerator for a few days or used for *in vitro* fertilisation straight after stripping the gonads. $0.5x10^{-1}$ N ammonia solution was used for artificial maturation of ova and *in vitro* fertilisation. Similar techniques have been well documented by various researchers (Wada, 1932; Tanaka & Kumeta, 1981; Hayashi & Seko, 1986; Rose, 1990).

The hatchery was semi-indoors, being a modified workshop. It accommodated 6 larval or spat tanks (1000 litres each). The micro-algae culture room was a similar set-up to that of Tarawa in the Republic of Kiribati, described by the author in an earlier issue of this bulletin (*Pearl Oyster Information Bulletin #9*, pp. 8–11). The larval and spat rearing methodology was basically the same as Ito (1996). Only two 1000 litre tanks were used for rearing 1.5 million larvae. After settlement, the spat were cultured in three tanks each with 60 000–100 000 spat and then later reduced to 40 000–70 000 spat per tank.

[1] Aquatech Oceania, 23 Depper Street, St Lucia, QLD 4067, Australia

Results and discussion

All the D-stage larvae were obtained from *in vitro* fertilisation using artificially matured ova and activated sperms. A total of 1.5 million fertilised eggs were obtained out of 4.3 million ova from 2 females. Although we have found that the sperm can be activated artificially by adding some chemical solution—e.g. sodium metasilicate, green-algae culture medium (Ito, unpublished data), trace metal mix (Ito, 1995)—we used a standard technique with $0.5x10^{-4}$ N ammonia solution for this on-the-job training. Fertilisation rates were 30–50% for 2 batches of stripped ova. The hatching rate of the D-veligers from fertilised eggs was 100% without any deformities.

From this very first hatchery operation, we successfully produced over 200 000 spat (1.5 mm to 3 mm in shell length on day 35, all visible to the naked eye) out of only 1.5 million D-stage veligers. The first batch of 20 000 spat (ranging from 1.5 to 4 mm in shell length), the second batch of 80 000 spat (average 3 mm) and the third batch of 70 000 spat (average 5 mm) were transferred from land-based tank culture to nursery farms for grow-out culture at the end of May, early June and mid June, respectively.

The present success rate from D-stage to 2 mm spat was 13%, which is considered to be very high from a single larval run (Note that the success rate to the 2 mm size has been 1–5% for commercial *P. maxima* spat production (Ito, unpublished data)). Our success rate is similar to that of Akoya oyster (*P. fucata*) with 15–35% success rate in Japanese pearl oyster hatcheries (Hayashi & Seko, 1989) and we believe that the success rate will be improved during the spawning season when using ripe gonads.

Artificial fertilisation techniques have always been considered a last resort, particularly for the silverlip pearl oyster (*P. maxima*) hatchery operations. It is always difficult to access spawning-ripe gonads outside of the spawning season (i.e. around 6 months from April to September in this region), and thus normal spawning induction techniques, using stressing of the broodstock by temperature shock, dry treatment, or such like, are not practical nor economical. To perform constant spat production throughout the year, the techniques for artificial maturation of ova, activation of sperm and fertilisation are the most reliable and economical, saving the hatchery facility labour cost and time.

We also demonstrated that long term (for 1 to 2 months after settlement) high-density spat culture (50 000 to 100 000 spat / 1000 litre tank) was possible using a simple, low-cost, partial flow-through culture system with a minimum algae culture facility with about 500 litre indoor and 1000 litre outdoor capacity. Roko Pearls has now two skilled hatchery technicians trained by us and expects to produce 200 000 spat (5 to 10 mm size) per run throughout the year.

Table 1: **Summary of hatchery run**

Days	Eggs/larvae/spat in 1000-litres tanks	Size (shell length)	Success rate *
0	4.5×10^6 ova		30 to 50% fertilisation rate (total of 1.5×10^6 fertilised eggs
1	1.5×10^6	85 µm	100% hatching rate (total of 1.5×10^6 D-stage)
7	8.2×10^5	105 to 115 µm	
9	4.6×10^5	130 µm ≈	Umbo stage
14	3.1×10^5		
16		240 µm ≈	30% eyed veliger (total of 1×10^5)
17	3.1×10^5		50% eyed veliger (total of 1.5×10^5)
18	Spat collectors in settling tanks		80% eyed veliger (total of 2.5×10^5)
24	3.0×10^5	300 µm ≈	Crawling pediveliger & spat
27	2.6×10^5		
30		0.5 mm ≈	All spat, no swimming larvae
33	2.0×10^5	0.5 to 2 mm	13% success rate from D-stage
37	2.0×10^5	1.5 to 4 mm	
38	2.0×10^5	1.5 to 4 mm (ave. 2 mm)	10% (20 000 spat) transferred to other farm
39	1.7×10^5	2 to 4 mm (ave. 3 mm)	40% (80 000 spat) transferred to nursery farm grow-out
54	7×10^4	3 to 7 mm (ave. 5 mm)	30% (40 000 spat) transferred to other farms
61	3×10^4	5 to 15 mm (ave. 10 mm)	20% (30 000 spat) transferred to other farm

* Success rate here does not represent survival rate from day 1, where some live larvae were discarded from the culture system during tank cleaning and size selection process

Aquatech Oceania owns expertise in hatchery and grow-out system design, staff training and commercial production for pearl oysters (*P. maxima*, *P. margaritifera*, *P. fucata* and *Pteria penguin*) and decapod crustaceans (prawns, crabs and spiny lobsters).

We emphasise our commitment to sustainable resource development and environmental awareness in business practices. We do not use any antifungal chemicals nor antibiotics for controlling water quality, but we adopt careful hatchery system management through continual technical improvement.

Acknowledgement

I would like to express my thanks to Mr and Mrs Saltmarsh of Roko Pearls for allowing me to publish a part of the results of this hatchery work.

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Major success for TMRC blacklip pearl oyster hatchery, Penrhyn Atoll, Northern Cook Islands

by Dr Rick Braley

During mid-1997 the Tongareva Marine Research Centre hatchery had achieved its goal of successfully mass producing blacklip pearl oyster (*Pinctada margaritifera*) spat. An Asian Development Bank project, the Outer Islands Marine Resources Management Training Project, which started in July 1996, substantially modified the existing hatchery and algal lab (original infrastructure resulting from the USAID project, 1991-1995) and continued with in-house training of staff. New seawater systems were constructed, one from the ocean-side of the atoll for the hatchery and one from the lagoon for the land nursery culture of spat. New reservoir and culture tanks were obtained, the flow-through system of larval culture was used and a specific protocol developed for TMRC on hygiene, feeding, and algal production.

The first substantial spat settlement was about 30 000. This was followed by what is perhaps a world record batch of 250 000 spat [estimate in August 1997 by the senior hatchery technician, Mataora Bill Marsters] for this species. After about 60 days the spat were transferred from the settlement tanks to land nursery raceways where they receive subsand-intake filtered lagoon seawater and are fed mass microalgae produced under the capable direction of senior algal technician Lolongi Taime.

A third batch of spat was earlier estimated to be >100 000 but in early November 1997 volumetric count estimates of spat on sides and bottom of tanks were about 200 000, while those on collectors (black boxes and PVC slats as described in *Pearl Oyster Information Bulletin # 10*, pp. 12–14) were estimated to be about 100 000.

Spat are being placed in the lagoon nursery in trays. An indication of growth rates and survival of small spat [caught on 3.6 mm mesh versus those on 6 mm mesh] placed out in trays after 1 month was: 3.6 mm grade: mean 120% shell DVM increase and mean 55% survival; 6 mm grade: mean 60% shell DVM increase and mean 60% survival. Improved trays and regular checks and cleaning should improve survival rates.

Marshall Islands farming expansion: New hatchery, new atolls, new techniques

by Neil A. Sims and Dale J. Sarver [1]

Hatchery Production

Efforts to expand pearl farming in the Marshall Islands received a significant boost over August–September 1997, with the first on-island hatchery production of local spat. Over 600 000 settled spat were produced from a single run in the temporary hatchery set up in Majuro. These spat have shown good early growth and survival during grow-out on the farm and in the land-based nursery system.

To meet the need for expansion to commercial scale of the Black Pearls of Micronesia (BPOM) farm in Majuro, hatchery operations needed to shift from the remote hatchery system in Kona, Hawaii, to an on-site set-up in Majuro. A temporary hatchery was therefore set up in a rented house next to the existing land-based nursery facility in Woja, Majuro.

A single batch of larvae was reared through to settlement over August and September. Most of the spat were held in an on-land nursery, and then moved out to the BPOM farm site during September and October. The remainder were held under different experimental regimes in the land-based nursery, and then moved out to the farm in late November.

Three separate batches of spat from this run were reared from single-female x single-male crosses. The same male was used for all three such crosses, providing three batches of full-siblings, each half-siblings with the others. The resultant spat are being raised separately on the farm, to provide experimental material for BPI's genetic improvement projects.

Farm Expansion

Refinements in handling of early spat both on the farm and in the nursery have resulted in improved survival and growth of these animals. The land-based nursery usually results in better survival, but the animals grow more slowly than those held on the farm. Plans for a larger-capacity nursery system are being implemented in stages, to provide increased algal production, higher flow-through rates and greater nursery holding-tank capacity. A large-scale permanent hatchery facility will also be built in the coming year.

This large increase in farm stock has also required a similar increase in manpower, to ensure that the spat are well tended. Growth in the fine-mesh bags on the longlines, as in the land-based nursery, is limited by the ratio of spat biomass to available water exchange. Overcrowding of spat (when survival is higher than expected) or fouling of the fine mesh bags (even at very low levels), can limit growth. Spat are stocked lightly, but there is still a clear pattern of stunting in bags where survival rates are high. As the spat grow, they must be repeatedly thinned, and moved into coarser-mesh bags. The timing of transfers to the next stages are crucial, particularly early in the grow-out.

Expansion of pearl farming in Majuro lagoon and to other atolls in the Marshall Islands is about to get underway. Grow-out trials at several sites throughout Majuro lagoon have yielded pleasing results. Most sites matched the growth and survival rates from the BPOM farm site at Didit Islet.

BPI has recently been awarded a three-year grant, through the US Department of Agriculture's Fund for Rural America (FRA), to expand their activites at the BPOM farm, and to set up satellite farm sites on two of the outer atolls. This FRA grant will allow these expansion sites to rear spat through the full grow-out cycle to seedable size, and to permit a first preliminary harvest, after pearls have been incubated for 12 months, to give some early indication of the quality of the resulting product.

The project involves a range of collaborating institutions, including Island Councils, Marshall Islands Marine Resources Authority (MIMRA), the College of the Marshall Islands' Land Grant Extension Program, the University of Hawaii Sea Grant's Pacific Aquaculture Development Program, University of Hawaii's Marine Option Program, and Hawaii Institute of Marine Biology. The emphasis for the FRA project is on training and extension; research and development efforts continue at the BPOM farm site and elsewhere through other projects and grant programmes.

Further Research

The new technique for grow-out of spat to juvenile size in individual mesh 'sausages' continues to be refined. This method has effectively eliminated the *Cymatium* snail predation problems experienced early on. Problems with fish attacking the 'sausages' have been minimised through use of protective plastic beads, and a central line of 4–6 mm

[1] Black Pearls, Inc. (BPI), Hawaii, and Black Pearls of Micronesia, Inc. (BPOM), Majuro

polypropylene, which prevents fish from breaking the sausages off the headline. Although the 'sausages' are labour intensive to set up, they overcome the necessity of repeatedly cutting clumps of spat apart to prevent stunting. The BPOM farm has completely eliminated the use of lantern baskets, with spat going straight from the spat bag to the 'sausage' and then to the net panel. Trials are currently examining the most cost-effective number of spat in each 'sausage' pouch, and the optimum cleaning regime for these 'sausages', and for net panels with older oysters.

Experimental work on the BPOM farm is also looking at deep-water culture, as a means of reducing the amount of fouling on early-nursery animals. Trials have shown growth rates to be comparable between larger animals held on longlines below 25 m depth, and tended only every six months or more, compared with animals held on the usual sub-surface longline arrays, and cleaned at least every two months. There is far less fouling on the deep-cultured animals, and the type of fouling organisms is noticeably different. Deep culture could therefore reduce the demand for manpower on the farm both in adult grow-out and through all stages of the nursery.

It appears that the high degree of mixing in the well-flushed Marshall Island lagoons ensures that the deep-cultured animals are still supplied with sufficient food and water exchange. In earlier work, Sims (1990) had shown that animals cultured in deep water in Manihiki lagoon showed slower DVM (dorso-ventral measurement) growth, but comparable increases in shell thickness to shallow-water cultured animals, suggesting some food or other limitation in the more stagnant deep water. Recent hydrodynamic and water-quality studies (see Miles Anderson's article in this issue) have confirmed this depletion in the entrapped deep water of this highly enclosed lagoon.

Black Pearls Inc. is also collaborating with a Maryland naval engineering company, Band, Lavis, and Associates, on a US Department of Defence research grant (through the Center of Excellence for Research in Ocean Sciences, or CEROS), investigating the use of non-toxic antifouling coatings of nets and lines. Candidate coatings have been identified, and over the next year these will be applied to various materials, and tested on different pearl farms and at other aquaculture and naval sites.

Under another CEROS grant, BPI is pursuing some early encouraging results in the use of probiotic bacteria to improve growth and survival of pearl oyster larvae and spat, and of other aquaculture species in the hatchery and nursery using both surface seawater, and the nutrient-rich deep sea water available at Kona's Natural Energy Laboratory site.

The ecological sustainability of pearl farming in Manihiki lagoon, Northern Cook Islands

by Miles Anderson [1]

Introduction

Culture of the black-lipped pearl oyster, *Pinctada margaritifera*, in the Northern Group of the Cook Islands began in the mid 1980s. The Ministry of Marine Resources (MMR), with the assistance of international aid donors, has sponsored a series of projects and activities encouraging the reasonable further development and expansion of the Cook Islands' black pearl industry. An integral part of this effort recognises the sustainable use of natural resources as the key to long-term success of the industry.

In 1995 the Asian Development Bank, in concert with the MMR, awarded a technical assistance contract to RDA International Inc. to establish a Lagoon Ecology Monitoring and Management Project (LEMMP) in Manihiki, an atoll in the Northern Cook Islands. The project mobilised in March 1995 under the direction of Dan Cheney with the construction of an environmental research and training centre, the Manihiki Environmental Laboratory (MEL). Technical assistance was provided by Project Manager, Miles Anderson.

[1] Analytical Laboratories of Hawaii Inc. and RDA International

The project concluded in May 1997, and the MEL's operations were handed over to the MMR. This article provides a limited overview of the field work conducted during the course of the project, and reports some preliminary water-quality monitoring results.

Materials and Methods

Overview

The LEMMP work programme was broadly aimed at undertaking environmental assessment of Manihiki lagoon for the development of ecologically-sound pearl farming practices and policies to ensure that the lagoon is managed in a sustainable manner. A baseline survey was conducted and a long-term environmental monitoring programme was implemented that would supply the needed information to meet this goal.

Other surveys contributed to an estimate of carrying capacity for farming pearl oysters in Manihiki lagoon. Studies such as farmed oyster population dynamics, hydrodynamic surveys of water movement in the lagoon and surveys of oyster pathology were among these. A comprehensive study of the population dynamics of wild black-lipped oysters in the lagoon was undertaken in which assessment of size distribution, sex ratios, rates of recruitment, mortality and fecundity were made.

Surveys also quantified impacts to lagoon water quality and sediment as a result of oyster feeding and the generation of organic material from farmed oysters and fouling organisms associated with farming structures. Simple water-quality indicators were identified that reflect the seasonal stratification patterns of the lagoon water and were applied to recommend areas which are most appropriate for farming as well as those which would be most advantageous to dedicate as marine reserves. Also, on-land activities were identified that can affect lagoon water quality and were included in the final recommendations for long-term management of the pearl production industry in the lagoon.

All the data were mapped, and the resulting spatial analysis was made available through a small computerized geographic information system (GIS). This GIS then formed the basis of other surveys such as plankton studies correlating bivalve spawning, and timing and location of spat-collector placement. Analysis of other spatial data led to recommendations such as maximum farming density and the width of a recommended buffer between farms.

Farm impacts on water quality

Three aspects of this work addressed the question of the impact of pearl farm on the environment:

- The potential impact on water quality due to filter feeding by the farmed oysters was assessed using chlorophyll-a analysis.

- The potential for impact on sediments under the farm from accumulation of organic material and metabolic by-products from the farmed oysters and associated fouling organisms was surveyed using sediment-oxygen demand.

- A hydrodynamic survey evaluated the extent to which re-circulation might cause accumulative impacts on water quality.

Reduction in particulates due to oyster filter feeding

A survey was designed to study the impact on the ambient water resulting from its passage over a pearl oyster farm. The extent of removal of phytoplankton is effectively measured by analysis of chlorophyll-a. Since most suspended material is removed from the water as a result of filter feeding, the relative reduction of chlorophyll-a reflects the relative reduction of most of the particulate material in the water column.

The oyster density on four farms used in this survey was determined to be 0.13, 0.19, 0.48 and 0.70 oysters per square metre of surface area using the GIS. A single up-current site was selected as a reference station and three other stations were established on the down-current edge of the farm. Three more were established 100 metres and another three 200 metres down current of the farm. Three control stations were established in an area which was unaffected by farming activity. Water samples were collected at three depths (2, 6 and 20 metres) from each sample station. Current velocities of the water passing across the farms were estimated to be 1 to 5 centimetres per second using diver observation of the distance suspended particles move during a specific amount of time.

The reduction of chlorophyll-a was compared to farmed oyster density. A relative change in phytoplankton concentration after the water passed over the farm was calculated by assigning the up-current station a value of 100% and comparing the down-current stations at each depth.

Sediment oxygen demand

Organic material such as faeces and debris from farmed organisms and biofouling on farm lines, buoys and other farm structures, falls to the sea floor where it decomposes. As the intensity of farming increases, the amount of organic material which rains to the sea floor also increases. The effects of this decomposition on water quality has not been thoroughly studied but there may be some risk of nutrient enrichment in aerobic conditions, or pro-

duction of noxious compounds in anaerobic conditions. The extent of this impact was assessed by measuring the sediment oxygen demand (SOD), the net amount of oxygen which is exchanged as a result of the biological activity associated with the sediment. A survey was established to evaluate the extent to which SOD is altered in areas used for farming black-lipped pearl oysters.

A sample of sediment was collected from an area which was not used for oyster farming and was used as a control. Experimental samples were collected directly under longline farms of varying oyster density ranging from 0.13 to 1.0 oysters per square metre of surface area. The experiment was again conducted using sediment collected under a rack-culture area where oyster farming is far more intense. In areas used for rack culture, farmed oyster densities reach 25 oysters per square metre.

Two standard dilution curves which compared the weight of sediment used for inoculation with the reduction of oxygen in the SOD test were developed. Sediment collected under low-density longline culture was used to inoculate samples for one curve and sediment collected under rack culture was used for the second. The curves were used to select the optimum amount of inoculant that would produce reliable data for each case.

Hydrodynamic considerations

The exchange of water over a marine farm provides the mechanism by which nutrition is brought into the area and by-products are removed. For this reason, as an integral part of the LEMMP, a hydrodynamic survey was completed wherein these patterns were identified and quantified. This work was completed through a cooperative effort between the LEMMP and the South Pacific Applied Geoscience Commission (SOPAC).

A one-month study of hydrodynamic patterns in Manihiki Lagoon was completed. To carry out the surveys three vane-type current metres, a conductivity-temperature-depth probe and a boat-mounted acoustic doppler current profiler (ADCP) were deployed. A global positioning system was used to establish base station positions, position bathymetry and to navigate to ADPC sites.

Results

Reduction in particulates due to oyster filter feeding

Several patterns emerged. At the down current edge of the farm the water that passed above the farm but not through it showed little change (Table 1, Figure 1). The water that passed through the farm showed an approximate 40% decrease in phytoplankton at densities above 0.4 oysters per square metre.

Table 1. Impact on water quality from farmed pearl oysters at the down-current edge from a farm, as a result of oyster feeding, showing the change of chlorophyll-a in water which has passed through and under the farm

	Down-current edge from farm		
Shell density	**2 metres**	**6 metres**	**20 metres**
0.13	7.87%	-0.83%	5.57%
0.19	8.33%	-1.52%	19.05%
0.48	16.67%	-42.67%	33.33%
0.70	9.26%	-40.67%	77.52%
Average	10.53%	-21.42%	33.87%

Table 2. Impact on water quality from farmed pearl oysters 100 metres down-current from a farm, as a result of oyster feeding, showing the reduced change of chlorophyll-a in water which has passed through and under the farm

	100 metres down-current from farm		
Shell density	**2 metres**	**6 metres**	**20 metres**
0.13	-7.92%	0.65%	6.80%
0.19	2.73%	1.67%	0.00%
0.48	9.50%	-4.67%	14.00%
0.70	-33.33%	-33.30%	10.00%
Average	-7.26%	-8.91%	7.70%

Table 3. Impact on water quality from farmed pearl oysters 200 metres down-current from a farm, as a result of oyster feeding, showing the ameliorated change of chlorophyll-a in water which has passed through and under the farm

	200 metres down-current from farm		
Shell density	**2 metres**	**6 metres**	**20 metres**
0.13	-8.47%	-4.76%	-3.84%
0.19	2.77%	2.73%	-0.20%
0.48	-4.11%	-4.68%	-5.88%
0.70	-7.41%	0.00%	7.04%
Average	-4.31%	-1.68%	-0.72%

However, the water that passed under the farm showed an increase in phytoplankton. At a farmed oyster density of 0.7 oysters per square metre, the increase in phytoplankton at the down-current edge was as high as 77% at the deep site. This increase is attributed to increased nutrient levels in the water as a result of metabolic by-products of oyster metabolism and that of other fouling organisms on the farm. Dissolved inorganic nutrient analysis was not available to this project, so this assumption was not tested.

One hundred metres down current from the farms, the impact had decreased significantly (Table 2) and 200 metres down current of the farm the impact was improved (Table 3, Figure 2).

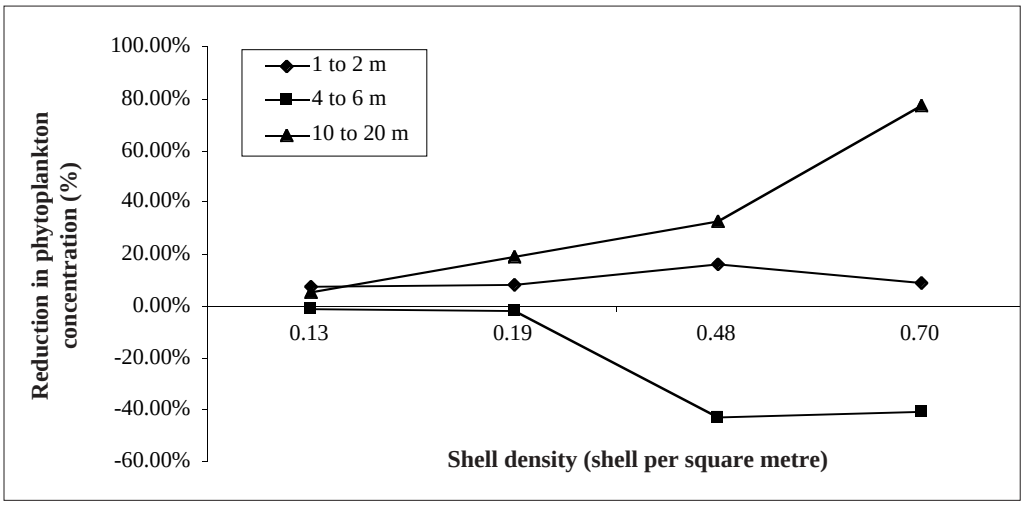

Figure 1: Change in phytoplankton as lagoon water passes over pearl oyster farms of four densities at three depths at the down-current edge of the farms

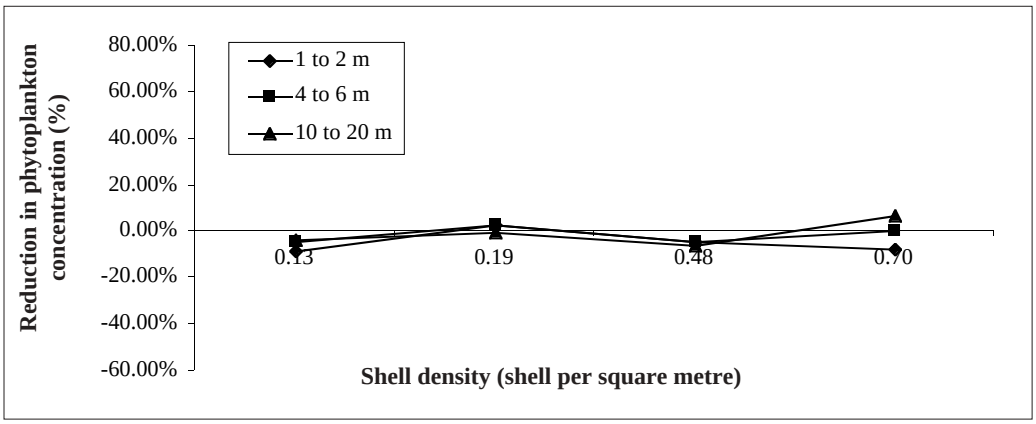

Figure 2: Change in phytoplankton as lagoon water passes over pearl oyster farms of four densities at three depths 200 metres down current from the farms

Sediment oxygen demand

Sediment collected under the farm which supports an oyster density of 1.0 oyster per square metre or less, produced no significant reduction in oxygen when inoculating a standard BOD bottle with as much as 50 grams of sediment. A 40% reduction in dissolved oxygen was measured when 10 grams of sediment collected from under the rack-culture area was used as an inoculant.

Hydrodynamic considerations

It was found that in prevailing trade wind conditions, the upper 27 metres of water in Manihiki Lagoon (the area used for farming black-lipped pearl oysters) exchanges with the open ocean approximately every 60 days and water currents rarely exceed 8 cm per second. This slow exchange and low current velocity is characteristic of closed or semi-closed lagoons.

Discussion

In the last decade, spatial data analysis has become a powerful technique for examining, understanding and displaying environmental relationships in complex data sets. The ability to identify ecological patterns in the context of hydrodynamic, chemical, biological and physical oceanographic properties has improved through the ability to attach data to maps displaying geophysical and man-made features.

The work carried out in Manihiki utilised this enhanced interpretive capability in the process of meeting the goals of the project. Combined with routine data-collection methods, spatial data management facilitated the development of the LEMMP in which ecologically sound black-lipped pearl oyster farming practices were identified to ensure that the industry is managed in a sustainable manner.

The results of the data presented in this paper show that in Manihiki Lagoon, given the prevailing hydrodynamic regime and farmed oyster density at or below 0.7 oysters per square metre, the impacts of the primary productivity and water quality were ameliorated 200 metres down current from the farm. It has also been shown that no discernible impacts existed in the oxygen demand associated with the sediment under a pearl oyster farm wherein farming intensity is maintained at these low levels. In developing a management plan, these data were used to recommend a 200-metre buffer zone between farms and an optimum farmed-oyster density.

When applying the results of this work to estimate the risk of environmental impact from pearl oyster farming in other areas, including other lagoons, hydrodynamic regime must be a primary consideration. Closed and semi-closed lagoons, open lagoons, bays and estuaries, sheltered coasts and open coasts progressively experience more water exchange and thus the risk of detrimental impact to water quality resulting from any perturbation is lessened respectively.

The study in Manihiki Lagoon exemplifies a situation in which the probability of degradation to water quality is exceptionally high due to the low rate of exchange of lagoon water with the open ocean. Therefore, the information presented in this report can be applied with significant margin when comparing it to environments typified by hydrodynamic regimes in which the rate of water exchange is greater.

This discussion represents only a small portion of the surveys that were addressed during the two-year field study. Subsequent to the completion of the LEMMP, the MEL continues to collect water quality and other data on a routine basis. The data is periodically reviewed for long-term trends that contribute to fine tuning the management strategies as the pearl production industry in Manihiki Lagoon matures.

New ACIAR-funded pearl oyster project: pearl oyster resource development in the Pacific Islands

by Paul Southgate [1]

The Australian Centre for International Agricultural Research (ACIAR)-funded project 'Pacific Island Pearl Oyster Resource Development' ran from June 1993 to June 1996 with a further period of bridging finance between July 1996 and March 1997 (see *Pearl Oyster Information Bulletin*, 9: 6-8, 1996).

This project, which focused on the pearl oyster resources of Kiribati, involved James Cook University (JCU) as the commissioned organisation, collaborating with the Ministry of Environment and Natural Resource Development in Kiribati, the ICLARM Coastal Aquaculture Centre (ICLARM-CAC) in the Solomon Islands, Fiji Fisheries and the Secretariat of the Pacific Community (SPC).

The major objectives of the Project were:

- to assess the natural stocks of pearl oysters in Kiribati and Fiji and the rates of spat-fall of blacklip pearl oysters in the atoll lagoons of Kiribati.
- to develop appropriate low-technology methods for hatchery and nursery culture of blacklip pearl oysters.
- to improve the yield of gem-quality and average-quality pearls through better bead insertion and oyster management practices.

During the Project, appropriate hatchery and nursery techniques were developed for *P. margaritifera* and a pilot-scale hatchery was constructed in

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Kiribati. The hatchery produced four batches of spat and demonstrated the feasibility of hatchery-based pearl oyster production in Kiribati. A review of the project was completed in April 1996 and a second-phase project was recommended.

In January 1998, a replacement ACIAR-funded project 'Pearl Oyster Resource Development in the Pacific Islands' was commenced. This new project has the following major objectives:

- to further develop and refine hatchery-culture techniques developed for *P. margaritifera* during the first-phase project;
- to investigate nursery and juvenile culture methods suitable for use in the atolls and open-reef systems of Kiribati and other Pacific nations;
- to examine the rate of spat collection of *P. margaritifera* and *Pteria penguin* in areas of Fiji and determine growth rates of spat and juveniles under culture conditions;
- to produce a simplified manual on the mariculture methods developed for *P. margaritifera* during this Project; and
- to develop an appropriate business plan for the establishment of a cultured pearl industry in Kiribati.

The collaborating institutions are James Cook University (JCU) [Commissioned Organisation]; Ministry of Natural Resources Development, Kiribati; Abaiang Island Council (Ministry of Home Affairs and Rural Development, Kiribati); Fisheries Division, Ministry of Agriculture, Fisheries and Forest, Fiji; ICLARM-CAC, Solomon Islands, and Ministry of Marine Resources, Cook Islands.

Research into hatchery and nursery culture methods will be conducted at JCU in collaboration with ICLARM-CAC. The results of this research will be immediately transferred to Kiribati, and to the Solomon Islands and Fiji where appropriate. Transfer of new technology during the Project will also occur through training courses to be held in Australia and Kiribati.

Research in Kiribati will be directed towards the development of site-specific nursery and grow-out techniques and will be focused on Abaiang Atoll. Experiments will be conducted to assess the most suitable culture methods and the best sites within the lagoon for pearl oyster culture. This research will be carried out by Kiribati Fisheries personnel assisted by an Australian ACIAR-OSB project scientist based on Abaiang Atoll and will be conducted in collaboration with the Abaiang Island Council. The pearl oysters used in these experiments will be produced in the pilot hatchery in Tarawa.

Spat-collection research in Fiji will be carried out by Fisheries Division, Fiji, assisted by staff from ICLARM-CAC. In the Solomon Islands, the results of this research will allow identification of the best option (ie. hatchery versus wild spat collection, and appropriate nursery techniques) for the establishment of village-based pearl oyster production. In Fiji, the feasibility of establishing pearl oyster farming based on wild collected spat will be determined.

Results of the research will be disseminated through the SPC *Pearl Oyster Information Bulletin* and through publication in international journals, trade magazines and newsletters.

For more information about the Project contact:

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Polishing pearl oyster culture in Micronesia

Source: *CTSA Regional Notes*, Vol #9, Fall 1997, p. 6

The US-affiliated Pacific Islands have a great potential to culture pearl oysters, with abundant pristine waters and inexpensive labour costs. Government entities and private aquaculturists in the region have been keen to exploit that potential.

To ensure fledgling efforts get off to a good start, the Center for Tropical and Subtropical Aquaculture's (CTSA) regional aquaculture extension specialist, Simon Ellis, studied pearl oyster culture techniques under the tutelage of Dr Maria Haws, an expert in pearl oyster culture. Readers in the US-affiliated Pacific Islands may remember Haws from the Summer of 1996, when she served as the CTSA Aquaculture Extension Specialist to Amercian Samoa, the Commonwealth of the Northern Mariana

Islands, the Federated States of Micronesia, the Republic of Palau and the Republic of the Marshall Islands. While in that post, Haws conducted a highly successful pearl oyster culture workshop.

In July 1997, Haws and Ellis travelled to the Marshall Islands to conduct a series of short demonstrations and informal discussions for farmers on a variety of topics, including pearl oyster biology and culture, reproduction, spat collection, oyster seeding, pathology, disease prevention, pearl production, farm engineering and farm economics.

While in the regional extension position, Haws wrote a pearl oyster culture manual. She noted a number of problems that farmers may face when culturing pearl oysters and suggested possible solutions.

One problem, common to farmers culturing almost all species, is a lack of reliable local source of stock. Haws commented that collection of pearl oyster spat forms the major obstacle to establishing a pearl oyster industry in Micronesia. She suggested that a possible solution would be regular collection of spat from areas where pearl oysters are naturally abundant. These spat would be best farmed in the same area. Transferring the spat incurs the risk of introducing disease and genetically swamping local strains. These risks can be minimised by developing transfer guidelines and training farmers in proper transport methods.

In addition, Haws said that keeping the oysters clean is important to their health, but novice farmers may spend too much time cleaning the animals, which increases farm labour costs. One solution is to adopt Tahitian methods and farm designs to increase efficiency and streamline all farm operations.

Haws noted that pearl oyster planting lines must be submerged deeply enough so that they are not moved by wind and wave action, which could shake the oysters off the line or negatively affect their feeding and growth. For that reason, farms must have trained SCUBA divers who can work on the stock.

Finally, she observed that the pearl oyster culture industry in Micronesia will require continuous technical assistance to become well established. The regional aquaculture extension specialist can make only four to five annual trips to each locale. To fill the gaps between his visits, Haws suggested that one or more local extension agents be hired, perhaps with funding from the Asian Development Bank or some other donor.

Observations on the impact of the installation of a pearl farm in Guaymas, Sonora, Mexico

by Enrique Arizmendi

Enrique Arizmendi, from Perlas de Guaymas, makes the following observations:

a. There has been an increase in the number of spat collected per bag for two consecutive years, both for *Pteria sterna* and for *Pinctada mazatlanica*, as our farm size has increased from research to pilot to commercial. We think this is the logical result of an important increase in the fertilisation rates of these pearl oysters.

b. Seed collection results in a re-use, not an extraction, of the organisms. We do seed collection and culture in the same bay and the pearl oysters stay with us for about four years, during which time they develop as fully mature adults and spawn several times before harvest. We don't know the survival rates from pearl oyster larvae to fully mature adults in the natural process but in culture it is about 80%. This is incredibly higher than the rate that can be deduced from observations on the number of adults in the natural beds (a few thousand) and of the larvae present (we can collect up to 600 *Pteria sterna* spat per bag).

c. Our collection and culture structures are working as artificial reefs for a great number of species. The Sonoran coast is very productive, but here at 28°N, there is a lack of suitable niches because there are no coral reefs, and rocky reefs are limited to the shoreline.

d. We have kept broodstock with the best traits for several years in the best conditions. The quality of these organisms for breeding is unsurpassable.

e. We, as the pearl industry leaders, agree with research groups in promoting the preservation of the natural pearl beds (the wild organisms) of both species of pearl oysters.

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The effects of the recent El Niño on pearl culture operations at Bahia de La Paz, South Baja California, Mexico

by Mario Monteforte

We registered nearly 4°C over the normal maximum temperature we usually read in the Bay, but this was only registered between the surface and 4 m depth. This acted to our advantage because we moved the whole installation to deeper waters. The cumulative average mortality was very similar to the normal average registered during the same season and within the same size and age of pearl oysters, this is very low (2.5 to 3.5%) .

On the contrary, we observed an extremely high natural recruitment. Our spat collectors (even the fact that we were not using 'the good ones') had averages of 150 spat per unit, when for those kind of collectors we usually had not more than 10 per unit previously.

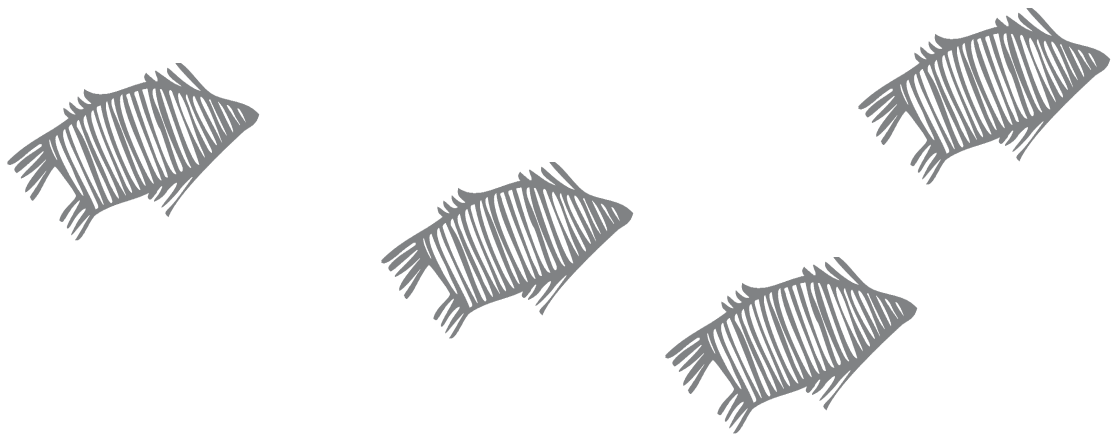
Among the other species associated with collectors of *Pinctada mazatlanica* (spat-fall of this pearl oyster in Bahia de La Paz is in summer), we observed a completely different composition to that we consider as standard. Many species were absent and many others were new. Vertical distribution was also all messed up both on the associated species and in *P. mazatlanica*. The maximum spatfall of *P. mazatlanica* takes place between 2 and 6 m depth and and is very rare below 8 m. This time the maximum spatfall was obtained between 5 and 12 m depth.

Every object on the bottom (old tires, ropes, the galvanised pipe structures used for bottom culture) was covered with spat of *P. mazatlanica.*

We believe that this event was a very important factor for the recovery of wild pearl oyster beds. We will follow some of these wild juveniles to see how they behave. Maybe in a couple of years the low density of natural beds will change for the better.

Note from the Editor: Mario Monteforte, of CIBNOR, La Paz, gives us below a recent update (20 January 98):

The temperature was 23.5°C today from surface to 30 m depth, against 19–20°C at the surface and the clear thermocline of 17–18°C between 9 and 12 m depth that we should expect at this time in a normal year. *Pinctada mazatlanica* is growing wildly. On the other hand, a good proportion of *Pteria sterna* should be mature and about to spawn, but less than 15 per cent of adult cultured specimens were found to be in stage two (that is almost ripe). In normal years, spat-fall of this species would be starting right now.



Pearl World news update

Source: *Pearl World*, the International Pearling Journal

Japan

The first Emergency meeting in 1997 into the mass death of Akoya oysters in the summer and fall of 1996 finally took place on 17 October in Watarai-gun, Mie Prefecture… a mere year-plus after the breakout. Testing by the Cultivation Laboratory reveals that existing parasites, bacteria and eumycetes are regarded as harmless, and no suspect virus has been detected so far. However, there still exists the belief in a chronic infection being the main cause of the extreme levels of mortality.

The predominance of malformed mantle lobe tissue seems to indicate a yet-undetected virus infection, food (phytoplankton) poisoning, or malnutrition. In addition, the widespread reddening of adductor muscles by carotenoid—possibly caused by an abnormal formation of collagen—is being suspected as a possible cause. This feared phenomenon is being seen in many prefectures this year as well; thus, more mass deaths are predicted.

At present, mortalities average 50–60 per cent for Koshimono in Ehime, 25–30 per cent for Tonenmono after Okidashi, and 10–15 per cent for 2-year old mother oysters. The figures are 30 per cent for Mie, and 40–60 per cent in Tsushima, Nagasaki.

It is readily apparent that the search for a practical synthetic nucleus continues. Patent application includes a molding material for the production of both pearl nuclei and synthetic pearls themselves, comprised of a thermosetting resin containing barium sulfate, having a 2.0 specific gravity and with an 80 whiteness degree.

Another documented method utilises an alkali (earth) metal oxide and a glass-forming oxide (among other ingredients) to 'provide a large-sized nucleus, excellent in yield and shape-providing property' along with the capability of controlling color tone and specific gravity. Components such as sodium oxide, calcium oxide, boron oxide and silicon oxide aim at providing a vitreous artificial pearl nucleus with a specific gravity of 2.8 plus or minus 0.2.

China

Reports coming out of China and Hong Kong are that another bumper year for Chinese freshwater pearls is in full swing. Reports are that more supposedly non-nucleated rounds and semi-rounds are appearing. The conjecture is that these shapes are being achieved by insertion of rounded pieces of mantle tissue.

Experts feel that at least 20 per cent of China's total output of freshwater pearls (FWPs) is in the coveted round or semi-round shape category. Dealers are also astounded by the rise in sizes. One reported that he was 'flabbergasted' by a selection of fine quality FWP drops measuring approximately 10 x 14 mm.

What is China's total output for the year? We hear figures ranging from 750 to 850 tonnes. In our opinion, this is way too low. From what impeccable sources tell us, we would not be surprised if it was half again, or even twice as much. Nobody really knows.

The one thing we all know is that Chinese FWPs are starting to give the Japanese Akoya fits. A decent strand of Akoya can easily run to US$ 4000, whereas a superb strand of Chinese FWPs in larger sizes

(up to 9 and even 10 mm these days) can be had starting at about a quarter of the cost. And which is the better investment, durability-wise? Pick the all-nacre FWP over the thin-nacre Akoya anytime, consumer advocates insist.

Tahiti

The recent Twentieth International **Poe Rava Nui** Auction is regarded as 'one of the most historic events during the years that sales of Tahitian black pearls have been organised for overseas and local buyers.'

The price per gram of a cultured black pearl at this auction averaged US$ 33.21, a level in keeping with the average Tahitian pearl export price which is up some 15 per cent over 1996.

Among the auction highlights: 100 per cent of the lots put up for sale were sold; 31 lots sold for 200 per cent or more above reserve price; one lot of 639 (9–12.5 mm rounds and semi-rounds) pearls sold for some US$ 126 000 or about US$ 198 per pearl, 190 per cent above reserve price; another lot of 186 medium drops sold for an astounding 410 per cent over reserve, tipping the sale scale at about US$ 330 per pearl.

No wonder the organisers are happy: Tahitian buyers dominated the action for the first time, and some US$ 4 830 000 were collected for the 63 988 pearls offered.

Martin Coeroli, Director of Perles de Tahiti, was quoted as saying that these results 'confirmed the increasingly higher price for Tahitian pearls of the past several months, with demand pushing up that price.'

Demand was certainly in force. Some attendees we talked to were dismayed at the feeding frenzy of smaller buyers, and worry about future escalations.

Exports of Tahitian blacks were up 9 per cent in volume and 32 per cent in value for the first three quarters of 1997. Japan's market share slipped to 50 per cent of volume, 40 per cent of value, while the USA became the largest Tahitian pearl export market as of September.

Tahiti Pearl News updates

Source: Excerpts from *Tahiti Pearl News*

20th Poe Rava Nui International Auction

The 20th International **Poe Rava Nui** Auction was one of the most historic events during the 18 years that sales of Tahitian black cultured pearls have been organised for overseas and local buyers.

For the first time in several years, the latest auction sold 100 per cent of the lots put up for sale. For the first time since 1994, the total value of those auction sales was more than 500 million French Pacific francs (CFP) [US$ 4.8 million]. And for the third straight year the average price per pearl sold at a **Poe Rava Nui** Auction was more than 7 000 CFP (about US$ 67).

During two historic days of sealed-envelope bidding from 17 to 18 October 1997, 45 buyers paid 501 805 857 CFP (about US$ 4.83 million) for 63 998 Tahitians pearls divided up into 129 lots. That produced an average purchase price per pearl of 7 842 CFP (about US$ 75.40), the highest level since 1994.

Most importantly, the auction produced an average price per gram of 3 454 CFP (about US$ 33.21). That is a price level in keeping with the average Tahitian pearl export price that has continued to flirt with 4 000 CFP per gram (about US$ 38.50) for the past several months, a level some 15 per cent higher than in 1996.

Still another historic aspect of the 1997 **Poe Rava Nui** auction involved the collective value of the 129 lots sold. That value represented a record 134 per cent increase in the collective reserve price for those lots at the opening of the auction.

'This amounts to a big satisfaction for us', said Alfred Martin, the director of the 20th **Poe Rava Nui** International Auction. He emphasised the important effort made to carefully select and group the pearls of each lot.

Martin Coeroli, director of *Perles de Tahiti*, which has been promoting Tahitian pearls overseas since 1993, summarised the auction results as 'a big success'. He added that the auction 'confirmed the increasingly higher price for Tahitian pearls of the past several months, with demand pushing up that price.'

That translates into auction prices returning 'to acceptable levels for sellers as well as buyers for the first time since 1994,' Coeroli said. Noting this was the first auction in several years during which all lots were sold, Coeroli said, 'Quality pays'.

He added that harmonising the lots with top-quality pearls presented assortments that were aimed at the buyer instead of the seller.

The end result was a **Poe Rava Nui** selection of 62 683 pearls that were divided up into 124 lots. Those pearls were chosen from a harvest of 88 334 pearls from 106 farm pearls spread over 15 atolls from the Tuamotu and Gambier Archipelagoes, **Poe Rava Nui** Board Chairman Pierre Lehartel said.

In 1996 **Poe Rava Nui** selected 75 044 pearls from 110 714 pearls submitted for auction consideration by 159 pearl farms. At the 1996 auction, of 138 lots offered, 14 lots were not sold at the auction. And at the 1995 auction, of a record 184 lots, only 99 lots found buyers. Another historic aspect of this year's **Poe Rava Nui** auction was the addition of five lots from *Tahiti Pearl Producers*, which began two years ago holding a yearly auction in April.

These five lots were sold for an average purchase price of 14 572 CFP (about US$ 140) per pearl and 7 271 CFP (about US$ 69.91) per gram. However, those high values were due to the small number of lots and their top quality.

Coeroli of *Perles de Tahiti* noted the diversity of this year's **Poe Rava Nui** auction buyers, the arrival of local wholesalers at the international level and the presence of many new buyers.

Most importantly, however, he said the auction was highlighted by competition among buyers at a time when the price of Tahitian pearls is rising. In the past, the auction produced competition among producers at a time when Tahitian pearl prices were falling.

Coeroli explained this year's phenomenon by saying, 'The minimum price was voluntarily set low to attract a maximum number of buyers. The purchase prices reflect the current prices for Tahitian pearl exports.'

Tahiti buyers dominate for the first time

Despite the buyers from 13 foreign countries, this historic 20th international auction was dominated for the first time by 11 buyers from Tahiti. Those local buyers collectively purchased 38 lots for 176 740 772 CFP (about 129 lots sold and 35 per cent of the collective value of the 129 lots). Among those 11 buyers from Tahiti were six jewellery boutiques, four wholesalers and one combined jewellery boutique and wholesaler.

There were buyers from 13 foreign countries at the auction, including: Japan (15), Hong Kong (3), USA (3), Italy (2), Australia (2), New Caledonia (2), Taiwan (1), France (1), Thailand (1), Switzerland (1), South Korea (1), Germany (1), and Spain (1).

Japanese buyers, who normally dominate Tahitian pearl auctions, slipped to second position this year. They bought most of the 40 lots, but they spent 160 million CFP (about US$ 1.5 million), which was slightly less than Tahiti's spendings.

Exports

September 1997 exports resulted in an average price per gram of 2 689 CFP (US$ 24.67), which was higher than the 2 249 CFP (US$ 24.18) average export price of 1996. But the September figure was down slightly from the August 1997 average price of 3 848 CFP (US$ 34) and that of July 1997, 3 899 CFP (US$ 35.4). The 20th **Poe Rava Nui** International Auction produced an average price per gram of 3 454 CFP (US$ 33.2).

In terms of September export markets, Japan, as usual, was the number one destination, but only in terms of volume. Japan imported 163 kg of Tahitian pearls, worth 352 million CFP (US$ 3.2 million). Singapore was the second biggest Tahitian pearl export destination with 92 kg that were worth 361 million CFP (US$ 3.3 million). And Japan's market share of all Tahitian pearl exports in September was only 50 per cent in volume and 40 per cent in value, compared with 77 per cent in volume and 80 per cent in value in September 1996. The United States were the third biggest Tahitian pearl export market in September with a volume of 62 kg worth 144 million CFP (US$ 1.3 million).

Nine-month totals also up over 1996

Tahiti's Customs Department statistics also show that during the first nine months of 1997, a total of 3 128 kg of Tahitian pearls worth 9.85 billion CFP (US$ 90.4 million) were exported. That was an 8.6 per cent increase in volume and a 32 per cent increase in value over the same period last year. The USA remained the n°2 export market for the first nine months of 1997. The n°1 Japanese market imported 1 838 kg of Tahitian pearls worth 5.43 billion CFP (US$ 50 million) during those nine months.

Ten countries illustrate dramatic export growth

The dramatic growth during 1997 in the overseas market for Tahitian black pearls is best illustrated by the large increases in the volume and value of pearls exported to 10 countries. This growth represents two important developments in the exporting of Tahitian pearls. First, it is an indication of the increased diversity of the export market. Second, it confirms Japan's smaller market share of Tahitian pearl exports. Still another example of the increased vitality of the export market is the 31.6% increase in the value of all Tahitian pearl products exported during the first nine months of 1997 compared with the same period last year.

Loose Tahitian pearl exports (1997 vs 1996; January to September)

Country	1997		1996	
	Volume (kg)	Value (million CFP)	Volume (kg)	Value (million CFP)
Japan	1,838	5,430		
Australia	126	303	76	156
France	25	79	17	36
Germany	38	153	5	32
Hong Kong	200	586	188	517
New Zealand	26	61	6	22
Philippines	122	337	125	211
South Korea	22	113	11	74
Switzerland	41	119	3	12
Thailand	15	60	0.78	1
USA	527	2,095	320	1,014

Balanced on pearls

Source: Excerpts from an article in *Island Business*, December 1997, p. 46

Exports of cultured pearls have soared to become a business critical to French Polynesia's future. Exports in 1995 were nearly 3.3 tonnes worth US$ 92.54 million. In 1996 exports reaped US$ 138.62 million. Those figures put pearls not so far behind annual tourism receipts of around US$ 200 million and completely overshadows all exports combined.

It's not just status as French Polynesia's number-two industry that makes the cultured pearl trade vital. Unlike tourism, much of the earnings from pearls are retained by the territory, with millions of dollars going to the thousands of people employed by pearl farms.

Except for the comparatively small production by the Cook Islands, where pearl farming began less than a decade ago and where farms at Manihiki were damaged by a hurricane, Tahiti's hold on black pearl farming is almost complete.

But Tuvalu, Kiribati, the Solomon Islands and other Pacific Island countries wish to enter the business too and want French and Tahitian technical support. Could their entry cause eventual saturation of the market? What is the success rate for starting farms?

Didier Sibani is French Polynesia's biggest pearl dealer. Maison *Sibani Perles* has 16 stores in the territory, some in Europe and Indonesia and will open five more in the territory and others in New Caledonia, Australia and Bali. He buys 150 000 top-quality pearls a year. At the October 1997 auction, he was the top buyer, buying nine lots for nearly US$ 425 000.

'There is no doubt that there are too many pearl retailers now in Papeete', says Sibani, who arrived there from France aged 17 and turned to pearl farming, then buying pearl and manufacturing jewellery, after deciding that shark fishing was not a way to make money.

'It's hard. The local market has two customers; locals and tourists. The local market is saturated and really hard,' he says.

Sibani retains pearl farm interests but mainly operates as a jeweller and trader in loose pearls oriented towards tourists.

The Americans and Japanese are the main buyers. Sibani says the local retail market is about saturated and the wholesale side needs restructuring and improved organisation, which is happening with government help.

'Until now production has been for volume, but now we are working to export only quality pearls and withold low-quality stuff. It took three decades for Tahiti's industry to climb where it is now, other countries will need at least 20 years,' he says.

'A lot of countries want to start this business but it is not easy to learn and it needs heavy investment. It is

a life experience. If you are too stressed, you don't get good pearls. That's why it is hard to get pearls from big islands and why we go to the Tuamotus where the water quality is better.'

The technicians who persuade an oyster to form a pearl by inserting a small shell bead as a nucleus in just the right part of the oyster 'need almost 5 000 grafts experience before they get not very good results—maybe one pearl from 20 grafts'. The Tahitians were taught by Japanese and Chinese technicians.

Sibani believes Tahiti's industry can triple sales of good-quality pearls to around US$ 500 million a year by capturing European and other markets beyond Japan and the United States where as jewellery pearls are still little known.

'The Japanese are the main buyers but sell to the United States, but some big Americans are becoming their own buyers. Hong Kong buyers are also very important; Europe is just beginning first with Germany, but now there is a big Italian demand. The French market is a very late developer.'

In a simple gold setting, Sibani sells a single pearl necklace or a pair of earrings for typically US$ 1 000 to US$ 2 000. Top prices for good necklaces are around US$ 50 000. Buyers buy in batches for the assembly of necklaces or other multi-pearl pieces. Forty pearls of similar quality, colour and diameter will fetch almost double the price of a mixed parcel. Sibani expects prices to climb for a few more years and then stabilise.

'Australian and Indonesian yellow pearls fetch a little higher than Tahitian prices but we will match Australian and Indonesian prices in two or three years. There is no danger of glut yet for good quality pearls. Saturation for bad quality has not arrived yet because jewellers are devising new setting styles for them.'

'Television sales are a new market device. Every day, from all around the world, we have requests for necklaces or earrings. It is quality, colour and size that count and it is hard for us to meet demand.'

'Sometimes you have exceptional pearls. We sold one of 20 mm, almost as big as a cherry, with green/blue colours, for almost US$ 40 000 a few weeks ago. I am sure it will fetch double or triple the price very easily,' says Sibani who has a personal collection of cultured gems and some 'not so nice' natural pearls.

What is the price for a natural pearl of exceptional quality found by accident in a lagoon. 'You don't have a price. You would have to sell it in a special way, to a special customer, perhaps to a museum, but unfortunately it is impossible to find them.'

Myanmar pearl enterprise and Tasaki Shinju Company to set up a joint venture

Source: Excerpts from an article in *The New Light of Myanmar*, 7 March 1997, p. 6

Reaching an accord between Myanma Pearl Enterprise and Tasaki Shinju Company of Japan in March 1997 has initiated a new step for the Myanmar's pearl production sector and the market-oriented economy adopted by the State, said Minister for Mines Lt-Gen. Kyaw Min.

He was speaking at Sedona Hotel where officials of MPE and the Japanese company signed a production-sharing contract on pearl culture to be conducted on Myeik archipelago. The Japanese company is experienced in pearl culture and distribution, and also possesses advanced technologies in this field, he added.

Tonga pearl farming to move forward

Source: Excerpts from the *Marshall Islands Journal* (29/8/98) and Hawaii Public Radio's Pacific Island News (November 1997)

The Marshall Islands Journal has reported that the King of Tonga announced plans to develop pearl farming in the Kingdom. Negotiations were reportedly under way with a Japanese company to extend pearl culture facilities in Vava'u. These primarily focus on the winged pearl oyster, *Pteria penguin*, for producing mabe (or half pearls). Some culture trials with the blacklip pearl oyster, *Pinctada margaritifera* are also under way. Meanwhile, Hawaii Public Radio's Pacific Island News has reported increased interest in Tonga's black pearl resource from several French Polynesian pearl farming companies.

It's got to be pearl-fect!

Source: Excerpts from an article by Suzi Jarrel in *Australian Jeweller*, Oct – Dec 1997, pp. 6–11

The magic of the oyster

In order to visit one of the land farms belonging to Paspaley Pearls, the largest producer of Australian South Sea pearls, I had to take a journey by sea plane. The farm itself is built on the land to service the oyster beds out in the sheltered bay.

But this is no health farm, it is the place where the oyster shells receive their tender loving care. Far removed from their chic destinations, the pearls grown here are looked after by crews consisting of young men and women. They work a 'two-week-on, one-week-off' shift on the farms, going out into the bay every day unless the weather conditions make this too dangerous. The seeded oyster shells are all placed in panels of six and each panel is hung down under the water on a line which is attached to another main line which extends across the bay. There are approximately 100 panels on each line and with lines strung across the entire bay, this is big business!

The big clean-up

Each of the shells is cleaned every three to four weeks for three years and that means a lot of time and commitment, not to mention financial investment. A total of about 25 people work each day on several cleaning boats out in the bay. These crews spend eight hours every day for two weeks at a time on these small boats. This is extremely monotonous work out in the hot sun and, as one of the crew put it, 'Here you get plenty of time to reflect on your life, where you have been and where you want to go from here'.

There is time, plenty of time for reflection. The camps are remote places and the work is physically demanding. Each panel must be brought up on board the ship and the seaweed and barnacles scraped off the shells, the ropes inspected and the whole panel washed before being placed back in the water. It's a strange life, some people love it and some only last one three-week shift.

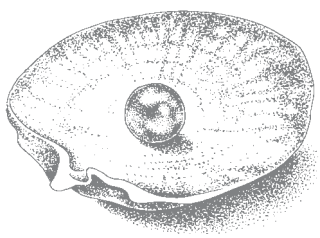
Harvest time

After three years in the oyster, the pearls are ready for harvesting. Broome Pearls invited me on board their ships, which are moored out at sea, for the ten-day harvest so I could see for myself the result of all this hard work. I was welcomed aboard by Michael Kallis, the owner and his general manager John Kelly. In his shorts and T-shirt, John, complete with earring, had all the appearance of a present-day pirate. But this man knows what he's about. Having first determined the state of the tides, he puts in motion the harvesting of 9,000 shells a day.

This involves 28 men on two boats, collecting the shells, removing the pearls and then returning the newly seeded oysters back to the lines at sea. Add to this equation the need to log all this information into the computer on board their new state-of-the-art ship, as well as keeping a wary eye on the weather for typhoons and you start to get an idea of John's workload. He even made time to explain it all to me.

The small cleaning boats are used to take the panels that are to be harvested from the lines and bring them to the mother ship. The first step, once aboard, is to place the shells into tanks of sea water, where they begin to open slightly. A wooden wedge is then inserted into the shells to keep them open and they are ready to be taken below deck to the operations room. Nothing prepared me for this process. Imagine a line of surgeons gowned and masked, ready to perform minor surgery requiring hygienic conditions and high precision aboard a boat moving in the swell of the sea and you have some idea of the skill required by these technicians.

Firstly, the technician inserts a small instrument into the opening made by the wedge and with one deft movement removes the pearl. And there it is in my hand—a perfect living gem. The skill of the technician can be literally life or death to the oyster. Most of the technicians return year after year to work on the Kallis boats. They say that conditions get better each year and that the new boat is really something else. One technician told me that his son has now followed him onto the boat and works with him. The people on board are extremely well looked after; Michael Kallis is a great believer in the 'get back what you put in' policy and certainly even after ten days cramped together at sea the atmosphere on board was good humoured and relaxed.



Grading the pearls

Back on dry land the next day, Michael Kallis took me to meet David Norman, the Master Grader who is responsible for the grading of the harvested pearls and the selling of the crop. An unbelievable sight met my eyes when David Norman took me through the vault doors into the grading room. There was a sea of pearls everywhere! In bags, on the table, in the safe. The pearls are firstly roughly sorted by size and colour.

Then they are cleaned and logged into the computer. The bags are double checked to ensure the number inside tallies with the number stated on the tag and then given for grading. The graders, all dressed in white, are seated at a table covered in white. This is to ensure that the colour of the pearl is not affected by any other colour around it. Using a board to roll the pearls along they use their skills to check the shape, size and colour of the pearl.

The colour can vary from a greyish hue through to a golden colour. These pearls are then bagged according to their size, etc., and given to David Norman. He grades the pearls still further, for quality and for sale purposes. Watching David at work surrounded by the sheer beauty of trays and trays of perfect pearls, destined to eventually make their way to the chic boutiques and jewellers around the world, is an image that will stay in my memory for a long time.

But none of this would be possible without the pristine, warm waters of the Australian coast. The companies using these waters need to work together to ensure that no pollution spoils this environment. The distance between each stretch of water used for the cultivation of the pearls is carefully regulated, as are the sizes of the farms.

The companies themselves take great care to keep the water free from pollution. Indeed, the whole pearl industry is environmentally friendly. Even the shells which can no longer be used for producing pearls are not wasted. The meat is taken from the inside and used in cooking. The shell is ground down for the mother of pearl products such as buttons.

If the future of the Australian pearl industry is to remain secure, everyone has to work together to ensure that the waters remain pure and unspoilt.

Pearls vs Tuna

by Neil A. Sims

There is much mileage made in the regional media out of the Pacific tuna industry. It certainly demands attention : there is an entire agency devoted to regional fisheries management (read 'tuna'), and a branch of another agency expending a comparable effort on tuna research. There are standing committees and ad-hoc committees, and whole phalanxes of staff in just about every national fisheries office.

All this attention over what? The entire Pacific-wide tuna catch – including that of various foreign fishing fleets – had an annual value of around US$ 1.7 billion in 1995 (Gillett, 1997). This is up considerably from 15 years ago, when the 1982 value of the catch was a mere US$ 375 million. Tuna's contribution to Pacific Island economies is mainly through licensing fees to governments (this might possibly explain why governments are so enamoured of the tuna industry). These access fees comprise around US$ 66 million per year, for the entire region (Gillett, 1997).

There may be some potential for expansion of the catch to perhaps 50 or 100 per cent of its current volume, without endangering stocks, but the only way to significantly increase its value to the Pacific Islands is to encourage greater participation in the fishery on the part of the islanders. Some modest gains have been made in this arena, but they appear doomed to be always modest. Gillet (1997) estimated that locally-based tuna vessels contributed maybe US$ 100 million per year to Pacific Island economies. There were perhaps 21 000 to 31 000 tuna-related jobs generated throughout the region (ibid).

By contrast, gross revenues for pearls from French Polynesia alone are around US$ 150 million. This represents roughly 10 per cent of the total value of the regional tuna catch—from one country, thirty odd lagoons. There are six or seven countries which can offer considerable scope for black pearl expansion. With continued strong promotional efforts, it is not inconceivable that this industry could sustain a three-fold, five-fold, or greater increase in volume and value over the next decade or two. In an article in this issue ('Balanced on Pearls', pp. 18–19), Sibani of Tahiti suggests that such an expansion could be easily sustained.

This article also touches on one most important—and most frequently forgotten—consideration: pearl revenues are earned directly by the individual farmers in the Pacific Islands. The revenues stay in the islands, and primarily on outer atolls, away from urban centres. It has multipier effects throughout the atolls themselves, and to the producing nations.

The best available information on job creation in the pearl industry is from French Polynesia in 1989, when 2 300 people were estimated to be directly employed in pearl culture. This number has probably seen a five-fold increase in the intervening years, as the industry has similarly grown since then. Using the same multiplier ratios as Gillett (ibid) of between 1:1 and 1:2 for direct: indirect jobs created, yields a total employment figure for French Polynesian pearls of between 23 000 to 34 000 jobs. Most of these, remember, are jobs on the outlying atoll islands.

Pearl culture is also an aquaculture industry. It is cultivating, not extracting. It is the essence of sustainability, in a way that wild stock exploitation (of finfish or shellfish) could never hope to be.

With the imminent hatchery-driven expansion of pearl farming across the Pacific, this industry will grow. It may never eclipse tuna in terms of total value of the catch, but it might possibly have already exceeded the tuna industry in terms of the revenues brought into, and circulated around within, the island economies.

No, we don't want to detract from the attention accorded to the Pacific pelagics. We all love our sashimi, and the access fees sure do help keep the governments running. But pearls have eclipsed most other likely candidates for comparison. There is little else in the marine sector by which to measure it. The total value of all other commercial fishing in the region, outside of the industrial tuna fishery, for example, is estimated to be around US$ 82 million p.a. (Dalzell, et al. 1996).

I know, I thump this drum every issue. Same drum, different beat. I guess I would just like to see more folk more aware of this perspective. Pearls deserve some greater recognition. Perhaps the place to start is for each of us to commit to memory a couple of the above facts or figures, and toss them out casually in conversation with one or two of your more influential friends.

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Pearls and Pacific regionalism

by Neil A. Sims

-The principal constraint to growth of the Pacific pearl industry in new areas has been the limited numbers and restricted distribution of wild stocks. Over the past decade, hatcheries have shown increasing promise, but the conventional wisdom was that you still couldn't seriously consider farming in areas without a large pool of wild oysters.

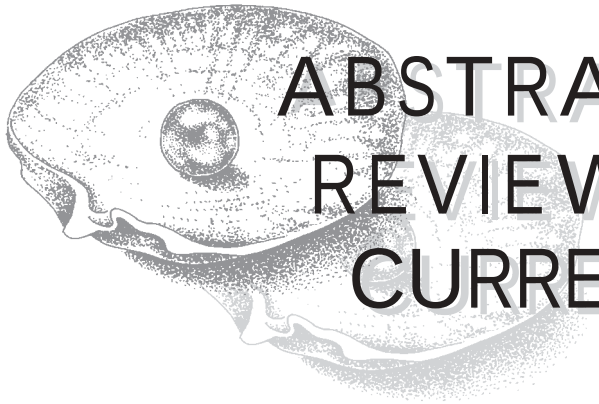
Over the last six months, however, the muted hatchery bugling has reached a fanfare crescendo. Simply-constructed, economically-run hatcheries have yielded spat in the hundreds of thousands for three separate projects. Post-settlement handling techniques have also improved dramatically, meaning that a far greater proportion of these spat will reach seedable size.

These milestones underscore the impending expansion of pearl farming across the Pacific. The lustre — and the lucre—of pearl farming has for too long been hidden beneath a bushel; or more factually, hidden beneath the surface of the NW Australian coast, or eastern Polynesian lagoons. Farming has for too long been tethered to wild stocks for collection, or for supplying consistent spat-falls to collectors. This is now changing. Pacific pearl culture is in the fledgling stages of becoming a regional industry.

We need to begin to think about what we might become, and what models are out there for regional co-operation. Yes, OK, pearl farms are local, not regional. Yes, the oysters don't migrate much. It is still a single market however, and we are all reliant on the same pool of seeding technicians, the same sources of supply for materials and nuclei. There are strong arguments for co-ordinated promotional efforts, and unified grading and pricing standards.

I remember those days, not so long ago really (the early 1980s), when a bilateral tuna fishing treaty was considered a rarity in the Pacific. With a gradual, persistent massaging, Pacific tuna interests are now able to sit down together, foreign fishing countries and island nations, as they recently did in Majuro, and consider a regional fishery management policy, and regional licensing agreements. Pacific tuna has come a long way in the 15 odd years that I've been following it.

The next 15 years should be equally momentous for Pacific pearling. We all need to begin to pay attention to these impending changes. We need to think about them, and devise strategies which can help build the industry up, without tearing each other down.



ABSTRACTS, REVIEWS AND CURRENT CONTENTS

Pearls of Pearl Harbor and the Islands of Hawaii:

The History, Mythology and Cultivation of Hawaiian Pearls

by Michael Walther, edited by C. Richard Fassler

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Breeding cycle of pearl oysters, *Pteria sterna* (Gould, 1851) and *Pinctada mazatlanica* (Hanley, 1856) [Pteriidae] in Guaymas, Gulf of California, Mexico

Source: Abstract from a Master's Degree thesis by Enrique Arizmendi Castillo, Instituto tecnólogico y de estudios superiores de Monterrey (ITESM), Campus Guaymas

Pearl oysters, *Pinctada mazatlanica* and *Pteria sterna*, have been an attractive resource for centuries in the Gulf of California, but natural beds were depleted to a point that populations became endangered and a fishing ban was imposed. Any further use of this resource will be linked to aquaculture operations and, for this purpose, it was relevant to know the breeding cycles.

Wild pearl oysters of both species from different points and cultured organisms from the ITESM long-line system, were sampled monthly for a one-year period. Gonad histology and condition index were used to find the seasonal cycle of gonad activity. Gonad width was also measured for *Pinctada mazatlanica.*

Pteria sterna presents its breeding season from October to April with two peaks. In culture, peaks are in November and April; in the wild the first peak lasts from October to December and the second is in April. Breeding season is of greater intensity and duration in the wild than in suspended culture. During the summer, gametogenesis is suspended and regression may be complete, the effects of summer are more pronounced in culture conditions than in the wild, the breeding cycle is asynchronous.

Sex ratio (F:M) is 0.45:1 in culture, and 1.4:1 in the wild. *Pteria sterna* is hermaphrodite and its primary gonad maturity may be either as males or females. Bisexual organisms were found only in culture (4.17 per cent) and it was considered to be transitional. First maturity may begin at 8 mm.

Pinctada mazatlanica presents its breeding season in summer (from June to September), with maturity peaks in June (main) and August (secondary). Regression is never complete and the gonad of a mature organism does not pass through an indeterminate sexual phase. In winter, organisms may enter a dormant stage being in practically any stage of gonad maturity. In the months when temperature dropped, ganetogenesis was absent. Its breeding cycle is asynchronous.

Pinctada mazatlanica is a protandric hermaphrodite whose first maturity is presented in a range of sizes up to 100 mm of height. Bisexuality was present in 1.4 per cent of the sample and it was considered to be transitional. Sex ratio (F:M) was 2.6:1, very different from any sex ratio of pearl oysters.

Of the three methods, used the histological procedures provided more information about reproduction and sexuality of these species; condition index marks maturity peaks when all samples come from the same location; and gonad width clearly indicates maturity peaks even for organisms that come from different localities of one area, besides being more objective, fast, easy and cheap than histological procedure.

James Cook University recent publications

Hatchery and early nursery culture of the blacklip pearl oyster *Pinctada margaritifera* (L.)

P.C. Southgate & A.C. Beer

Department of Aquaculture, School of Biological Sciences, James Cook University of North Queensland, Townsville, Queensland 4811, Australia

Journal of Shellfish Research, 16(2):(1997)

This paper reports on the spawning induction, and larval and early nursery culture of the blacklip pearl oyster *Pinctada margaritifera* (L.). Spawning was induced by manipulating the water temperature in the broodstock tanks from an overnight low of 22°C to a high at spawning of 32–33°C. Larvae were cultured in 500 l tanks in which the water was replaced every 3 days (static system) or in 500 l flow-through tanks in which 100 per cent of the tank water was changed every 24 hours.

There was no significant difference in growth of the larvae in static or flow-through tanks. Mean (±s.e.) antero-posterior shell length (APM) on day 20, when the first larvae were removed from larval culture tanks into settlement tanks, was 214.38 (±3.0) µm and 217.52 (±2.93) µm for static culture and flow-through culture tanks, respectively. Spat held in settlement tanks had a mean (±s.e.) dorso-ventral shell height (DVH) of 1.38 (±0.03) mm at 49 days post fertilisation when they were placed in plastic mesh trays and moved to the ocean nursery site.

After 106 days spat were removed from collectors and graded. The mean (±s.e.) DVH of 106 day old spat was 13.91 (±0.27) mm; the largest individual had a DVH of 23 mm while the smallest was less than 2 mm. At grading, 0.2, 8.9 and 67.3 per cent of spat were retained on 15, 10 and 5 mm plastic mesh, respectively and 23.6 per cent fell through the 5 mm mesh.

Growth of spat in plastic trays and pearl nets was assessed at densities of 10, 50 and 100 per tray and at densities of 20, 50, 100, 150 and 200 per net over a 19-week growth trial. DVH was significantly greater in pearl oysters held in plastic trays at a density of 100 per tray (40.48±0.9 mm). Oysters held at this density also had the greatest APM (39.68±0.9 mm) and the greatest wet weight (7.44±0.4 g).

Pearl oysters held in pearl nets showed the greatest DVH (39.22±0.6 mm), APM (38.36±0.6 mm), HL (34.47±0.5 mm) and wet weight (6.84±0.8 g) at the lowest density of 20 per net. These values differed significantly from those of juveniles held at a density of 100 per net and also from those held at a density of 50 per net in all except wet weight.

The DVH and APM of oysters held at a density of 20 per pearl net were significantly greater than those of oysters held at a density of 10 per plastic tray, and there was no significant difference in HL or wet weight between these two groups of animals. The presence of leather jackets (*Paramonacanthus japonicus*) significantly affected growth rates of the spat.

Effects of stocking density on the growth and survival of juvenile silverlip pearl oysters (*Pinctada maxima*, Jameson) in suspended or bottom culture

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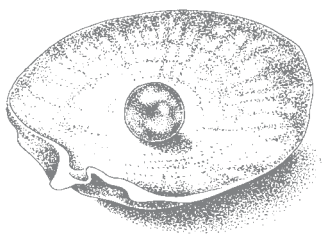
Journal of Shellfish Research, 16(2):(1997)

The growth and survival of juvenile silverlip (or goldlip) pearl oysters, *Pinctada maxima* were compared at two stocking densities: 28 individuals per net (75 oysters / m^2) and 48 individuals per net (128 oysters / m^2) with animals held either in suspended or bottom culture. The experiment was terminated during the 6th week due to high mortality in bottom cultured pearl oysters.

Mean (±s.e.) survival was best in 28-pocket nets held in suspended culture (99.0±1.6%), and was significantly better than any other treatment ($P<0.01$). Survival was also high in the 48-pocket nets in suspended culture (94.8±3.6%). Mean (±s.e.) survival in bottom culture was significantly lower than either stocking density in suspended culture ($P<0.05$) being 15.8±7.8% and 13.3±3.6 % respectively for 28- and 48-pocket nets.

Pinctada maxima held in suspended culture were significantly larger ($P<0.001$) than those in bottom culture. In both suspended and bottom culture, *P. maxima* in the 28-pocket panel nets were larger in shell height and hinge length ($P <0.001$) than those in the 48-pocket panel nets.

Additionally, pearl oysters held in bottom culture had brittle shell margins, particular at the growth processes. The results indicate that culture system had a greater influence on the results than stocking density. Differences in the availability of food in the water near the surface and water near the seafloor, are believed responsible for the result. The total phytoplankton count per litre of sea water, the dry weight of suspended solids and the diversity of species was always greater near the surface.



Inducing detachment of silverlip pearl oyster (*Pinctada maxima*, Jameson) spat from collectors

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Aquaculture, 154:(1997)

A number of stress factors were assessed for their potential to induce detachment of silverlip (or goldlip) pearl oyster (*Pinctada maxima*, Jameson) spat from spat collectors. The factors assessed were: increased salinity to 40 parts per thousand (ppt) or 45 ppt, reduced salinity to 30 ppt or 25 ppt, raised (to pH 10) and reduced (to pH 4) pH and exposure to air.

All treatments promoted significantly greater ($P<0.001$) per cent spat detachment than the control treatment of 'normal' sea water (34 ppt, pH 8.0). The pH 10 treatment resulted in heavy mortality (86%) after 1 hour and was abandoned. The greatest percentage of detached spat (92.3± 0.6%, mean ± s.e.) resulted after 1 hour exposure to hypersaline sea water at 45 ppt; this was significantly greater ($P<0.05$) than for other treatment.

The next best treatment was pH 4, which resulted in 85.6±2.3% detached spat after 1 hour. Exposure to the treatments beyond 1 hour, except in the case of exposure to air, did not yield significant increases ($P>0.05$) in the proportion of detached spat. Spat that had detached in the treatment baths within the first hour began to re-attach during the second hour.

With the exception of the pH 10 and air exposure treatments, detached spat in all treatments had firmly re-attached and had apparently adapted to the new environmental conditions after 24 hours. Spat exposed to air for up to 6 hours survived. No mortality was recorded for any treatment 24 h after the spat were returned to control sea water.

Assessment of the nutritional value of five species of microalgae for spat of the silverlip pearl oyster, *Pinctada maxima* (mollusca: pteriidae) (Jameson)

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Asian Fisheries Science, 10(2):(1997)

A feeding trial was conducted to assess the nutritional value of five monospecific microalgal diets for spat of the silverlip (or goldlip) pearl oyster, *Pinctada maxima.*

The five species tested were *Isochrysis* aff. *Galbana*, (T-ISO), *Pavlova lutheri*, *Chaetoceros muelleri* (formerly *C. gracilis*), *Chaetoceros calcitrans*, and *Tetraselmis suecica*. Spat were 75 days old at the start of the growth trial which ran for 21 days.

Pearl oyster spat fed with *C. muelleri* showed the largest increase in ash-free dry weight (organic content), which was significantly greater ($P<0.05$) than for any other species. The mean ash-free dry weight (AFDW) of spat fed *T. suecica* and T-ISO did not differ significantly from each other, but were significantly greater than for spat fed *C. calcitrans* and *P. lutheri* ($P<0.05$).

The final AFDW of spat fed *P. lutheri* was not significantly different from that of unfed spat ($P>0.05$). Differences in the food value of the five species of algae could not be explained by their reported nutrient composition alone. The results illustrate the importance of experimental testing of algal diets for bivalve spat rather than sole reliance on published nutritional values.

Effects of stocking density on the growth and survival of early juvenile silverlip pearl oysters, *Pinctada maxima* (Jameson), held in suspended nursery culture

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Aquaculture 153 (1997): 41–49

This study investigated the effects of stocking density on the growth and survival of juvenile silverlip (or goldlip) pearl oysters, *Pinctada maxima*. Spat were resettled onto PVC slats (75 x 500 mm^2) and held in suspended nursery culture for 6 weeks at four stocking densities: ten juveniles per slat (1.3 juveniles per 100 cm^2); 50 juveniles per slat (6.7 juveniles per 100 cm^2); 100 juveniles per slat (13.3 juveniles per 100 cm^2) and 150 juveniles per slat (20 juveniles per 100 cm^2).

Best survival was recorded at a stocking density of ten juveniles per slat (80±4.36%, mean±s.e.) which was significantly higher than the other densities tested ($P<0.05$). Survival did not differ significantly between the other densities tested ($P<0.05$). Best growth, measured as wet weight, shell length and shell height was shown at a density of ten juveniles per slat, where wet weight and shell length were significantly greater than at any other stocking densities ($P<0.05$).

Shell height was also significantly greater at a density of ten juveniles per slat than at all other stocking densities with the exception of 50 juveniles per slat. Spat were significantly ($P<0.05$) smaller at each increase in stocking density from 50 juveniles per slat to 150 per slat. The incidence of growth deformities increased with increasing stocking density. These increases were significant ($P<0.05$) between all densities apart from 100 juveniles per slat and 150 per slat, where the difference in the number of deformed animals was not significant ($P>0.05$).

The ratio of shell height to shell length was also influenced by stocking density. Differences between the shell height: shell length ratios were significant between all stocking densities ($P<0.05$) except 100 juveniles per slat and 150 juveniles per slat, where there were no significant differences ($P>0.05$).

Fouling animals and their effect on the growth of silverlip pearl oysters, *Pinctada maxima* (Jameson) in suspended culture

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Aquaculture 153 (1997): 31–40

A comparison was made of the growth of 1-year-old silverlip (or goldlip) pearl oysters, *Pinctada maxima*, cleaned every 2, 4 or 8 weeks or after 16 weeks.

The diversity of fouling animals was recorded and their dry weight (DW) estimated. Survival was 100% in all treatments, with the exception of a single death in one replicate cleaned every 4 weeks. The DW of fouling animals increased steadily over the first 10 weeks of the experiment before declining during weeks 10 to 16.

Significant ($P<0.05$) differences in the DW of fouling animals between treatment was observed, and pearl oysters' growth was affected by fouling. The wet weight, shell height and shell length of pearl oysters cleaned every 2 or 4 weeks was significantly greater ($P<0.05$) than that of pearl oysters cleaned every 8 weeks or after 16 weeks. The most common fouling animals were: barnacles, *Pinctada* spp., *Pteria* spp., *Crassostrea* spp., and polychaete worms.

Some pearl oysters that were left uncleaned for 8 or 16 weeks had shell deformities caused by *Pteria* spp. invading the shell margin. Based on this study, fouling animals should be removed on a monthly basis to maximise growth and reduce the risk of growth deformities. More regular cleaning, while having no deleterious effects on pearl oyster growth or survival, appears to be unnecessary and may add to operational costs.

Byssus production in six age classes of the silverlip pearl oyster, *Pinctada maxima* (Jameson)

Joseph J. Taylor[1,2], Robert A. Rose[1] & Paul C. Southgate[2]

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Journal of Shellfish Research, Vol. 16, No. 1, 97–101, 1997

Two experiments were conducted to study byssus production of silverlip (or goldlip) pearl oysters, *Pinctada maxima*, from six different age classes.

In the first experiment, *P. maxima* aged 75 or 120 days were removed from their point of attachment by severing the byssus and were placed in clear plastic Petri dishes. The production of byssal threads and the behaviour of the pearl oysters were monitored over a 120-hour period. Emerging byssal threads were pinkish before changing to green. Juveniles at 75 days of age began reattaching faster than juveniles at 120 days of age.

However, after the first 12 hours, older individuals had produced significantly more ($p<0.001$) byssal threads than the younger individuals and they produced significantly more ($p<0.001$) byssal threads over the 120-hour period. Additionally, byssal thread production for the younger juveniles did not increase significantly ($p>0.05$) after 48 hours, whereas byssal thread production from older animals continued to increase significantly ($p<0.001$) after this period.

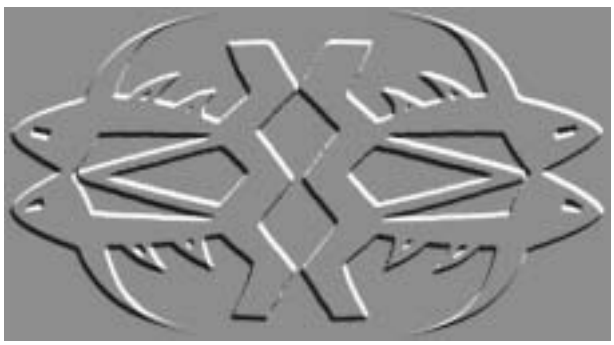
The maximum number of threads produced by a single individual in the older age class was 30, compared with 16 in the younger age class. Juvenile *P. maxima* were observed to voluntarily eject the byssal apparatus, move, and reattach within 24 hours.

Re-attachment after voluntary ejection of the byssus was faster than after mechanical severing. In the second experiment, older *P. maxima* aged 7, 9, 11 or 13 months were removed from their nets after severing the byssus with a scalpel.

These oysters were placed in nets in an area of either strong (2.5–3.5 knots) or mild (<1 knot) current. Pearl oysters placed in a mild current reattached faster than those in a strong current.

However, after 4 days, pearl oysters aged 13 months in the strong current area had produced significantly more threads ($p<0.05$) than those in the mild current, and the same was true for 11-month-old pearl oysters by Day 5. From Day 5 onward, there were generally more threads produced by pearl oysters in strong current compared with mild current; however, these differences were not significant ($p>0.05$) for pearl oysters aged 9 and 7 months. By the end of the 11-day experiment, 9-month-old oysters had produced significantly more byssal threads than any other age class, and there were significant differences between all age classes in the number of threads produced.

The results of these simple experiments provide useful information on the time for reattachment of different age classes of *P. maxima* in a variety of culture conditions after mechanical severing of the byssus.



AQUACULTURE '98

Abstracts of posters and papers which were presented at the World Aquaculture Society Meeting in Las Vegas from 15 to 19 February 1998.

Recent developments in the farming and marketing of Tahitian black pearls

C. Richard Fassler

Aquaculture Development Program, State of Hawaii Department of Land & Natural Resources, 1177 Alakea Street, Room 400, Honolulu, Hawaii 96813.

Tahiti's black pearl industry has enjoyed a period of rapid expansion, attaining a value of US$ 140 million in 1996. Exports for the first half of 1996 were up 123 per cent in volume and 43.8 per cent in value. Entering 1997, per-unit prices improved, and the industry outlook was strongly positive, despite the fact that enormous quantities of freshwater, white pearls from China have entered the market and have now reached such a volume that they are sold by the kilogramme. Part of Tahiti's success can be credited to continued advances in *P. margaritifera* hatchery and farming methodology. Another reason has been the efforts of G.I.E. Perles de Tahiti, the industry marketing arm. With a highly effective marketing campaign that has included advertisements, a newsletter, participation at jewelry trade shows and even a website, G.I.E has effectively maintained and expanded product demand.

This paper discusses the major factors behind the impressive performance of Tahiti's black pearl industry, and considers the future outlook for black pearl farming.

The old and the new of Australian pearl production

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[1] Pacific Seafood Management Consulting Pty. Ltd, Level 1, 277 Centre Rd, East Bentleigh, VIC 3165, Australia

The pearl culture industry in Australia has been operating since the mid 1950s and annually is worth in excess of US$ 150 million. The main culture species is the golden-lipped *Pinctada maxima* with farms operating in the northwest of Western Australia (mostly centred around Broome), the Coburg Peninsula and Darwin-Bynoe Harbour regions of the Northern Territory and north Queensland, especially in the Torres Strait region.

Wild-stock shells are harvested from the seabed under a quota system to prevent overfishing of the stocks. In the past few years, commercial-scale techniques for the hatchery production of seed have been developed and several farms are now growing hatchery-reared individuals.

However, unlike Indonesia, the numbers of hatchery-reared stock on the farms is significant to the total number of shell stocked. The effect of increased supply through hatchery production of spat on Australian South Seas Pearl production is yet to be determined.

Traditional raft culture is still used in some parts of Queensland, however, most farmers use surface or sub-surface longlines. Bottom culture still exists in a few areas. Plastic mesh net panels hold the shell in individual pockets and this assists regular cleaning using high-pressure water jets onboard small tender boats. Harvesting of the pearls takes place about 2 years after implantation and some shell may be reseeded up to 3–4 times before being used for mabe (half pearl) production. Sales of by-products include mother-of-pearl shell as well as dried oyster meat.

The culture of several other species is also being undertaken at a relatively small scale. These include the blacklip pearl oyster *P. margaritifera*, the white oyster *P. albina* and the penguin oyster *Pteria penguin*.

Experiments with the culture of pearls in abalone (*Haliotis* spp.) in Tasmania have shown some repeated success with both round and mabe pearls, although at present it is too early to accurately assess the market value of this unique product. Several inland fish farmers are attempting to culture the local freshwater mussel (*Velesunio ambiguus*). Sales have been limited to aquarium trade, however some trials with pearl production are underway.

Pinctada nursery culture: overcoming the bane of *Cymatium*

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[1] National Marine Fisheries Service, Southwest Regional Office, Pacific Area Office, 2570 Dole St., Honolulu, Hawaii 96822

Expansion of black pearl culture in the central and western Pacific Islands is constrained primarily by the scarcity of oysters for farm stocks. Recent hatchery developments have opened up opportunities for farming in Hawaii and Micronesia. Spat collector trials in the Solomon Islands have also shown good promise.

In each location, however, ocean nursery grow-out has not been without setbacks. Spat and juvenile oysters in bags and lantern baskets have been subject to massive mortalities from serial predation by *Cymatium* gastropods.

Up to now, the only means for controlling *Cymatium* predation has been constant vigilance, with bags and baskets checked regularly for dead spat or snails. This is always an added labour cost, and is often an impractical demand on pilot-scale or start-up operations. Even with weekly surveillance of the farm lines in Majuro, Marshall Islands, *Cymatium* predation levels resulted in an attrition of up to 10% of juveniles per month.

Ongoing trials by Black Pearls Inc., have developed a system of holding juvenile oysters in individual compartments in mesh stockings. Even with two or three spat in each stocking compartment, the impacts of a single predatory snail are negligible. Once it has consumed one or two spat the snail is too large to pass through the mesh to the adjacent compartment. Adoption of this innovative grow-out technique has resulted in *Cymatium* predation levels dropping dramatically in trials in Hawaii and Majuro.

Some initial problems were reduced growth rates (due to the mesh constricting around the growth margin of the oyster) and fish predation on the exposed stockings. These problems have been simultaneously overcome by placing large biobeads inside each compartment. This stretches the stocking away from the growth fringe, and affords excellent protection for the spat. By providing a practical, inexpensive link between the hatchery and the grow-out panels for larger oysters, this innovation now brings the promise of this lucrative industry closer to fruition.

The combined effects of temperature and salinity on the growth and survival of the black pearl oyster, *Pinctada margaritifera* (L), larvae

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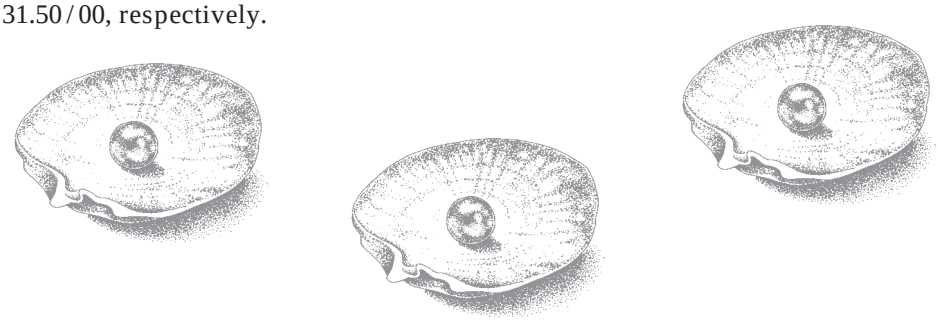
Laboratory experiments of a 4x4 factorial design were used to examine the combined effects of temperature and salinity on the survival and growth of larvae of the blacklip pearl oyster, *Pinctada margaritifera* (L).

Response-surface contour diagrams were generated to provide estimates of conditions for optimal responses. Temperature and salinity ranges for maximum survival and growth of 15 days-old larvae were 21 to 22.5°C, 25 to 28.50/00 and 26.5 to 28.5°C, 27.5 to 31.50/00, respectively.

Temperatures of 35°C or greater were lethal for larvae. At all temperatures tested, larval growth and survival were lowest at 40 ppt. Based on two-way analyses of variance, both salinity and temperature exerted significant effects on growth and survival, but temperature was clearly the dominant factor. No statistically-significant temperature-salinity interaction was found for growth by the sixth day. In 15 days-old, survival and growth showed a significant temperature-salinity interaction.



Nucleus implantation for cultivation of black pearls: review of current technology and constraints for development of the industry

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Cultivation of black pearls is initiated by insertion of a round shell nucleus into tissue(s) of blacklip pearl oysters (*Pinctada margaritifera*), accompanied by a carefully prepared graft of mantle tissue. If the surgical procedure is performed properly and adequate grow-out conditions provided, the tissue graft will grow around the nucleus enclosing it in a thick layer of tissue with nacre-producing cells forming the interior layer. Nacreous layers are subsequently deposited around the nucleus to form a cultivated black pearl. Several variations of the implantation procedure are described in detail.

The multi-billion dollar black pearl industry depends on the ability of the technician to execute this delicate and complex surgical procedure. Although the implantation procedure is fundamental to producing high quality pearls, relatively little information is available to the public or industry outside the small circle of seeding technicians.

The majority of seeding technicians are highly trained Japanese nationals who function as a professional guild, closely guarding the technology. Within the last 15 years, more non-Japanese have learned to perform the procedure, but generally with a lower rate of success. Technology transfer occurs through limited opportunities for observation and extensive trial and error resulting in high mortality rates, poor quality pearls and economic loss.

The number of seeding technicians available for hire (about 500) is insufficient to service the number of existing and potential farms. Even the finest technicians exhibit highly variable and often low success rates further impeding the probability of establishing and operating a profitable pearl farm. During the first 45 days of the post-implantation period, the best technicians can expect a 60–80 per cent retention rate. Of the remaining pearls, more than 50 per cent will be of such poor quality that they cannot be sold. A variety of critical factors in the implantation procedure and farm management are responsible for host pearl oyster mortality, implant rejection and poor nacre quality.

Pearl production is one of the few highly lucrative and sustainable development opportunities for many island nations. Inability to gain access to seeding technology has suppressed economic development and causes economic loss due to farm failures. Research to improve existing technology, dissemination of results and increased technical assistance would help eliminate this obstacle to production of quality pearls.

The significance of a specific irritant (foreign body) in the deposition of pearly layer

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A quality nucleus can produce a quality pearl, but several other factors greatly affect pearl formation. Some produce quality pearls, while others do not.

Pearl colour can also vary from culture area to culture area. The most important factors appear to be depth and light penetration. The quality of phytoplankton which constitute the food of the oyster or mussel is another factor. It has been noted that repeated pearl harvests in the same grounds can lead to poor pearl quality. Changing the raft location is recommended. In addition, seasonal changes can have an effect.

The placement of the nucleus into the oyster can cause variations in colour. With *Pinctada fucata*, while the pearl produced in the ventral region of the gonad is often white or golden, those placed in the dorsal gonadal region tend to be grey or white. In the freshwater mussel, *L. marginalis*, there is a wide range of colour variation, depending on gonadal placement. The condition of the gonad is another consideration, as is treatment and care at surgery.

Temperature can have a significant effect on pearl quality. When the temperature is below 10°C, the oyster's metabolism is at a minimum level and the nacreous layers deposited are thinner than at higher temperatures.

Pearly layers can be deposited around any inert substance, and a variety of substances have been used as a core material. For spherical pearl however, selecting the correct nucleus is extremely important.

Beads made out of shells are most suitable because:

1. shell material has the same general physical properties of nacre;

2. the density of the shell material is about the same as that of nacre;

3. the shell beads can be accepted in the gonadal area; and

4. heat-resistant properties of shell material and nacre being the same, the calcium carbonate secreted by the pearl-sac, either in the aragonite or calcite form, binds homogeneously and firmly with the calcium carbonate layers of the shell beads, with the help of the initial organic conchiolin layer. Therefore, the pearly component tends not to separate from the nucleus, and the layers of nacre tend not to crack when the pearl is drilled.

Traditionally, the raw material employed to fabricate nuclei has been freshwater shell. Most marine shell nuclei crack when drilled. Recently, some species of marine shell have been discovered to be suitable for nuclei. Giant sizes (up to 22 mm) have been produced with excellent results. This paper provides more details on the above observations, and discusses, in particular, recent experiments utilising nuclei from marine shell.

Cellular model for marine invertebrates as a tool for pathogenic studies

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Infectious diseases have been recognised as one of the factors limiting the development of marine invertebrates farming.

We have developed cell cultures in penaeid shrimps and black pearl oysters (*Pinctada margaritifera*) in order to obtain a tool for the determination of the virulence factors responsible for the pathogenicity of bacterial strains and replication of virus.

Primary cell cultures were obtained in M 199 medium prepared with 0.01 M Tris solution (pH 8) supplemented with antibiotics and fetal calf serum. Cell sheets were obtained from hearts and gonads of *Pinctada margaritifera* and from *Oka* organ, ovary, hemocytes and embryos of penaeid shrimps.

In vitro essays for detection of virulence factors (attachment, cytopathic effects) of various vibrio strains have been performed on shrimp ovary and hemocyte primary-cell cultures.

Highly pathogenic vibrio strains induced cytopathic effects. The incubation time of cell culture derived from the ovary and Oka organ with TSV and IHHN has also been determined. Disorganisation of nuclear structure has been observed in some nuclei.

Perlas de Guaymas: an update on the first commercial marine pearl farm on the American continent

Sergio Farell[1], Enrique Arizmendi, Douglas Mc Laurin & Manuel Nava

[1] Project 'ITESM – Perlas de Guaymas', Instituto Tecnólogico y de Estudios Superiores de Monterrey-Campus Guaymas, A.P. 484, Guaymas, Sonora 85400, Mexico.

ITESM-Perlas de Guaymas started a commercial pearl farm operation back in January 1996 in Bacochibampo Bay, Guaymas, Sonora, in the central Gulf of California, Mexico. Our production of pearls consists of high quality all-natural colored mabes and cultured round pearls, mainly from *Pteria sterna* and some from *Pinctada mazatlanica.*

Since this project has been working at a commercial scale we have had to solve several new problems which arised: new predators; improved quality standards, resulting in a lower production than expected (since low-quality items are destroyed); and the commercialisation of a large volume of the new mabes has entailed costs in the education of possible buyers.

Rope-hanging culture was used in research and pilot culture steps of this project without a problem for two years but once rope numbers increased, big snappers (*Lutjanus guttatus*) and triggerfishes (*Balistes polypis*) started to take a quota of the pearl

oyster production, mainly from *Pteria sterna* stocks. Other predators, like rays and skates, are present in the area but they have not yet been detected in the farm.

Quality standards have improved as a result of two processes: as we learn more about cultured pearls we become more exigent, but also we are aggressively promoting these new pearls by giving the best quality for a certain price. The result has been a reduced number of mabes produced because the sale of low-quality items would eventually kill the market. The colored pearls from the Gulf of California are new but only for the people of the industrial 20th century because this area was the main source of natural colored pearls for the jewelers of Europe and New York from the 16th to the 19th century. White pearls were always more abundant but now the bleached white is the only pearl people are looking for. So we have undertaken a campaign of publicity including a description of the history and an explanation of what a clean industry the pearl oyster culture industry is.

To date we have harvested 30 000 mabes and we are waiting to harvest 300 cultured round pearls for 1999 and 10 000 for 2000.

Cultured pearls project as a universitary enterprise

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The two species of pearl oysters native to the Gulf of California, **concha nacar** and **madre perla**, respectively *Pteria sterna* and *Pinctada mazatlanica,* were over-exploited for 500 years and almost disappeared. In 1940, the Mexican Government prohibited fisheries of both species. In 1994, this measure was reinforced and the pearl oysters were considered as endangered species, subject to a special protection.

Due to their status as endangered species, considering the historical and social importance this resource had at regional level, and also the technical feasibility to produce pearl oysters in a hatchery, the UABCS began an aquaculture project in 1993. The goal was to promote the creation of pearl culture enterprises in the region. Research and development activities are also carried out.

Since 1992, a group of **concha nacar** obtained as spat in plastic collectors was cultured on a longline. At the end of 1993 they were used as parental stock to produce some 3 000 juveniles in the laboratory (F1), by improving conventional hatchery techniques (spawning, fertilisation, larvae care and nutrition, settlement, and nursery).

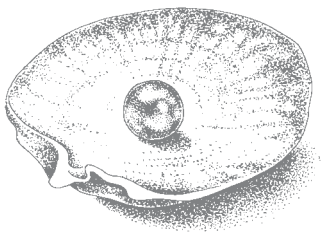
Selected organisms were used again in January 1997 to produce 65 000 *P. sterna* seed (F2). One-third of these will be used as seed to create banks, ensuring the re-establishing of populations. Spawning to obtain more seed is scheduled every summer for *P. mazatlanica*, and every winter for *P. sterna*. Parental stock will be selected from those with the fastest growth rate, best-coloured mantle, and best shape.

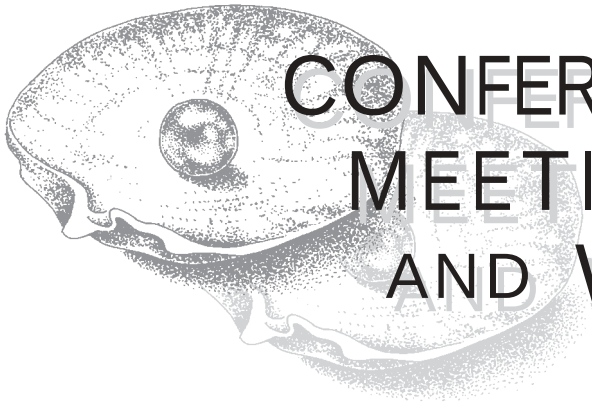
Regarding *P. mazatlanica*, a spawn of 35 000 organisms was obtained in the summer of 1997. Parents were collected by placing onion-bag-type spat collectors in the sea. Half the organisms will be used as seed, also in order to create natural banks.

Seed, as juveniles and adults, are maintained in plastic cages and lantern-net cages. They are attached to longlines and suspended from fibreglass rafts, in Pichilingue at Bahia de La Paz.

Up to now results are strongly encouraging, given the high quality of nacre produced by pearl oysters, and the beauty of the half-pearls available for sale, with prices from US$ 14 to 40 per piece, depending on degree of perfection, luster, size and absence of imperfections. About 2 000 half-pearl implanted *P. sterna* will be produced every month from December 1998 onwards, and operations will begin with *P. mazatlanica* in March 1999. The first round pearls are expected to be produced in 1998.

The University programme hosts two national aquaculture projects, provides courses for Bachelor and Master of Science degrees, and has published and discussed results so far obtained in international meetings.





CONFERENCES, MEETINGS AND WORKSHOPS

Freshwater mussel symposium

Source: Ohio Division of Wildlife

The Columbus Zoo, the Ohio Biological Survey, and the Ohio Division of Wildlife were hosting a special symposium from 6 to 8 March 1998 focusing on the captive care and propagation of freshwater unionid mussels. The purpose of the meeting was to provide a forum for the discussion and dissemination of information on the rearing, maintenance, and long-term care of juvenile and adult mussel populations under artificial conditions.

The symposium was held at the Holiday Inn Columbus Worthington Conference Center in Columbus, and the programme included oral and poster presentations, workshops and keynote address. Scientists, researchers, and professionals from industry, academia, public aquaria, and federal and state agencies were encouraged to participate.

Pearl culture expert seeks hatchery sabbatical position

Mario Monteforte, of CIBNOR, in La Paz, Baja California Sud, Mexico, writes:

After finishing my post-doctorate in August or September this year (1998), which deals with the biology and ecology applied to pearl oysters and pearl culture in Bahia de La Paz, I am planning to take a sabbatical year (this is a system we have in some Mexican institutions whereby after 6 years of work we can ask for the 7th to do anything academic anywhere). I have been in the CIBNOR for almost 11 years leading the Pearl Oysters Research Group, so it is a fair time for me to take my sabbatical.

I would be very interested in working with a hatchery project for some months. We are starting hatchery research on *Pinctada mazatlanica*, and we would be grateful for some information exchange and collaborative research work. All of my expenses would be covered during this period, but I would appreciate any additional compensation.

Mario Monteforte
CIBNOR, S.C.
Km 0.5 Acc. Telefonica, El Conchalito.
La Paz BCS 23080 MEXICO
E-mail: montefor@cibnor.mx

Seeking employment

American, 56 yrs, two years experience as site manager/farmer of small *Pinctada margaritifera* farm. Thirteen years as a commercial abalone diver. Extensive marine and manual skills background. University business degree.

Jerry Myers
P.O. Box 3439
Majuro, Marshall Islands 96960
Fax: c/o +1 808 672 9722

PIMRIS is a joint project of 5 international organisations concerned with fisheries and marine resource development in the Pacific Islands region. The project is executed by the Secretariat of the Pacific Community (SPC), the South Pacific Forum Fisheries Agency (FFA), the University of the South Pacific (USP), the South Pacific Applied Geoscience Commission (SOPAC), and the South Pacific Regional Environment Programme (SPREP). Funding is provided by the Canadian International Development Agency (CIDA) and the Government of France. This bulletin is produced by SPC as part of its commitment to PIMRIS. The aim of PIMRIS is to improve the availability of information on marine resources to users in the region, so as to support their rational development and management. PIMRIS activities include: the active collection, cataloguing and archiving of technical documents, especially ephemera ('grey literature'); evaluation, repackaging and dissemination of information; provision of literature searches, question-and-answer services and bibliographic support; and assistance with the development of in-country reference collections and databases on marine resources.

PIMRIS
Pacific Islands Marine Resources Information System