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INFORMATION BULLETIN

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The Green Pearl Issue

From the Editor

No, this is not an entire issue devoted to abalone nacre. No, we aren't dedicating an issue to the peacock greens of Tahiti. And we haven't figured out how to use copper nuclei. This issue has been catalysed by a string of contemporaneous threads braiding themselves together over these past few months, perhaps this past year. We are seeing the ascension of pearls and pearl farming as the paragon of environmental consciousness. This could be: a) a head-in-the-sand response to the continuing market trends, b) an awakening of pearl farmers to their complete and utter dependence on how everyone else treats our oceans, c) recognition that pearl farming has now become mainstream, and is no longer a remote, arcane art, excluded from the other social forces that push or pull us, or d) all of the above.

Consider some of the contents in this issue. Bo Torrey has taken to thumping the Pew Oceans Commission podium, on behalf of the world's oceans. In Australia, researchers are proposing using pearl oysters as bio-remediation tools, and are arguing the case for pearl farms as environmentally benign, nay, beneficial. In Hawaii, Black Pearls, Inc. has conducted lab and field trials to establish *P. margaritifera* as a biomonitor for heavy metals in tropical waters. A couple of abstracts we reprint here focus on the effects of pearl farming on genetics of wild pearl oyster stocks.

So, are pearl farms bad, benign, or beneficial? Years ago, we had suggested to several individuals actively involved in environmental conservation in the South Pacific that instead of (or as well as) setting up a National Marine Park, they should set up a pearl farm. Our suggestion was ignored, or dismissed, I guess. I've not heard of any pearl farms in any Southeast Asian or Melanesian National Parks, but I still think it's a stellar idea. The biological benefits are tremendous (all that wonderful vertical relief for biomass to build up, and for fish recruitment), the protection afforded coral reefs by a pearl farm's armed guards is

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unimpeachable, and there is no other industry that provides such stable, lucrative employment opportunities for isolated atolls. You have probably heard all this before, but please allow me to restate the case for the defence *en toto*.

The benefits from pearl farming

Pearl farming is an ideal development opportunity for remote communities. It is a sustainable, lucrative industry, and in many cases it provides both direct and indirect benefits to the environment. The direct benefits are from reducing the pressure on stocks depleted by years of pearl shell fishing, and fostering the recovery of pearl oyster populations. Indirect benefits are in providing a viable, sustainable industry for rural areas and isolated atolls, and in encouraging greater stewardship of marine resources.

Pearl farming is eminently sustainable, from a stock management perspective. In almost every pearling area in the world today, farming is based on spat produced in hatcheries, or taken from artificial spat collectors. The only continuing reliance on fishing of wild stocks for farms is in northern and western Australia, where the collection of wild oysters is a tightly regulated, stable fishery.

Pearl farms can help overfished stocks recover by acting as reproductive nodes — aggregations of large, densely packed, well-tended adult oysters. The large number of fecund oysters, in close proximity to each other, results in better synchronisation of spawning, higher fertilisation rates, and far greater numbers of viable larvae, compared to the conditions of a depleted population, where oysters may be hundreds of meters, or even miles, apart. In French Polynesia and the Cook Islands, stocks formerly suffered from continual boom-and-bust fishing for the oysters, solely for the value of the pearl shell. However, over the last few decades, since the advent of large-scale farming in these atolls, spat falls and wild oyster stocks have both increased dramatically. Black Pearls, Inc. has a pending application for a pearl farm lease here in Hawaii that is largely justified by the project being a public–private partnership: a pearl farm and stock re-establishment programme rolled into one. The oysters on the farm will be the broodstock that replenish the surrounding reefs with Hawaii's imperilled endemic oyster.

Pearl farming is labour-intensive, and provides employment for both farm workers and in spin-off secondary support industries. Pearl farming thereby relieves pressure on other marine resources, such as reef fisheries, that might otherwise be subject to unsustainable commercial exploitation.

Pearl farming also encourages island communities towards greater stewardship over their natural resources, and fosters reassertion of their traditional tenure regimes. At a pearl farm in Palawan, Philippines, where we have worked for about five years, the pearl farm areas were the only ones where there was any reasonable coral reef left. Prior to the farm's establishment, I was told, dynamite fishing was rampant throughout the area. To this day, the reefs that lie outside of the range of the farm guards' spotlights and AK-47s, are completely damaged. The reefs beneath the pearl farm rafts and longlines are indescribably beautiful.

Pearl oysters are filter feeders, and require no supplementary feeding. In areas of high water turbidity, the oysters may even improve water quality, by clearing suspended particulates. The

animals are highly susceptible to any environmental perturbation, which is why farms are often located in remote areas. Farmers therefore are often strong advocates for marine environmental protection and management.

Pearl farm developments across the Pacific are supported by a wide range of environmental and development agencies, including the WorldFish Center in Malaysia, Sea Grant College programme in the US-affiliated Pacific, ACIAR (Australian Center for International Agricultural Research), and the Secretariat of the Pacific Community (SPC–our publisher).

We believe so strongly in the power of the pearl to protect that Black Pearls, Inc. eagerly compiled a comprehensive EIA for a pearl farm proposal by the Cook Islands government to develop pearl farming in a national park in the Cook Islands, in the remote lagoon of Suwarrow. We believe that there is no incompatibility between the protected park status and the pearl farm operation; indeed, the farm would have provided some capability to enforce the national park management plan, and would have afforded some level of protection for the fragile reef resources. We are waiting to hear of the next move in this direction by the Cooks government, or perhaps Suwarrow will be left languishing.

Green tinge to this POIB issue

Environmental consciousness grows apace. Bo Torrey's *Pearl World* (*The International Pearling Journal*) recently focussed an entire issue on the Pew Oceans Commission report, entitled "What's happening to our oceans". The subtext of this issue was "So you love pearls? You need to be more environmentally aware and active, or there may not be any more". Bo is to be applauded for taking such an activist stance. There is not much in the Pew report that relates directly to pearling, so rather than reprint large sections of this issue here in POIB, we suggest that, if you are interested, you write to Bo and ask him for a copy of that issue (Volume 12, No. 2). By the way, we still shamelessly lift excerpts from several other *Pearl World* articles for our POIB, as usual. There is simply no better source of information on what's moving, shaking, and breaking in pearling.

The environmental impacts of pearling were recently a hot issue in New South Wales, Australia, where the government fisheries agency and private partners were proposing to expand some pilot-scale trials with the local akoya-relative (*Pinctada imbricata*) in Port Stephens. This project earned an initial thumbs-up from the environmental commissioner appointed to adjudicate the project proposal. It now seems, however, that the opponents have hounded the project to death.

In an attempt to provide some perspective (or perhaps just because it was an interesting bit of science), the researchers working on this project also recently published an article pointing out the powerful bio-remediative potential of pearl oysters, particularly their ability to remove heavy metals from polluted waters.

Closer to home, Black Pearls, Inc. has been working for several years on a US Department of Defense research project to validate the use of *P. margaritifera* as a heavy metal monitor. We publish excerpts from the report of our first stage of this work; a second stage has just been initiated.

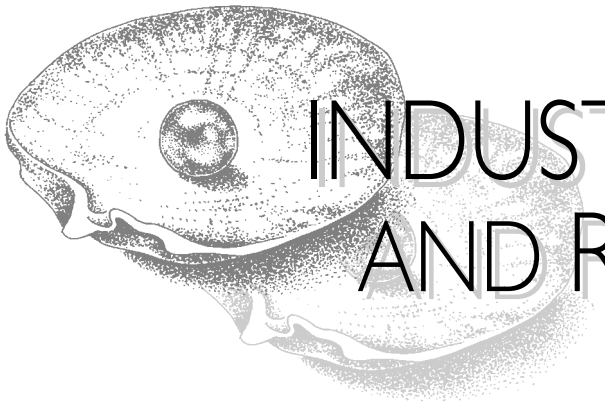
This issue also refers to two articles on pearl oyster genetics, as they relate to our environment (see "Other publications noted", p. 39). One article from Mexico suggests that the uncontrolled plunder of the pearl oyster beds in the last century has had a significant impact on population structures of *P. mazatlanica* along the Pacific Coast of the Americas. The other article assesses the impact of pearl farming on the genetic variability of wild and cultured oysters in French Polynesian lagoons, and gives a "green" light.

Two other noteworthy inclusions in this issue: In the Abstracts section (p. 24), we provide a list of advance abstracts for the pearl sessions at the upcoming World Aquaculture Society meeting in Honolulu, in March 2004. Richard Fassler is billing this as the tenth anniversary of "Pearls '94 ". We hope to see you there.

And in the News and Views section (p. 18), we start off with a wonderful tirade from a very irate technician, berating your editor about my "negative remarks about technicians (who) won't reveal operations techniques, and the so-called exorbitant fees that they charge". This letter was faxed in anonymously. If the author(s) had identified themselves, and asked for my response, I might have pointed out that these comments weren't mine. I write the editorials, and the occasional tirade of my own (under my own byline), but the rest of the POIB consists of contributions from other correspondents, or excerpts from other articles published elsewhere. In this instance, the negative remarks about technicians were included in an excerpt from a story in the Cook Islands News. This article was itself paraphrasing Cook Islands pearl farmers' comments. They said it; someone else wrote it down; we just copied it. Anyone who knows us knows that we love our seeding technicians.

But, not to worry. As vitriolic as this letter is, as wrongly-directed as it is, and as anonymous as it is, I've opted to publish it all anyway. There's nothing like a spot of lively debate to keep us all mentally acute! We all need to vent, every so often, and where else better to vent than in your local POIB. So, if you feel so inclined, pick up that pen, or clack away at that keyboard, and let us know what you think — even if you are wrong!

Neil A. Sims



INDUSTRY NOTES AND REPORTS

Pearl commission holds first meeting in Tahiti

Source: Oceania Flash (21 January 2003)

The first meeting of the Pearl Farming Advisory Council was held last week in Papeete to introduce a code of ethics to the lucrative industry, the daily newspaper La Dépêche de Tahiti reports.

One of the main objectives of the new council was to increase the quality of French Polynesia's black pearls, a prime export for the French Pacific territory. In the past few months, the territorial government has introduced more stringent quality control measures in a bid to deter low-quality producers who are selling at much lower prices.

This at times resulted in a significant drop in prices at international auctions held by local producers in the capital. One of the measures was to systematically carry out a census of all producers in the territory, but this was a laborious exercise as French Polynesia covers an area equivalent to that of Europe. The census, which started in November 2001, was scheduled to be completed in June this year.

Other measures included the introduction of a professional ID card for producers, upon completion of a compulsory training workshop. One of the council's new powers is to recommend the delivery of a new ID card and its renewal, and launch disciplinary action against producers deemed to have breached local regulations. French Polynesia's President Gaston Flosse, who is also in charge of the pearl farming industry portfolio, chairs the Council. Other members are representatives from the pearl farming industry and the local government.

After holding talks with Chinese President Jiang Zemin, during a recent visit to China in October 2002, Flosse successfully pleaded for Beijing to lower its import tax on Tahitian black pearls from 24 to 10 per cent, as part of the "most favoured nation" status. According to statistics, pearl farming and related industries currently employ some 7000 people in Tahiti, in over a 1000 pearl farms throughout French Polynesia's far-flung archipelagos. The fastest growth in turnover occurred between 1998 and 1999, when the industry grew 23 per cent. But business slowed in 2000. On a global scale, Tahiti currently produces about a quarter of the world's black pearls.

Pearl prices plunge in French Polynesia

Source: RNZI (9 June 2002)

Black pearl prices in French Polynesia have registered a massive fall at the United Pearl Producers fair in Papeete.

The president of pearl company Poe Rava Nui, Alfred Martin, said the price per gram has plummeted to under USD 12, which is a fall of more than 33 per cent in the past five months.

Martin said compared with the prices fetched a few years ago, black pearl prices are down by 80 per cent. He said in an unprecedented development, more than half of the quarter million pearls on offer failed to sell.

One producer said despite government efforts to impose quality controls there is a parallel trade

between foreign buyers and local producers that bypasses the official auctions and evades the export tax.

Black pearl farming is French Polynesia's second biggest income earner after tourism and provides about 10,000 jobs.

Tahitians: Is the end of the free fall in sight?

Source: *National Jeweler* (16 July 2003)

As part of renewed efforts to shore up prices in the Tahitian cultured pearl market, which has suffered precipitous declines over the past year, the government recently enacted more measures designed to limit supplies, improve quality and punish smugglers.

"The market's been complaining about the drop in prices, and the Tahitian government has been taking that very seriously," said Devin Macnow, the US representative for Perles de Tahiti, the worldwide marketing association for the Tahitian cultured pearl industry.

The association's new chairman, Pierre a Teriitehau, joined Macnow and General Manager Martin Temehameharii Coeroli at the JCK Las Vegas 2002 Show in early June to announce a round of legislation that went into effect this spring, including the creation of a code of conduct that farmers must abide by if they wish to receive an official pearl producer's license.

The code of conduct obligates producers to maintain an official inventory book for auditing purposes, Teriitehau said. It also allows them to produce no more than 12,000 oysters per hectare, "to protect the industry and the oyster itself." And according to new regulations, producers have to meet minimum standards for equipment and building restrictions.

"We have a transition period of 18 months — there are two systems now in place," Teriitehau continued. "But all producers must be in conformity with the regulations before the end of 2003."

The government has divided up the licensing system into two categories — oyster producers and pearl producers — that will total 700 licenses. Non-licensed producers who attempt to smuggle their goods out of the country will face fines ranging between two and 10 times the amount of the seized pearls, Macnow said.

The government is putting teeth into these measures by installing three new X-ray machines at the Papeete airport (at the check-in luggage, hand luggage and freight areas) that, with the aid of a beefed-up security force, are capable of inspecting 20,000 pearls a day.

But even as they legislate more and more controls, the Tahitians insist that prices have been on a steady rise since December, 2001, and that supplies are shrinking, compared to the deluge seen in years past.

Coeroli said the year's production is expected to total 9 tonnes, down from 10 t in 2001 and 11 t in 2000. Optimally, the island nation will produce between 8 t and 9 t of its famed black pearls per year once production is stabilised, he said. But privately, some dealers wonder if the measures are enough to resuscitate the market, which they fear has yet to hit bottom. Top-quality pearls in rare colours like light grey and pistachio are holding their own, but business in the bread-and-butter black goods is reportedly very quiet.

"The cycle is long in the tooth", said Alex Vock of ProVockative Gems in New York. "We're moving into other things now, like estate jewellery".

It's the supply, stupid!

Source: *Pearl World, The International Pearling Journal* (April/May/June 2003, Vol. 12, n° 1 – Editorial)

A significant percentage of pearl dealers are not happy campers. They continue to be concerned with the fallen (and continuing to fall) prices of Tahitian goods, along with the ever increasing tsunami of Chinese freshwater pearls (CFWPs). The major problem is that Tahitian and CFWP pearl farmers have simply been producing too much product for the pipeline.

A new consensus of opinion now seems to add whitelip South Sea pearls (SSPs) to this list of growing complaints, complaints that nowadays also focus upon oversupply by whitelip SSP producers.

Many feel this is exacerbating the downturn in the consumers' perception of the value of cultured pearls.

Dealers *in toto* seem to remain very worried about the general outlook for the industry for the remainder of this year, and into the near future.

Their worries seem justified as, at the Tucson Gem Show, I saw necklace after necklace, loose pearl after loose pearl, significantly reduced in wholesale price from just over a year ago.

Only high-end akoya seemed to retain a semblance of price stability, and that was probably because the plethora of akoya dealers has declined over the past four or five years.

The speculation is that the leaders in the akoya business have pretty much weeded out many of the Johnny-come-latelies, and that supplies of top quality akoyas remain relatively scarce and relatively expensive, thus retaining their price levels.

Of course, this akoya stablility is not the result of any deliberate, positive human intervention: it's mostly because Mother Nature inflicted punishment on the Japanese industry for its many decades of wretched excess (including a total lack of environmental concern and common sense housekeeping hygiene).

Handy information: Key Tahiti cultured pearl numbers

Source: *Perles de Tahiti Bi-Monthly Newsletter* (September–October 2003)

The Tahiti cultured Pearl ranks number 2 in the world among loose exported cultured pearls. The Tahiti Cultured Pearl is French Polynesia's most valuable export.

Pearl farms

1076:	68 farms 75+ acres
	255 farms 12–75 acres
	753 farms under 12 acres

Employees

Salaried:	1320
Family:	4304
Total pearl industry:	7042

Imported materials

1998:	1.5 Bn CFP (USD 14.2 M)

Sales

Local: 1998:	3 Bn CFP (USD 28.3 M)

Exports

1998:	15.2 Bn CFP (USD 143.4 M)
1999:	18.7 Bn CFP (USD 170 M)
2000:	21.4 Bn CFP (USD 167.2 M)
2001:	14.7 Bn CFP (USD 111.4 M)
2002:	14.2 Bn CFP (USD 113.6 M)

World market share (loose pearls)

1998:	27.2%
1999:	25.9%
2000:	24.3%
2001:	21.0%

Palau woos black pearl farming

Source: *Palau Horizon* (4 June 2003)

Black pearl farming will be introduced in Palau by Japan, according to President Tommy Remengesau. He said this new venture is the result of his successful meeting with government officials of Ishigaki Prefecture last month.

Remengesau said black pearl farming is a thriving industry in Ishigaki and suitable for Palau's climate. In the past, he said, there had been talks about black pearl farming in Palau but these were never actively pursued. This year, he said the group behind the successful black pearl industry in Ishigaki will travel to Palau to initiate talks with state governments regarding a possible joint venture.

Remengesau said a study made by the group showed that Palau has potential for black pearls. He said the group has already identified four sites in Palau where black pearl farming could thrive. At least eight years would be needed to produce black pearls, the president said.

Palau tries hand at black pearl farming

John A. Concepcion

Source: *Palau Horizon* (23 October 2003)

The possibility of establishing a black pearl farm in Palau is getting nearer to reality as efforts to cultivate black pearl oysters by the Bureau of Marine Resources seem to be paying off.

The government is being aided by a senior volunteer from the Japan International Cooperation Agency (JICA) in its bid to cultivate oysters that would bear black pearls here in Palau.

JICA senior volunteer Osamu Taniguchi said that by December, the reproductive organs of blacklip oyster he collected some six months back would become mature.

In an interview, Taniguchi said that the juveniles that were gathered from shells they collected are already in their early stages, and are called "spots."

He said that out of 70 to 80 shells they collected, thousands of juveniles could be produced. The spawning season, he said, started in August and will end in December. Taniguchi said they need mature cells for black pearl culture.

Taniguchi arrived in Palau last April, and is scheduled to stay here in Palau for two years. Before his assignment here, he had been in the Philippines for 20 years, the last 12 years of which he spent on cultivating oysters that bear black pearls.

Since arriving here in Palau, Taniguchi said that he has surveyed different areas in Palau because there is currently no information on blacklip oysters in the country.

He said that it would take around two years for juvenile oysters to grow into adults, and another two years for the adults to produce black pearls.

The 56-year old JICA volunteer said that Palau needs thousands of oysters in order to produce a significant number of black pearls.

Controversial NSW pearl farm gets thumbs up

An inquiry has recommended approving the establishment of a pearl oyster farm at Port Stephens in New South Wales (NSW) despite strong opposition from environmental and conservation groups, as well as local residents.

The inquiry commissioner, Kevin Cleland, presented his findings to NSW Deputy Premier and Minister for Planning Dr Andrew Refshauge for parliamentary consideration, last month. Those who oppose the development believe it will degrade the environment and the natural beauty of Port Stephens, restrict use of the public waterway, damage the area's important and burgeoning tourism industry and endanger marine animals, particularly dolphins and whales.

Australian Radiata Pty Ltd has proposed the pearl oyster farm, which would involve a small land base site and five deep-water lease sites. Cleland outlined the possible benefits of establishing the farm and addressed the concerns in his report, ultimately finding that "the environmental aspects of the Port Stephens Oyster Industry… do not preclude its approval".

The endemic oyster species, *Pinctada imbricata*, would be cultured from approved stock to produce small- to medium-sized high quality pearls in the development. More than two million oysters would be implanted annually according to plans, creating 80 full-time jobs. The resulting pearls would be worth an estimated AUD 12 million.

However, Nature Conservation Council of NSW coastal policy officer Raquel Carter told the inquiry that the economic and social risks potentially associated with the proposed development far outweighs any benefits to the Port Stephens community.

Cleland recommends a cautious approach. He admits the pearl industry aquaculture equipment does pose a marine animal entanglement risk, and has recommended cautionary measures. The commission also recommends that one of the lease areas not be approved.

The situation should also be monitored upon approval, the report recommends, with aspects curtailed or operations modified if there are unforeseen negative effects.

RESEARCH NOTES AND REPORTS

Pearl farming in Micronesia

Maria Haws[1] and Simon Ellis[2]

Source: *Pearl World, The International Pearling Journal*
(July/August/September 2003; Volume 12, Number 3)

Pearl World's editor note:

We were delighted to have recently received an in-depth article entitled "Pearl Farming in the Republic of the Marshall Islands and the Federated States of Micronesia" from Maria Haws and Simon Ellis, subtitled "Overcoming challenges to pearl farming development through an integrated, science-based approach." We herewith reproduce the article in its entirety for the benefit of our subscribers.

Introduction

The authors of this article, Maria Haws and Simon Ellis, are two aquaculture scientists who have worked in the Pacific region for ten and seven years, respectively, researching and promoting pearl culture, and other aquaculture species such as sponges, giant clams, soft and hard corals and other aquarium species. In this article we present a slightly different perspective as individuals who have focused largely on the science and development aspects of pearl farming in Micronesia.

For the purposes of this article, the focus will be on the Republic of the Marshall Islands (RMI) and the Federated States of Micronesia (FSM) as a model for pearl farming development. With the exception of Kiribati, which has a fledgling pearling industry, none of the other islands in Micronesia currently have existing pearl farms.

The basis for sustainable pearl farming in FSM and RMI has been slowly established over the last 10 years with little global attention.

With several high-quality and sizeable harvests under their belts, the pearl farming world is beginning to sit up and take notice of the beautiful, limited production pearls leaking out of Micronesia.

If anyone outside this region has been lucky enough to buy one of these rare pearls (nearly all sales are made locally), they are sure to notice that Micronesian pearls have some distinguishing qualities over black pearls produced in the Indo-Pacific region.

Pearls from FSM and RMI seem to appear in two extremes, either the very bluish-green or silvery-metallic, both of which commonly have strong rose overtones. Since farmers are aiming at maintaining quality, these pearls are also notable for their thick nacre, ranging from 2–3 mm and upwards.

A brief history of Micronesian pearl farming

FSM and RMI have naturally occurring populations of the blacklip pearl oyster (*Pinctada margaritifera).* No recent reports of goldlip pearl oysters (*Pinctada maxima*) naturally occurring in FSM and RMI have been uncovered, although the Japanese and others have attempted to introduce goldlip

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and akoya oysters into Palau and goldlips into RMI as late as 1998. It appears that goldlip and akoya oysters do not survive well in these waters, although blacklips thrive.

Since WWII, several attempts were made to establish pearl farming in the region, but none took hold until the early 1990s, when the Marshall Islands was the site of two pioneering pearl farming efforts. In 1993, a public-private partnership was formed between the Marshall Islands Marine Resources Authority (MIMRA) and Black Pearls of Micronesia, lnc. (BPOM), a subsidiary of Black Pearls Inc. based in Kailua-Kona, Hawaii.

A pearl farm that eventually became fully privatised was established in Majuro lagoon. At the same time, Robert Reimers Enterprises, Inc. (RRE) — a large, diversified, Marshallese-owned company that had had good success in farming and exporting giant clams for many years — established another pearl farm on neighbouring Arno Atoll. These farms became the catalyst for pearl farming development in the region and both companies have recently established two more farms.

BPOM, which is now primarily locally owned, has established a satellite farm on Arno while RRE has a new and thriving farm on Jaluit Atoll, located 200 miles from Arno. Majuro can also boast two pearl hatcheries, one at the College of the Marshall Islands (CMI), and a larger, commercial-scale hatchery overseen by MIMRA and supported by the cooperative efforts of a number of entities (see below).

In the Federated States of Micronesia, the Ponape Agriculture and Trade School (PATS), a regional vocational training school, established the first demonstration and training farm, and pearl hatchery. The College of Micronesia Land Grant Program has replicated the PATS success by establishing a pearl hatchery and two demonstration farms. The only private farming efforts in FSM occur at Nukuoro Atoll in Pohnpei state and a new farm in Chuuk.

Although the nine pearl farms are still small, total pearl oysters under cultivation is estimated to be around 100,000. The farms began in the mid-1990s with small harvests of 300–500 pearls. Recent harvests have topped 3000 pearls. Rapid expansion is expected now that the hatcheries are in full operation.

A different path to pearl farming development

One question that commonly comes up, particularly among those of us in government and educational institutions that support pearl farmers with technical assistance and training, is why — given the recent woes of the global pearl industry — would anyone advocate starting yet more pearl farms, especially in light of the special challenges that Micronesia faces in terms of development?

As a collective group of private and public sector partners, we have learned valuable lessons from the tribulations of the pearl farming world, and have adopted strategies and approaches that we hope will allow us to establish a sustainable and unique pearl farming industry. These are examined and discussed below.

Dependence on hatchery-produced spat

FSM and RMI were initially slow in developing pearl farming simply due to the fact that pearl oyster populations are relatively small in comparison to those found in the Polynesian islands. These appeared to have been decimated by early, intensive mother of pearl fisheries and have never recovered.

The same is true in Hawaii, where both black pearls and small, golden pearls from the small Hawaiian pearl oyster (*Pinctada radiata*) were common, and the abundance of the latter gave Pearl Harbor its name.

Only a few islands can boast a high level of natural spat fall, such as Nukuoro, which was able to become the first successful pearl farm in Micronesia due to this attribute.

Several research projects and sporadic attempts have resulted in some borderline results at collecting wild spat in several locations, but it has become obvious that collecting wild spat in marginal areas requires a high level of expertise and incurs costs that make establishing hatcheries a feasible and attractive alternative. Four hatcheries now operate in RMI and FSM. Only the MIMRA-operated hatchery in Majuro is considered to be of commercial scale, but given that the farms are still small, even relatively small hatcheries such as those operated by CMI and PATS are sufficient to adequately supply existing and new farms for some time.

Small demonstration hatcheries have shown that hatchery production of pearl oyster spat can be done cost-effectively and by personnel with limited technical training.

CMI, PATS and new UH-Hilo hatcheries have all been established on shoestring budgets and using bare bones, standard rearing methods.

While the need to rely on hatcheries for farm stock may be viewed as a great impediment, it has a num-

ber of advantages. First, farms in Micronesia cannot expand beyond reasonable limits and so create disease and other environmental problems because hatchery operators, who are mostly government and university supported, can take appropriate steps to regulate farm sizes to prevent impacts. Second, hatcheries will allow the improvement of pearl oyster stocks through genetic selection.

At the same time, the introduction of pearl oysters from other regions, that might swamp out the special characteristics that pearls in our region exhibit, can be avoided. Hatchery production can therefore help keep pearls high quality and unique enough to give Micronesian farms an edge in the global market.

Training and technical assistance

FSM and RMI each maintain a special relationship with the United States. Support agencies include the United States Department of Agriculture entities (Land Grant, Center for Tropical and Subtropical Aquaculture), the National Oceanic and Atmospheric Administration, Sea Grant, National Marine Fisheries Service, and others.

In addition, the islands have their own colleges and Land Grant offices, and receive support from universities around the world, such as the University of Hawaii-Hilo, University of Guam, and University of the South Pacific, among others.

Research

No productive sector can thrive and improve without constantly seeking ways to understand and control basic aspects of the farming process.

Desired outcomes of current research are to: increase understanding of the basic biological and environmental components of pearl farming; optimise the cost-effectiveness of farming and hatchery methods; and improve and control pearl quality (size, lustre, colour) and other production factors (survival, grafting results, etc.).

The number of active and closely cooperating researchers in Hawaii and Micronesia who are investigating key questions is a significant advantage our region has compared to others.

Among the current research efforts underway are:

1) improving hatchery and nursery methods (PATS);
2) population genetics studies of pearl oyster populations in Hawaii and Micronesia (University of Hawaii-Hilo and Hawaii Institute of Marine Biology);
3) improvement of grafting methods (University of Hawaii-Hilo); and
4) periodicity of spawning seasons (PATS and CMI).

Since most of these efforts are supported by public funding, research results are available to anyone.

Public-private partnerships and cooperation

The many actors in the Micronesia/Hawaii pearl arena rapidly realised that their only hope of surviving and competing with the more established Polynesian industry was to team up and work together to establish and improve the local industry.

Overall, our collective of researchers, farmers, and government agents have learned to work together well on issues of common interest.

For example, the MIMRA-operated hatchery in Majuro was first founded as a private enterprise, but after private funding became scarce, a team composed of private industry (BPOM, RRE), educational institutions (UH-Hilo, CMI, PATS) and government agencies (MIMRA, USDA, Sea Grant) came together to provide funding and operational support to keep the hatchery operating for the benefit of all.

Another example is a recent project funded by USDA to the tune of USD 1.6 million under which seven educational institutions have come together to provide integrated support to the industry and build local capacity within the private sector.

The Pacific Aquaculture Center at UH-Hilo, PATS, CMI, COM, University of Alaska Fisheries Industry Technology Center, Pacific Business Center Program at UH-Manoa and the Coastal Resources Center at the University of Rhode Island are working together with industry and government partners to provide training, extension, research and marketing assistance to the pearl industry.

Economics, marketing and business management

Economics, marketing and business management are often ignored aspects of industry development. This has not been the case for pearl farming in FSM and RMI.

Led by Dr Quentin Fong of the University of Alaska, data were collected from the farms and hatcheries and compiled with data from biologists in an effort to develop a bioeconomic model of the industry.

This will provide a better understanding of production economics, risks and critical points where research is necessary to improve the profitability of the farms and hatcheries. With rapidly increasing production the day will soon come when production will exceed the local demand. To date, farmers have had little trouble selling nearly all their pearls directly into local markets in Micronesia as loose, undrilled pearls.

To ensure that farmers get the best price for their goods, training has been provided in pearl grading (thanks to the help of the Gemological Institute of America), sales methods (thanks to "After Midnight Jewelers"), basic pearl jewellery setting and integration of pearls and pearl shells into local handicrafts (thanks to Joan Rolls of the Cook Islands, who started this effort).

The environment as the basis for production

One of the special contributions of pearl culture is that it is often one of the few viable development alternatives for Pacific Islands, allowing small island cultures to survive and thrive. This paradigm can only exist when the basis for both cultural and physical survival on a small island, the marine environment, is not affected by economic activities. Although we can point to many examples of environmentally friendly pearl farming, unfortunately, there are far too many cases where pearl farming has impacted the environment and the culture of those practising it.

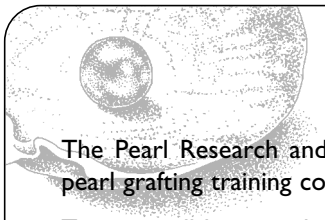
With several hatcheries now online in FSM, RMI and Hawaii, the group of colleagues working on pearl farming issues has come together to assess gaps in the policy and regulatory frameworks of the various islands to assure that an atmosphere conducive to pearl farming exists, and that adequate controls are put in place to make pearl farming as beneficial as possible.

To this end, Policy Working Groups comprising government officials, researchers, and industry members have been established in Hawaii, RMI, FSM and Palau in the last year to work on these issues.

These efforts are led by Dr James Tobey of the University of Rhode Island, and supported by USDA and the David and Lucille Packard Foundation, along with the local conservation, government and university groups (CMI, Hawaii Aquaculture Development Program, Conservation Society of Pohnpei, Palau Conservation Society, Pohnpei State Marine Resources, MIMRA and others).

One of the first practical results of this work has been the development of a set of Best Management Practices (BMPs) for pearl farming. These BMPs are based on the premise that good farm practices not only increase profitability, they also protect the environment. The BMPs have been generally accepted by the stakeholders. We would be interested in others reviewing and commenting upon these BMPs (see www.uhh.hawaii.edu/~pacrc).

It should be noted that the BMPs were informed by work conducted in the Cook Islands by Ben Ponia (Secretariat of the Pacific Community) and Ian Bertram (Cook Islands Ministry of Marine Resources).



Pearl grafting programme

The Pearl Research and Training Program at the University of Hawaii-Hilo is offering pearl grafting training courses in partnership with pearl farms in the Marshall Islands.

Training will be provided by a highly qualified grafting technician on a commercial pearl farm for 10 days and will be accompanied by training in basic pearl farming methods on the farm. Additional training after the initial 10 days can be arranged.

The number of participants will be limited to six. A sliding fee scale is available.

Interested persons should contact Dr Maria Haws (haws@aol.com) to apply. Send a letter of interest, description of background and a resumé by email.

Conclusion

By taking an integrated, science-based approach to pearl farming development, we hope that Micronesian pearl farming can indeed become a major contributor to the economies of FSM, RMI and other Micronesian nations, not to mention a major player on the world scene.

Micronesian pearl farms are challenged in some ways, but their ability to produce unique and high-quality pearls in a pristine environment is what promises to be the key to surviving in the turbulent world of pearl farming. The key success to date has been the highly collaborative and cooperative efforts by teams of government officials, university personnel and farmers.

We hope to expand this cooperative network to include more individuals who are active in these issues in other parts of world, so we extend the invitation to you all to communicate and explore collaborations that will help the pearl industry improve and move forward throughout the Pacific region.

Trial farming the akoya pearl oyster, *Pinctada imbricata*, in Port Stephens, New South Wales[1]

Wayne O'Connor, Norman Lawler and Michael Heasman

Source: New South Wales Fisheries Final Report Series No. 42. January 2003.

Summary

Several species of pearl oysters occur naturally in New South Wales coastal waters. One of these, the akoya pearl oyster, *Pinctada imbricata*, is of considerable commercial importance overseas and is the subject of research in NSW. This research had three major aims: to learn more about the biology of this pearl oyster; to develop the techniques necessary for commercial production of pearl oysters; and to see if pearl oyster farming is likely to harm the environment. This report presents the outcomes of this research.

Aspects of the biology of the akoya pearl oyster include:

- changes in the reproductive condition of akoya in Port Stephens;
- growth rates of akoya in NSW;
- akoya tolerance to changes in temperature and salinity;
- akoya tolerance to air exposure;
- anaesthetics for akoya, and
- predatory flatworms and their control in akoya culture.

A detailed discussion of the techniques used to produce commercial numbers of juvenile akoya oysters is given as well as a description of the techniques used to produce the same species of pearl oyster in China.

In 1999, a private company constructed an experimental pearl oyster farm at Wanda Head, Port Stephens. This allowed an assessment of the potential impacts of pearl oyster farming. The chemical composition of the seafloor and the animals living in it were compared between the farm and eight other sites in Port Stephens. These comparisons have not detected any changes as a result of the farming activities.

During this research, observations were also made of a second native pearl oyster species, the bastard oyster, *Pinctada albina*. A record of the seasonal change in the reproductive condition and a description of the early development of *Pinctada albina* are given.

1. Editor's note: A full pdf version of this research report is available at the NSW Fisheries site: http://www.fisheries.nsw.gov.au/sci/outputs/aquaculture/s_akoya_pearl.htm. If that doesn't work, go to the NSW Fisheries website at www.fisheries.nsw.gov.au, then to "Publications", "Science", "Scientific outputs", and "Division of Aquaculture".

Pearl oysters as a sensitive, sessile monitor for non-point source heavy metal pollution

Dale Sarver[1], Neil Anthony Sims[1] and Valerie Harmon[1]

Background

This work assessed the feasibility of using pearl oysters as a bioindicator of heavy metal pollution in near-shore areas of Hawaii and other tropical regions. Bivalves are well known for their ability to concentrate heavy metals, and they are used extensively in temperate areas to monitor pollution. The Oyster/Mussel Watch Program has hundreds of sites along all the coasts of North America, and similar programmes exist in Europe. The tropics have no such programme. Heavy metal pollution is certainly a concern in these areas, especially in harbours and shoreline military facilities.

Pearl oysters have several characteristics that make them an ideal candidate for biomonitoring. First, they are known to be exceptionally good at concentrating heavy metals in their tissues. Second, they have a wide Indo-Pacific distribution, which would allow collection of comparable data throughout the region. Third, pearl oysters are a commercial species; proven hatchery techniques allow production of large numbers of genetically similar animals of known ages for use in trials. In addition, these oysters can be held in oyster panels in a variety of locations. They can be suspended at any depth from the bottom to the surface using vertical float lines, and can be located throughout harbours or along exposed stretches of coastline.

Pollution levels in the water column are never constant. Much of the heavy metals are bound up in sediments, and can be re-suspended during storms, instances of high surf, or periods of runoff. These relatively short-lived pulses can reach problematic levels, but are seldom observed in standard long-term monitoring programmes. In addition, many pollution incidents are caused by short-term incidents such as spills or accidents.

Hatchery-reared pearl oysters can be deployed for any length of time, from a few weeks to a year, depending on how fine-tuned the data needs to be. The analysis does require an Atomic Absorption Spectrograph machine, but these are common equipment in most water quality laboratories, and the samples can be frozen for long periods of time and shipped long distances.

This project sought to determine the feasibility of using the pearl oysters for such a monitoring programme. Controlled exposure trials in the laboratory, as well as trials in the ocean, were carried out.

Two other novel techniques were applied to determine where these metals were accumulating: in the tissues, organelles, or shell layers. One approach utilised an electron microprobe to determine the amount of metals accumulated in the shell. The other method incorporated an energy filtered transmission electron microscope to locate where the metals were accumulating in the soft tissues.

Tank trials

Tank trials were performed to test the effects of both high and low levels of metals exposure to Hawaiian blacklip pearl oysters (*Pinctada margaritifera galtsoffi*). Tank trials with eight, three-month-old oysters per 40-liter tank were initiated on 12 September 2001. The trials tested two different water sources (NELHA and BPI water systems), and compared two different concentrations of metal ions (high and low). The experiments therefore consisted of four treatments as follows: 1) one treatment with BPI water and no added metals, 2) one treatment with NELHA water and no added metals, 3) one treatment with low dosage tanks dosed with 5 parts per billion (ppb) cadmium, 5 ppb copper and 25 ppb zinc (with BPI water) and 4) one treatment with high dosage tanks dosed with 10 ppb cadmium, 10 ppb copper and 50 ppb zinc (with BPI water). Oysters shells were measured at the start and end of the experiments. Algal feed was added three times a day.

On day 15, half of animals from each treatment (four individuals) were sampled, and the remaining four animals in each treatment were sampled on day 30. Sampling of oysters was done by removing them from the treatments and allowing them to purge out the ambient solution for two hours in treatment water that had no metals added. The animals were then chilled, to allow them to be opened easier. The soft tissue was excised, and the tissue and the shell from each animal were rinsed in distilled water, labelled, and frozen separately. The samples were shipped to South Carolina on dry ice for analysis of the tissues and shells for metal accumulation.

1. Black Pearls, Inc. P.O. Box 525, Holualoa, HI 96725 USA

A tank was set up at high dosage levels with larger animals for the microprobe and energy filtered transmission electron microscope (EFTEM) work to identify which tissues within the oyster will accumulate the most metals. It was necessary to utilise larger animals so that individual tissues within the oysters could be separated. Procedures for this trial were identical to the procedures used for the other tank trials. This tank was sampled after 30 days of metal exposure.

Field trials

The same cohort of oysters (three months of age) that were utilised for the tank trials was utilised for field deployment at five sites. Deployment involved measuring the animals, inserting them into a mesh bag with large plastic beads as a substrate and suspending the mesh bag in the water column for the exposure period. Twenty animals were deployed at Kawaihae Harbor, and twelve animals were deployed at Kaloko Reef, on the Big Island of Hawaii. Twelve animals were deployed in Keehi Marina, Kaneohe Bay, and Pearl Harbor, on Oahu. All groups of oysters were retrieved for analysis after periods ranging between 92 and 100 days of exposure. Tissue processing was done as with previous trials: animals were opened, soft tissue was removed and rinsed in distilled water, shell was rinsed in distilled water, and samples were frozen prior to analysis.

Conclusions

1) Pearl oysters do indeed concentrate heavy metals such as copper, cadmium, and zinc.

2) Rates of accumulation were directly proportional to both concentration in the environment, and duration of exposure.

3) There are very significant differences in metal levels in oysters held at the different locations. High levels of copper were found in Honokohau and Keehi harbors, and elevated levels of zinc occurred in Keehi, Kawaihae, and Honokohau Harbors. However, the relatively low levels of zinc and copper in Pearl Harbor were surprising. Also, high levels of cadmium on Kaloko reef were puzzling.

4) Metal concentrations vary with time. A second deployment of oysters at Pearl Harbor showed zinc levels more than double those of the earlier test, even though the exposure period was only 30 days compared with 90 days for the earlier test. The zinc levels for Kaloko reef were also higher in the second trials.

5) Heavy metals are not greatly concentrated in the shells of pearl oysters. The electron microprobe was not able to detect significant levels of these substances in the shells.

6) The energy filtering transmission electron microscope does not appear to be a good tool for detecting and locating elevated heavy metal concentrations in oyster tissues.

Blacklip pearl oysters therefore appear to be a suitable organism for heavy metal pollution monitoring. A successful protocol for laboratory experiments to determine levels of bioaccumulation over time and at different concentrations has been developed. Also, methods for field trials to monitor environmental pollution levels have also been demonstrated.

There is good potential for using this animal and these methods for environmental monitoring in tropical areas. This species has a wide range throughout tropical and sub-tropical waters of the Indo-Pacific region. Trials with other heavy metals — strontium, cobalt and lead — are currently being conducted. There may be potential for using pearl oysters to monitor levels of radioactive strontium and cobalt in the lagoons of atolls used for atomic weapons testing in the past.

Note

This work was conducted as part of Contract No. 48210, for CEROS (Center of Excellence for Research in the Ocean Sciences), an agency of the U.S. Department of Defense.

A full report, including detailed tabulation and graphs of results, is available at the Black Pearls, Inc. website: www.blackpearlsinc.com, under the Research and Development/Marine Biotechnology/

Researchers at Gemological Institute of America act quickly to protect the interests of the trade and public

Larne Boyles

Source: *The Loupe* (Summer 2003)

Shane McClure was flipping through a local newspaper in October 2001, scanning the pages filled with news of the 9/11 aftermath, when he came across one particularly alarming headline: "Coming Soon: Irradiated Mail."

The shocking banner topped a story alerting readers that the US Postal Service was planning to use a new treatment method on mail to destroy spores of anthrax, a toxic substance that had previously been detected in envelopes and taken the lives of several people and made many others ill. By screening envelopes and packages with specific doses of radiation, the harmful biological agent could be eliminated, the Postal Service said.

In theory, the concept was a brilliant one to allay the concerns of Americans who had come to fear the daily task of opening their mail. But for McClure, director of West Coast Identification Services for the Gemological Institute of America Gem Trade Laboratory, and a number of other GIA researchers, the move signalled serious red flags for the gem and jewellery industry.

"Irradiation and coloured gems don't mix," he said. "Irradiation is often intentionally used to change the colour of some gem materials. Irradiating mail containing coloured gems could have an unintentional (and undesirable) result."

Many pearls and coloured gemstones are shipped through the US Postal Service, and GIA researchers saw potential ramifications for the industry if all packages were subjected to the irradiation process. But McClure said, he and his team felt it was necessary to test the possible effects of the process before sending out a public warning.

McClure and other GIA researchers worked directly with Surebeam, one of the companies that would perform irradiation for the Postal Service, to conduct these various tests. Sixteen gem materials known to be affected by irradiation, including kunzite, sapphire and Chinese freshwater cultured pearls, were subjected to this process after being packaged in the standard manner used in the gem and jewellery industry. "All of the gem materials, except diamond, showed a dramatic change in colour," McClure said. "For some, the effects were temporary, for others permanent. Either way, this was potentially a big problem for the coloured stone and pearl industry."

In November 2001, the Institute issued an alert to the trade to warn about the effects of postal irradiation. GIA's proactive response in this case is just one example of how it looks out for the interests of the trade and the public at large, said William E. Boyajian, president of GIA. "When coloured stone and pearl issues arise, the industry looks to GIA for answers," he said. "It's our mission to ensure the public's trust in gems and jewellery by upholding the highest standards of integrity through research, and we are prepared to do just that."

Chinese freshwater cultured pearls

The GIA research department comprises a team of highly skilled and experienced scientists, gemologists and laboratory technicians using state-of-the-art facilities. Equipped with the latest in scientific instrumentation, the Institute is well prepared to respond to critical coloured stone and pearl issues.

GIA's access to these and other resources, such as its extensive database of gemological information, has aided in a number of research projects in recent years, including the Institute's work on Chinese freshwater cultured pearls (FWCPs) in the late 1990s and early 2000s.

When large (10+ mm) near-spherical, freshwater cultured pearls (FWCPs) from China began appearing on the market in unexpected quantities during the mid-1990s, the trade wanted definitive information about the culturing process. Although Chinese FWCPs typically had been formed by the surgical implantation of a piece of mantle tissue from a donor mollusc, some industry members suggested that bead nucleation was responsible for most of these large, almost round cultured pearls.

Unlike standard nucleation with shell beads, however, these theories suggested that low quality, all-nacre, freshwater cultured pearl rejects were being used as the bead nuclei. The main concern was that the resulting cultured pearls might be indistinguishable from normal tissue-nucleated FWCPs or even natural pearls on X-radiographs.

"If the suspicions of the trade were true about how these large Chinese freshwater cultured pearls were grown, the perception would be that they were less desirable," said Thomas M. Moses, vice president, Identification and Research Services at the GIA Gem Laboratory. "We wanted to perform the necessary research to properly identify the nucleation technique."

Moses joined scientists from other laboratories to determine the specific process. He worked closely with Kenneth Scarratt, laboratory director at the American Gem Trade Association Gemological Testing Center, and Shigeru Akamatsu, former manager of the Pearl Research Laboratory at Mikimoto and Co. The team performed X-radiography on approximately 41,000 samples, some of which they cut in half and examined with a gemological microscope. They found no evidence of Chinese FWCPs that had been nucleated with freshwater cultured pearl rejects.

They concluded that the vast majority of large, rounded freshwater cultured pearls from China were grown using mantle tissue inserts only. They attributed the larger sizes to the use of larger host mussels and larger, modified pieces of mantle tissue. The team published the results in the Summer 2000 and Summer 2001 issues of Gems and Gemology.

"This study clearly shows the importance of research, because the results of that research can often help bring useful and necessary knowledge to the trade and public," Moses said. "When there is not enough information about a gem material or new treatment, the public can often lose confidence in their purchases," McClure said. "GIA strives to disseminate the results of research based on hard facts from scientific, rigorous testing and highly trained researchers and gemologists. That is why we pull in every resource we have to resolve these issues as quickly as possible."

Key pearl reports

(Compiled by James Shigley, PhD)

Below is a timeline of important pearl entries from G&G's Gem Trade Lab Notes and Gem News Sections (1981–2002)

Spring	1982	Cultured pearls from Lake Biwa, Japan
Summer	1984	Freshwater cultured pearls with lentil-shaped nuclei
Summer	1985	Freshwater cultured pearls from China
Fall	1986	Treated black cultured pearls
Fall	1991	Tissue-nucleated saltwater cultured pearls
Winter	2001	The effect of postal irradiation on gemstones

Pearl description system still being fine-tuned, GIA says

Victoria Gomelsky, Diamond/Gemstone Editor

Source: *National Jeweler* (1 April 2003)

Three years ago, the Gemological Institute of America (GIA) embarked on a project that promised to change the way pearls are bought and sold. Today, that effort — the creation of a pearl description system that will standardise the language pearl dealers use to describe their products — is still being fine-tuned, said GIA Gem Trade Laboratory Vice President Tom Moses at a seminar held on the first day of the Hong Kong International Jewellery Show.

The colour theory behind the sophisticated system will help pearl specialists pinpoint where each gem lies in a three-dimensional "colour space" as defined by its hue, tone and saturation. GIA has identified 19 essential hues or "colour names." Pearls in each of these hue categories are also plotted on a centre axis that indicates their tone, from white to grey to black.

"It's important to remember that these spaces are fairly large — the same nomenclature can accommodate different colours," Moses said, emphasising the need for robust descriptions that don't give too-precise colour specifications. "Every description is a range."

The institute faces some unique challenges when it comes to creating a uniform pearl lingo, Moses said. For one, pearls, unlike inorganic materials such as textiles and paints, don't fill the entire colour space — at least as far as the untreated ones go. They are limited to shades of white, gold and black, although the Tahitian goods admittedly appear in a wider range of colours.

For another, pearls often display a complex mosaic of colours, with body colour, overtone and orient coming together in a wild medley of shades that can be difficult to separate. Using a slide of a magnificent Tahitian pearl that he described as having a "bluish-green body colour with a strong green-rose overtone and an overlay of strong orient," Moses said such examples "throw a wrench into the description system because [they are] so complex."

Plastic and steel pearl imitations

Source: *Gems and Gemology, September 2002*

During the Basel World Watch and Jewellery Show in April 2002, the SSEF Swiss Gemmological Institute received three parcels of predominantly small brownish grey to dark grey and pink "pearls" for testing.

The 548 samples were all undrilled, and ranged from approximately 2 to 12 mm in diameter. They were round to button shaped, drop shaped, and baroque. At first glance, all looked quite convincing. However, when we immersed them in carbon tetrachloride for X-radiography, two black, slightly baroque spheres (each approximately 3 mm in diameter) were seen to float, which indicated they were imitations. When examined with a gemological microscope, they revealed a slightly uneven, granular surface. They also appeared to be very soft, as evidenced by the fact that when tested with a needle on an inconspicuous spot, the surface was indented. A hot point applied to the surface produced a typical smell of burned plastic. On the basis of these characteristics, these "pearls" were identified as black plastic.

X-radiographs revealed a second pair of imitations in the same parcel. Both were perfectly round (4.75 mm in diameter) and showed complete absorption of X-rays. Microscopic examination of these silvery grey spheres revealed small brownish spots on their surface, but not the suture lines that are commonly seen on natural or cultured pearls. Also, each weighed approximately 2.20 ct, which is about three times greater than genuine pearls of similar dimension. Qualitative chemical analysis with EDXRF spectrometry revealed only iron with a trace of titanium. On the basis of these combined characteristics, these spheres were identified as steel. All of the other samples in the parcel revealed characteristic features of natural (i.e. not cultured) pearls in the X-radiographs.

Although the SSEF laboratory has encountered plastic imitation pearls on occasion, these are the first steel imitations that we have encountered.

For more gemological updates from around the world, see the Gem News International section of Gems and Gemology. To subscribe, visit www.gia.edu/gandg or contact Subscriptions Manager Debbie Ortiz at dortiz@gia.edu. Call toll free 800-421-7250, ext. 7142. Outside the US and Canada, call 760-603-4000, ext. 7142.

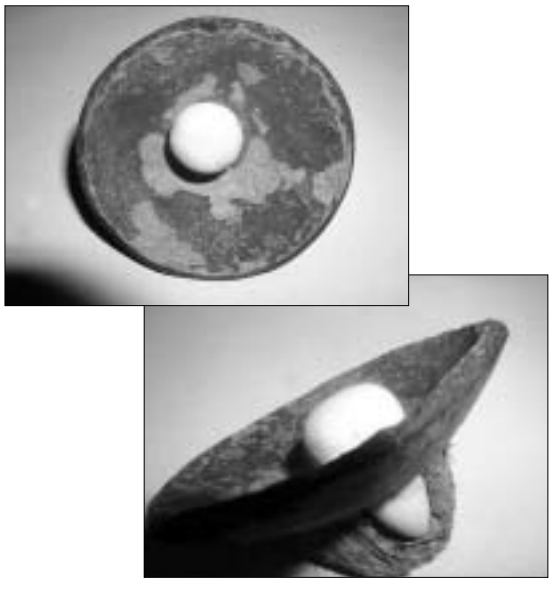
Editor's note: This report was prepared by Dr Michael S. Krzemnicki of the SSEF Swiss Gemmological Institute.

Coconut pearl saga continues…

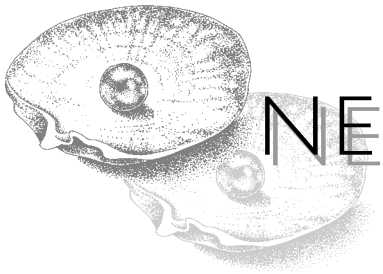
With reference to your article on the Coconut Pearl (*SPC Pearl Oyster Information Bulletin* #14, December 2000, p. 40, "Garden Islands of the Great East: Collecting Seeds from the Philippines and Netherlands India in the Junk, *Cheng Ho*", David Fairchild, 1943. New York: Charles Scribner's sons. 239 p.) and an interesting article on the coconut pearl by Professor Wayne P. Armstrong of Palomar College in San Marcos, California (www.coconut.com/features/cocopearl.html), I have in fact such an item in my personal collection. I would like to seek your professional opinion on how much the pearl would be worth in monetary value? I have attached two photographs of my coconut pearl.

I bought this pearl 22 years ago in North Borneo (currently known as Sabah, Malaysia). It is about 7 centimetres in circumference and about 2 centimetres in diameter. Please take a look at it. I would appreciate your kind comments.

Mr N.M. Ngoi (Email: nmngoi@yahoo.com.sg)



Editor asks: Would anyone out there care to offer Mr Ngoi an opinion on his pearl? Please keep us informed of any news in this area.



NEWS AND VIEWS

Technicians branded by your negative remarks

Dear Editor

Interesting to read your negative remarks about technicians that won't reveal operation techniques, and the so-called "exorbitant fees" that they charge. I see no comment has been made about the hundreds of pearl shell technicians who have received no payment over the years by farms who probably had no intention of honouring their agreements, from the very start. Based on receiving a percentage of the harvest after two years, many technicians have to fund their way into a job. That is they must pay for their airfares and provide nucleus at their own cost. They must then operate large amounts of oysters in difficult conditions, while they are stuck on an atoll, totally isolated, with no communication, miles away from family and friends, and medical care should something go wrong. Technicians on a percentage deal have to wait two years or more for payment. Even if a low up front fee is asked for, most farms insist on a percentage deal. This way, farms get out of any up front fees. By the time the harvest has arrived many technicians have funded their way into their second operation with the farm at their own cost of many thousands of dollars. As you can imagine, once you enter into a percentage deal with a farmer, then you are totally dependent on the farmer's honesty for payment and your results. Many technicians who have entered into percentage deals, have mysteriously had their shell die off over the two years, or the shells have been stolen, or a storm wiped out the farm, or there were problems at the market. Any number of scenarios can be drummed up. Sometimes the problems are genuine, many times they are designed to get out of paying technicians.

Around April 2001, a well known technician who often let locals look over his shoulder and was well loved and respected in the industry, died in a drowning accident in the Cook Islands. It was sad that he died frustrated with a number of pearl farmers who would not honour payment even after pearls cultured by him had long since been sold. Many technicians have found themselves in the same situation.

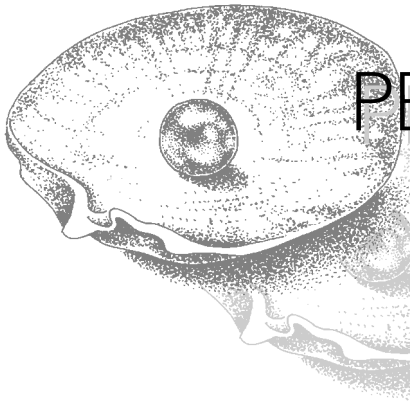
So Mr Sims, next time you or any other "desktop pearler" take your feet off the desk and put your hand out for a cheque, spare a thought for the hundreds of technicians, who are working like dogs in isolated places, all hoping to get paid and cover their costs and pay there bills on a promise. Why don't you give it a go yourself. Perhaps you would charge "an exorbitant fee" to make it worth your while. Most technicians we know just want a fair deal for services provided.

Nucleus manufacturer makes flattering comments . . . and a modest suggestion *from Tim Parrot*

The latest POIB was very informative and well written. Your writing style is very clever and thoroughly enjoyable. "Editor not edicter", was my favourite line.

Finally a question that has been on my mind for some time. Would it be possible to add our business to your technician registry as a nucleus supplier? This seems a reasonable extension of the goals of the registry, to increase farmer awareness of their seeding options. If possible I would prefer to receive a list of pearl technicians so that we could prospect them directly. The technicians are probably the ultimate key to nucleus sales, particularly these days.

Editor replies: We are always highly susceptible to flattery, but I am not sure if there is a need for a listing of nucleus suppliers. I will take guidance from our readership: Would those of you working in the South Pacific want to see an expanded list of service providers, to include nucleus suppliers, and perhaps also suppliers of other pearl farm equipment or other service providers? Please write and let me know if this would be helpful. I will presume that no answer means you are not interested.



PEOPLE, PRODUCTS AND PROCESSES

Interview with a hatchery guru

Source: *Jewellery News Asia* (October 2002); reproduced in *Pearl World, the International Pearling Journal*

The following article by *Jewellery News Asia*'s Contributing Editor, Jennifer Henricus, appeared in the October 2002 issue and covers what is going on with one of the top marine biologists in the field, an old and dear friend of many in the business named Dr Bob Rose.

Australia-based Pearl Oyster Propagators Pty Ltd (POP) pioneered pearl oyster hatchery and cultivation technology in 1989 in Australia as well as in other pearl producing countries, including Indonesia and Thailand. Owned and managed by marine biologist and aquaculturist, Dr Robert Rose, POP has made numerous innovations in hatchery technology including stock enhancement or selective breeding to produce mantle tissue used to influence the colour and coating of South Sea pearls. Dr Rose and his team have also developed techniques and aquaculture practices that have contributed to successful farming of *Pinctada maxima* and *Pinctada margaritifera* oysters to produce saleable pearls. In this interview, Dr Rose talks about POP's innovations in the husbandry of pearl oysters, throws light on some of the techniques that influence [the] colour and quality of South Sea pearls and shares his vision for the future of pearling.

JNA: In your view, what is the most significant innovation in pearling that POP has made in the past 13 years?

Dr Rose: I feel that our greatest achievement has been to reliably and routinely produce large numbers of oysters for commercial production of South Sea pearls. We were among the first non-Japanese scientists to grow *Pinctada maxima* oysters from larvae and produce saleable South Sea pearls on a commercial scale, demonstrating to non-Japanese pearl farmers that by running a farm with hatchery, nursery and grow-out facilities it is possible to grow oysters that are as good as wild oysters and can produce commercial quantities of high-quality pearls.

Now we are typically able to achieve 97 per cent or more saleable pearls from a harvest of hatchery-produced oysters, with the pearls from the first operation averaging around 0.78 momme per piece. This was done using research results developed by a small team of biologists and myself at the Western Australian Fisheries Department, which was funded by the Australian Commonwealth Fishing and Research Development Corporation (FRDC).

The FRDC project was partly aimed at catching up with Japanese hatchery technology already established and to discover new technology that would propel the Australian pearl industry. In our case as well as with Japanese research, Australia was the starting point. Japanese scientists researched and developed the technology to pilot-scale level in Australia before moving to Southeast Asia and applying it commercially. We, too, had to go overseas first before we could apply the technology in Australia.

At the end of the Western Australian FRDC project, we set up POP and offered to establish a cooperative venture for Western Australian pearl producers, who at the time were producing all of their pearls from wild stock. The proposal was rejected and soon afterwards, Norman Analau of PT Moluccas Mariculture invited me to work with him in Indonesia. Once we demonstrated that it was commercially possible, POP began working back in Australia, as well as in Southeast Asia.

JNA: What is POP's involvement in pearling in Australia, Indonesia and Thailand?

Dr Rose: We have surveyed farm sites throughout Southeast Asia, designed and built six hatcheries

and three farm-based camps, operated them and trained staff. Often we have medium to long-term management contracts.

Our involvement depends on the perceived needs of the farmer. Generally we work with companies expanding or moving to uncharted waters of hatchery production. In 13 years POP has trained over 35 aquaculturists and reared at least 1.1 million oysters used for pearl cultivation.

In Australia we designed and supervised the construction of the Darwin Hatchery in the Northern Territory for Kim Male, a second- generation pearler, and Steve Arrow, a pioneer in Australian pearling. We also designed and supervised the construction of the Cone Bay hatchery for Maxima Pearling with David Jackson.

Overseas we designed and supervised the hatchery for KRI at Bacan, Indonesia, and in Thailand we designed and operated a hatchery for Robert Wan for *Pinctada maxima* oysters.

More recently, along with Kim Male, we had a vision to establish a pearl farm near the Gulf of Carpentaria. That vision led to the setting-up of two pearl farms belonging to Toomebridge and Arafura Pearls Holdings in Elizabeth Bay in the Northern Territory.

JNA: What are the benefits and disadvantages of pearling in Australia compared to Indonesia, the Philippines or Thailand?

Dr Rose: Australia is one of the last places where pearls can be produced on a commercial basis from wild oysters. The coastal waters of Western Australia are like a huge, natural nursery/grow-out habitat for young oysters. Settlement of juveniles into the area is routine and reliable each year. The natural survival levels are so high that it is economically worthwhile to put expensive divers onto large boats to comb the sea floor for these wild oysters. The farms are located in remote areas which are generally safe from pollution., theft and competing human activities. The disadvantages are the expensive operating costs and more recently the lack of marine areas suitable for pearl cultivation.

Factors affecting colour

JNA: What has your research in mantle tissue selection demonstrated about colors and coatings of pearls?

Dr Rose: Although the Japanese have been trying to manipulate the color of pearls genetically since 1947, our preliminary work has shown that the graft, or saibo tissue, used in the insertion of the nucleus, is very important in determining the white/silver colors of pearls, while the host oyster is not terribly important.

We have noticed that some of the yellow and golden colors are not determined solely by the graft tissue, and that there appears to be an interaction between the donor tissue, host oyster and marine environment.

Our findings supported those of Japanese farmers in Indonesia who had been working on this earlier, and our figures agreed with the work recently published at the World Aquaculture Society's conference in China this year.

JNA: When going for golden pearls, what are the innovations that ensure golden instead of cream or yellow?

Dr Rose: I'm afraid we cannot answer this question at present with any certainty. All we can say is that the production of golden pearls is less predictable than producing silver/white pearls.

The selection of saibo tissue from golden-lipped oysters can lead to the production of silver/white, cream, yellow or golden pearls. What does help to ensure golden pearls is that the mantle tissue is carefully selected from oysters with "strong" golden-lipped characteristics.

Hopefully our investigations into the importance of different shell color in young spat and juveniles, which is still in progress, will shed some light on this topic in the future. Interestingly, we have found that some of the color types seem to have poorer survival rates in different areas.

Environmental fluctuations

JNA: Are there signs of El Niño effects in the waters around Australia? How do you think this will impact on pearl production in the next few years?

Dr Rose: According to the Australian Bureau of Meteorology, there is an 80% to 90% chance that Australia will experience an El Niño weather pattern this year.

Generally El Niño occurs every four to seven years and lasts 12 to 18 months. An El Niño event will elevate seawater temperatures above normal and this will possibly affect food availability.

JNA: There is a theory that pearl oysters can be grown in inland seawater tanks away from all the environmental fluctuations, EI Niño effects, disease and other hardships of growing oysters in oceans. Do you subscribe to this theory?

Dr Rose: The late Michael Kallis of Broome Pearls once said you can grow tomatoes in the Antarctic if necessary, it is just a matter of cost. I have personally worked with *Pinctada maxima* for over 21

years and do not feel that keeping them in a tank is worth the effort.

It is a myth, in my opinion, that this predominantly subtidal, high-turbidity-loving bivalve is going to grow into a 2.7 to 50 kilogram animal and live for 50 years, not get sick, eat nutritious, fatty acid phytoplankton and produce 15mm pearls by living in a tank, unless the tank is the size of a very small bay with excellent water circulation.

JNA: Have you discovered the perfect place for pearling?

Dr Rose: No, everything is a compromise. However, one thing I have noticed is that whenever ventures set up in an area that has a single "bottleneck" opening connecting the farm to the open sea, the farms generally have problems related to water circulation and quality. Farms located in these situations have periodic mortality outbreaks among farm stock, widespread disease, toxic phytoplankton blooms or lengthy periods of extreme physio-chemical conditions, such as high temperatures, low salinities or low oxygen concentrations.

Making findings public

JNA: As a scientist, would you consider it important to make public your research findings for the greater good of the industry?

Dr Rose: As an applied scientist, I feel it is important to make available all of my research findings to the entire industry, providing the institution funding the work agrees to this.

In any case, the research should be relevant to the needs of the industry and should be of a fundamental or generic nature, such as improving our understanding of the oyster's reproduction, physiology, ecology and life cycle. Pearling companies can then use the information practically.

JNA: How has this been viewed by established producers who still continue to operate, often in great secrecy?

Dr Rose: POP became a service company because the Western Australian pearling industry rejected the cooperative idea back in the 1980s. Many of the big companies probably felt that moving from research into development would disrupt the status quo. These companies claimed that secrecy was a vital aspect to their business and simply did not wish to do business with us.

Not surprisingly, we were more valuable to smaller pearling companies as they were hungry to acquire a commercial edge. POP has trained many aquaculturists who now work throughout Australia and in Southeast Asia both in the private sector pearling and non-pearling industry and in public service.

The future

JNA: What are POP's plans for the future?

Dr Rose: To work with farmers striving to produce the "merino" pearl oyster, the perfect oyster that will produce the perfect pearl as did animal husbandry with the merino wool sheep.

Our motto is to bridge the gap between old and new with research and development; but most importantly, we will continue to embrace pearl specialist Andy Müller's most appropriate business rule: KISS- keep it simple, stupid!

Request for help with *Pteria* identification

Editor's note: We received the request below from Dr Pramod. *Pteria* taxonomy not being my strong suit (well, OK, *taxonomy* not being my strong suit), I took the liberty of offering him the most capable and eager assistance of the POIB readership, to help him in his quest. So, all you underutilised and under-appreciated taxonomists out there, here's a chance to strut your stuff. Please keep us informed of how it goes.

Dr Pramod writes:

Respected Sir,

It gives me immense pleasure to introduce myself as G. Pramod. I am a researcher in the Department of Marine Living Resources, Andhra University, India, and I have been working on fringing and patch coral reef pearl oysters along Visakhapatnam, northeast coast of India (eastern Indian Ocean) for the past three years. We have been analysing seasonal and annual trends in population structure, ecology, and use of different substrates by pearl oysters up to 10 km from the coast, over a stretch of 42 km, as part of the "Pearl Oysters Assessment Program of the northeast coast of India". We are facing a shortage of literature on identification of winged pearl oysters in tropical environments, as very little work has been done in India on these aspects and very few sources from international journals are available. I came to know about you through the

Internet, and discovered that you are engaged in studies on pearl oysters.

I request your help with the identification of *Pteria* pearl oysters. I sincerely hope you will understand our situation and will accede to my request and help me with this identification. I will be glad to furnish any further information regarding our work.

Thanking you. Yours truly,
G. Pramod

Dear Sir,

Thank you very much for considering my request. Your honour, in India we have very few bulletins for identification of pearl oysters and corals. I would be grateful if you could present my request in the forthcoming POIB issue. I have been studying benthic invertebrates along the rocky intertidal areas of the northeast coast of India, and especially pearl oysters found attached to sea fans. I have encountered two species of *Pteria* sp., which are yet to be identified. I would be grateful to any scientist who could help me with this identification. I can send them pictures of these two species. I have encountered *Pteria* sp. attached to six species of colourful sea fans (Gorgonids). I am currently searching for sources of identification for sea fans, and *Pteria* spp. I am studying their associations with other hard structures: associated fauna like sponges, polychaetes, fouling organisms, and the depth to which they are encountered, etc. The bulk of my collection comes from drift nets, bottom set trammel nets (three layered net), fishing hooks, and from divers in shallow water areas searching for ornamentals. Other avenues including scuba diving are also being explored.

Thanking you. With warm regards,

G. Pramod
Research Scholar
Andhra University
96/2,1-56-26 Muvvalavanipalem
Visakhapatnam
530017 A.P
India

MOP nuclei for seeding pearl oysters

From: Dr Stefan Maser (14 October 2002)

Dear Neil,

I guess you still remember that we are a manufacturer of perfect, round white MOP nuclei from *Pinctada maxima*. Besides our very competitive prices I would like to emphasise that our nuclei are polished without any chemicals.

Besides unglued MOP nuclei, we produce also glued MOP nuclei up to 20 mm diameter. In this context, I want to point out that our used glue is developed and applied for medical human purposes and is therefore absolutely not toxic. I can say with our seven years experience that:

- the glue has not caused any undue deaths, and
- there is no conspicuous fracturing during gestation period.

That means the expense for larger white mussel shell nuclei is no more necessary due to the cheaper and absolute comparable covering of pearl nacre on our MOP nuclei. In other words; pearl farmers will save time and a lot of costs, they are in a position to increase their profits significantly!

We are able to supply unglued MOP nuclei up to 12.7 mm diameter and glued MOP nuclei up to 20 mm diameter.

Now we are seeking pearl farmers contacts. Can you publish this request in the next issue of Pearl Oyster Information Bulletin? Your support is greatly appreciated.

Dr Stefan Maser
Email: Stefan.maser@aura-nopfdesign.de

AURA Knopfdesign GmbH & Co. KG
Robert-Bosch-Strabe
14 D-72189 Vöhringer
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Change of address: Beatrice L. Burch

Thomas A. Burch, M.D. and Beatrice L. Burch are now residing at:

3599 Sylvan Pines Circle
Bremerton, WA 9831, USA

Ph : (360) 373 1299
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ABSTRACTS, REVIEWS AND CURRENT CONTENTS

World Aquaculture Society conference: Honolulu, 1–5 March 2004: Pearls '94 redux (or almost)

Source: *Pearl World, The International Pearling Journal*

How quickly time flies! Are we getting that old that quickly? Do you remember when we all congregated in Honolulu a decade ago, all bright eyed and bushy tailed, ready to put the pearl world in order? Well, something somewhat akin to that event is taking place this spring, in the same location: a comprehensive pearl session on the technical side of cultured pearling, much like the R&D discussions presented by researchers in conjunction with the full conference ten years ago.

The notification of this upcoming event came in to us recently:

2004 will mark the 10th anniversary of Pearls '94, a "world pearl" conference in May 1994, in Honolulu, that many have considered one of the most important events in the history of pearling. This was the first time (and last time) that farmers, scientists, retailers and wholesalers, and the jewellery press from throughout the world assembled to discuss the challenges facing the industry.

It was a rare sight, indeed, to see major exporters, importers and wholesalers rubbing elbows with pearl farmers from Tahiti, while discussing the latest developments in farming with researchers from Australian universities.

A "mini" celebration of Pearls '94 will be the Pearl Session at the World Aquaculture Society's annual meeting in Honolulu from 1–5 March 2004. Richard Fassler, who organised and chaired the '94 event, will co-chair the Session with Dr Maria Haws of the University of Hawaii at Hilo.

Unlike Pearls '94, the Pearl Session will be restricted to research presentations. However, according to Fassler, the session will offer the largest number of papers — 25 — in a decade, and researchers from India, Mexico, Australia, French Polynesia, the Federated States of Micronesia, the Marshall Islands, China and the US will be on hand to explain their work and answer questions.

Herewith we present some of the initial speakers and abstracts for the World Aquaculture Society confab. For more information on the conference and to register online, go to the World Aquaculture Society website (www.was.org) and click on "Aquaculture 2004". For WAS members, the registration fee is USD 295 (student: USD 125); for non-members the cost is USD 395 (student: USD 175). The cost goes up after 16 January 2004.

Since chairing *Pearls '94*, Fassler has organised Pearl Sessions in San Diego, Las Vegas, Seattle, Sydney, Bangkok and Beijing. He sees this session as a unique opportunity for persons in the industry to update themselves on the latest developments in pearling. He can be reached at: rfassler@dbedt.hawaii.gov

"Since most of the participants at our Pearl Sessions have known each other for many years, our discussions are unusually frank, interesting and productive," Fassler pointed out. "This session promises to be our biggest and best since '94!".

Growth and survival of hatchery-produced spat of *Pinctada margaritifera* during the ocean nursery culture in Pohnpei lagoon

by Masahiro Ito, Martin Hagilmai and Justino Smith
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Spat of the blacklip pearl oyster *Pinctada margaritifera* were produced from the hatchery built by the College of Micronesia Land Grant Program (COM) at Nett Point in Pohnpei, Federated States of Micronesia. On day 44 after fertilisation, the spat attached to "in-tank spat collectors" were transferred to the grow-out farms that were also built by COM. The growth and survivorship of the hatchery-produced spat were monitored during the ocean nursery culture. The spat were protected by spat bag (0.75 mm by 1.5 mm mesh) and suspended from a surface long line system at 2–3 m depth. After two months of initial ocean nursery culture, they were removed from the collectors and sorted into 48-pocket (4 mm square mesh) nets. At 4, 6 and 9 months of culture, they were further sorted and transferred into 24-pocket (20 mm mesh) nets, 15-pocket (30 mm mesh) nets or lantern (9 mm mesh) nets, respectively. The spat grew to the mean (± SE) antero-posterior shell length (APL) and dorso-ventral shell height (DVH) of 38.0 (±7.1) mm and 39.8 (± 6.4) mm, 57.4 (± 6.2) mm and 55.5 (± 7.1) mm, and 81.9 (± 8.1) mm and 83.9 (± 7.6) mm at 6 months (n = 206), 9 months (n = 87) and 12 months (n = 118) of the ocean nursery culture, respectively. The size of hatchery-produced spat after 184 days (6 months) of the ocean nursery culture in Pohnpei were similar to those at 196 days reported by Southgate and Beer (1997) from northeastern Australia. Compared to the best growth in Australia given by Southgate and Beer (2000) for the hatchery-produced juveniles between 7 months (DVH 41.5 ± 0.6 mm; n = 40) to 12 months (DVH 65.8 ± 1.0 mm), those juveniles in Pohnpei grew faster from 6 to 12 months reaching 83.9 (7.6 mm with a maximum DVH recorded 97.6 mm. Survival rates from 4 to 12 months and 6 to 12 months in Pohnpei were 83.2% and 91.3%, respectively (n = 6384 at 4 months; n = 5814 at 6 months; and n = 5310 at 12 months).

Ongoing hatchery and ocean nursery trials with several batches since the first quarter of 2002 revealed that the survival rates were constantly high during the monitoring periods from 4 to 6 months, 6 to 9 months and 9 to 12 months, which scored between 88.9% and 98.5%. Hatchery-produced juveniles also showed uniformity in their shape, e.g. average DVH/APL (± SE; n) ratios of the first and second batches from the hatchery runs in 2002 were 1.035 (± 0.050; n = 118) and 1.042 (± 0.085; n = 139) at 12 months of nursery culture, respectively, and there was no significant difference (P>0.05) between their average ratios.

These findings suggest that our grow-out culture methodology is proving its efficiency, that the farming environment of the Pohnpei lagoon in Micronesia is well suited for growing hatchery-produced *P. margaritifera,* and that we could have the potential of producing high quality black pearls as well. Nuclei implantation commences from September 2003 to conduct pearl quality experiments using the hatchery-produced and wild-caught pearl oysters.

Status of blacklip pearl oyster farming in the Republic of the Marshall Islands

by Manoj Nair, PhD
Aquaculture Research Scientist, USDA Land Grant, Cooperative Research And Extension College of the Marshall Islands, PO Box 1258, Majuro, MH 96960, Republic of the Marshall Islands. Email: manojnair999@yahoo.com

Pearl farming is one of the important sources of revenue for a number of the Pacific Island nations, including the Republic of the Marshall Islands (RMI). This aquaculture venture has been one of the main aquaculture revenue earners after the giant clam mariculture. The blacklip pearl oyster *Pinctada margaritifera* is also available in some of the selected atolls of RMI where they are being exploited for commercial purposes. There are four successful pearl farms in the country; they are in the process of expansion and several new entrepreneurs have also shown keen interest in pearl farming. However the major bottleneck for the successful and sustainable pearl farming in the region is the non-availability of sufficient wild pearl stocks.

Earlier studies have shown that the natural stock in RMI cannot support the industry operating commercially in a sustainable manner, and there is every possibility of the existing small stocks of pearl oysters being totally fished out. Experiments on wild spat collection in the different atolls have also given poor results. This problem has been successfully overcome recently with the development of commercial hatch-

ery technology to produce spat for the industry. Seeing the importance and the potential of pearl farming as a primary or supplementary source of income to the community, the government is in the process of encouraging small-scale ventures as alternate income generation methods to the traditional one of copra production, while simultaneously initiating steps on sustainable fisheries management strategies. This paper discusses the present status and the future pearl farming scenario in RMI.

An overview of pearl farming in India

by Manoj Nair, K.K. Appukuttan and T.S.Velayudhan
Aquaculture Research Scientists (same contact as in previous abstract)

India is well known from time immemorial for the production of beautiful natural pearls. The country has a wealth of pearl producing oysters. The main ones among these are the akoya oyster, *Pinctada fucata*, distributed throughout the famous Gulf of Mannar, Palk Bay and Gulf of Kutch. This oyster is often mistakenly identified and wrongly reported by many — even now — as *Pinctada radiata*. The blacklip pearl oyster *Pinctada margaritifera* is found in the Andaman and Nicobar Islands.

Pearl culture in India was first conducted on an experimental scale in the early seventies by the Central Marine Fisheries Research Institute (CMFRI) at its Tuticorin Research Centre on the southeast coast of the country. The Institute had initiated experimental pearl production in 1972 and the first Indian cultured pearl was produced the following year. Hatchery technology was developed by CMFRI for both *P. fucata* and *P. margaritifera* in 1982 and 1987, respectively. With the technology on sea farming of pearl oysters, and both cultured pearl production and hatchery production being standardised after repeated experimentation, pearl farming was taken up by private entrepreneurs and coastal community groups on both coasts of India.

This paper, in addition to giving an overview of evolution of the Indian marine pearl farming, discusses recent innovations like onshore pearl culture.

Development of pearl aquaculture and expertise in Micronesia

by Masahiro Ito, Robert Jackson and Singeru Singeo
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The pearl industry in Micronesia has the potential of becoming a major source of export income once it is developed. French Polynesia in the South Pacific alone exported over USD 100 million worth of cultured black pearls in 1999. Other Pacific countries are actively trying to develop their industry following the lead of French Polynesia and the Cook Islands. Micronesian nations are far behind these South Pacific island nations in the development of their pearl industries. One of the reasons for this is the fact that there is not sufficient number of mother-of-pearl oysters that could be collected from the wild to supply pearl farms on a regular basis. In 2001, the College of Micronesia (COM) embarked on a search for technology for production of pearl oyster spat in order to get around this lack of naturally occurring wild spat supply in the Micronesian region. Funding was provided by the United States Department of Agriculture (USDA) and Department of Interior's Office of Insular Affairs (DOI) in support of this search for the pearl technology under a project called "Development of Pearl Aquaculture and Expertise in Micronesia" (hereafter simply termed "the Project").

The general purposes of this Project are to provide training programmes for: a) development of the pearl industry in Micronesia, and b) development of local human resources for supporting and maintaining the pearl industry once it is established. Funding support enabled the Project to commence its Phase 1 activity during the first quarter of 2001 and continued until the fourth quarter of 2002. All of Phase 1's objectives were accomplished: an Australian expert in pearl oyster hatchery technology was hired; a hatchery was established in an abandoned dock warehouse at Nett Point, Pohnpei; and the pearl expert and his Micronesian staff/trainees successfully conducted hatchery and ocean nursery events during this initial phase, resulting in tens of thousands of blacklip pearl oyster spat, which are growing at the two demonstration farms (also established by the Project).

Three Micronesian staff are being trained as future trainers in spat production and farm grow-out technology with the participation of more than 40 trainees from local communities, schools and colleges. The Project entered into Phase 2 in the first quarter of 2003, proceeding to complete the necessary evaluations and demonstrations to the critical issues in the pearl industry development including actual pearl production and business development. Phase 2 includes: a) expansion of training of hatchery and grow-out farm techniques, plus second generation skill training by the Micronesian trainers; b) implementation of pearl production trials and evaluation of seeding and pearl production techniques; and c) collaboration with institutions in the region and government agencies in developing business models for the Micronesian pearl industry.

First harvest of black pearls from the imperiled native Hawaiian pearl oyster, *Pinctada margaritifera galtsoffi*

by Neil Anthony Sims and Dale J. Sarver
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The native Hawaiian blacklip pearl oyster, *Pinctada margaritifera galtsoffi*, is a distinct endemic subspecies of the fabled Tahitian pearl oyster, *P. margaritifera*. The Hawaiian pearl oyster was once common, and was traditionally used by Hawaiians in making fishing hooks and lures, other tools and ornaments. This oyster has become increasingly rare since Western contact, due primarily to commercial fishing.

The last significant stocks of *P. margaritifera galtsoffi* were fished out at Pearl and Hermes Reef in the 1920s, when over 100 tons of pearl shell were taken from this shallow, open lagoon. Recent surveys by NMFS divers found only 30 adult shells in over 18 diver-hours. All of these oysters were above 20 cm in shell diameter, suggesting that recruitment is negligible.

Stocks remain uncommon around the main Hawaiian islands, despite legal protection. Relict stocks in a few areas, such as Kaneohe Bay, still show decline. Although hatchery techniques are now well-established for this species, stock recovery in Hawaii is limited by heavy predation on the reef, pilfering by divers, pollution in protected reef and lagoon areas, and low water-residence time for larvae in open reef systems. Predation by fish and octopi is very heavy. Grow-out trials in protective cages left oysters vulnerable to *Cymatium* and other predatory snails settling out of the plankton. The most effective stock re-establishment plan would therefore be to set up reproductive reserves of large, densely-aggregated, older adult oysters. A "reproductive node" of closely-packed, highly fecund animals would be able to synchronise spawning and achieve high fertilisation rates, resulting in large numbers of larvae.

These larvae would then be dispersed by currents, eventually settling out naturally onto the reefs and lagoons throughout the group. Serendipitously (or otherwise), such a "reproductive node" can be provided almost precisely by a commercial pearl farm operation. Black Pearls, Inc. (BPI) has therefore been developing the concept of Hawaii's first pearl farm as both a commercial business and a conservation tool. In essence, the pearl farm becomes a financially self-sustaining (or profitable) means for resource enhancement.

BPI assisted in the rewriting of Hawaii's ocean leasing legislation, and has since completed the lease application process for a 75-acre area next to Honolulu's International Airport. In 2003, BPI harvested the first genuine "Hawaiian pearls™" from this site. This now provides a distinctive line of local of pearls and pearl shell jewellery, an opportunity for Native Hawaiian artisans to once again work with their local material, and an added romantic allure to the islands.

Development of antiseptic procedure to improve cultured pearl formation in *Pinctada margaritifera*

by N. Cochennec-Laureau, P. Haffner, D. Saulnier, S. Langy and A. Fougerouse

Cultured black pearls from *Pinctada margaritifera* (Linnaeus) are a significant industry for French Polynesia. Pearl formation requires the inserted mantle tissue to form a complete sac around the shell nucleus and to secrete successive layers of nacre onto the bead. Despite the relative success of this pearl

formation method, substantial failures occurred. The purpose of this presentation is to study the effect of an antiseptic process on mortalities from the surgery and nucleus rejection.

The use of an antiseptic during grafting experimentation had no significant effect on mortality and bead rejection. However, an antiseptic has proven very effective in reducing the number of total bacteria isolated from the pearl bag. Two dominant bacteria were isolated from *P. margaritifera* after nucleus insertion. Phenotypic and molecular characterisation showed that one strain is similar to *Vibrio harveyi* and the other differs on one phenotypic character from *V. alginolitycus*. These results suggest that improvement of hygiene for all aspects of the pearl surgery really has a great impact on reducing bacterial contamination. Further work is planned to confirm the possible impact of these two strains on mortality and/or nucleus rejection by experimental infection.

Insulin accelerates shell growth and pearl nacre deposition in *Pinctada margaritifera*

by Kennedy T. Paynter and Maria Haws
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Peptides in the insulin family and vertebrate growth factors (hormones) have been shown to increase the growth rate of a variety of bivalves.

We conducted a series of experiments to determine whether or not exogenous growth factor treatment would also increase nacre deposition around an implanted pearl nucleus. Insulin was administered to mother shells of the blacklip pearl oyster, *Pinctada margaritifera*, which had previously been implanted with pearl nuclei. The pearls produced from the treated oysters were significantly larger in diameter than the pearls from untreated oysters. The experiments were conducted in Tahiti on a commercial pearl farm. Fifteen shells, implanted one month before, were treated in each group. The control group received a 1-ml injection of filtered seawater once per month for five months. Another group received 1-ml injection of 10^{-4} M insulin and the third an injection of 10^{-6} M insulin each month. Insulin solutions were prepared in filtered (2µ) seawater. Injections were performed using a 1-ml syringe and a 2-inch 18-gauge needle, inserting the needle through the byssal notch and into the visceral mass. The oysters were kept immersed and horizontal for one hour before redeployment into a hanging net panel array being used by the farm. Pearls were harvested one year after treatment began. To measure shell growth, the ventral shell margin of each oyster was trimmed with shears back to the thickened, highly calcified region of shell after each treatment. Subsequently, the growth from that margin was measured each month.

The treated animals showed immediate reaction to the treatment by gaping widely, while control animals kept their valves closed. No increased mortality or nucleus rejection was associated with insulin treatment. Shell growth from the trimmed margin was greatest in the highest treatment group but significantly higher in both groups compared to the control group. Pearls were harvested seven months after treatments began. Pearls harvested from the control group had a mean nacre thickness of 1.65 mm. Pearls from the low insulin treatment (10^{-6} M) had a mean nacre thickness of 1.75 mm and pearls from the high treatment group had a mean nacre thickness of 2.08 mm. Insulin had a large positive effect on pearl nacre deposition in the blacklip oyster. The commercial applications of this treatment seem substantial and obvious.

Using pearl oysters as heavy metal monitors in tropical waters

by Dale J. Sarver, Aaron Ellis, Neil Anthony Sims and David Wise
(see previous contact data)

Accurate and cost-effective methods are needed for monitoring heavy metal pollution levels in tropical oceans. Direct measurement of metals in seawater is inappropriate for most tropical oceans and areas, as it requires regular sampling programmes, expensive equipment, and sophisticated analytical expertise.

Further, metal pollutants are usually sequestered in sediments, and water samples often miss the major peaks of exposure when sediments are resuspended during storms or other events. Because of these inadequacies, marine filter-feeding bivalves, such as mussels (*Mytilus edulis*), are widely used as bioaccumulators for marine pollution monitoring.

The "Mussel Watch" system has proven very successful, and continues to be the most comprehensive measure of coastal marine metal pollution in the US. However, these mussel and oyster species are limited to temperate water regions of the globe, and there are no comparable subjects for monitoring of oligotrophic tropical waters. Our research results demonstrate that pearl oysters are the ideal warm-water complement to the Mussel Watch work. *Pinctada* South Sea pearls are cosmopolitan in distribution, sessile, and long-lived. Initial trials have confirmed a phenomenal propensity to accumulate heavy metals in the Hawaiian pearl oyster (*P. margaritifera galtsoffi*). In controlled tank trials, copper, cadmium, and zinc showed constant rates of bioaccumulation in pearl oyster tissues, directly proportional to the metals' concentration in the tank water, and the duration of exposure.

These trials also established standards for field monitoring, with demonstration trials providing preliminary data from around the Hawaiian Islands. A second series of field trials underscored the significant temporal variability that typifies heavy metal monitoring.

Ongoing research is now expanding the range of metals to include strontium, cobalt and lead. Monitoring levels of radioactive strontium and cobalt could be an invaluable tool in remediation and repopulation of atolls in the South Pacific (such as Bikini and Enewetak Atolls, in the Marshall Islands, Christmas Island, in Kiribati, or Muroroa, in French Polynesia), which were sites of earlier atmospheric and underground nuclear bomb tests by the US, Britain and France.

Nucleus quality and substitute of routine shell

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A study was undertaken to answer several questions on the particularity of the shell for the nuclei, such as properties of a suitable nucleus, and what makes nucleus perfect for seeding in an oyster: Its hardness? Its density? Its surface smoothness? Its colour? Or its brightness?

Why is a freshwater shell only suitable for nuclei? Does it affect the pearl quality? Or is it suitable because it is easy to drill? Does the shell of the nucleus decide the quality of pearl or the acceptability by the recipient oyster? Can a nucleus cut from a saline water shell that has an equal ability to get drilled and has a perfect surface smoothness — similar in all the above factors — produce a similar quality of pearl?

The author tested several shells from both saline and freshwater environments to come up with a substitute for the routinely used freshwater shell, and received interesting results. All the aspects (above) of the nucleus and the results of the experiments/comparison tests will be discussed in this paper.

Genetic diversity of the pearl oyster *Pinctada fucata* as revealed by AFLP analysis

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The pearl oyster *Pinctada fucata* is the common species cultured for pearl production in China and other countries. In recent years, mass mortality has impacted the pearl industry in China and a national selective breeding programme has been initiated to improve the culture stocks. However, there are concerns that the genetic variability among the stocks might have already been reduced after more than 30 years of culture with artificial propagated spat.

The present study aims to elucidate the genetic diversity of *P. fucata* populations in southern China by amplified fragment length polymorphism (AFLP). Individuals from a wild and a cultured stock were collected from each of three localities in China, including Daya Bay, Beihai Bay and Hainan Island. Oysters from Japan that were recently introduced for culture in China, and wild oysters from Australia were also studied for comparison. A total of 241 individuals were analysed using three pairs of selective primers and 184 loci were scored. The proportion of polymorphic loci (99%) and the average heterozygosity (HO) show that the Chinese populations, both wild and cultured, have similar genetic diversity to the Japanese and Australian populations.

A table depicts the proportion of polymorphic loci (P) and heterozygosity (HO) over loci. The total gene diversity (HT) of 0.353 and within-population gene diversity (HS) of 0.334 over 184 loci indicates that the genetic diversity is largely maintained within populations. The coefficient of genetic differentiation (GST) value (0.053) and fixation index (FST) value (0.041) suggest a lack of genetic differentiation between populations, including the cultured populations, indicating the presence of gene flow among them.

In conclusion, results from the present study suggest that *P. fucata* in China is rich in genetic variability and its culture industry would benefit from a selective breeding programme.

This work was supported by research grants from the Chinese University of Hong Kong and the National High Technology Research Development (863) Program, Ministry of Science and Technology, People's Republic of China (Project code: 2002AA603022).

Effect of temperature on oxygen consumption and ammonia excretion of the pearl oyster *Pinctada mazatlanica*

by Pedro E. Saucedo, Lucia Ocampo, Mario Monteforte, and Horacio Bervera
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The effect of temperature on oxygen consumption and ammonia excretion in the pearl oyster *Pinctada mazatlanica* was studied as a strategy to define the optimum thermal range for experiments on reproductive conditioning of broodstock. Adult oysters were taken to the laboratory, acclimated for two weeks at four temperatures (18, 23, 28, and 33°C), and transferred to respiration chambers for individual measurements of oxygen consumption and ammonia excretion at these temperatures. Respiration and excretion rates, as well as routine respiratory/excreted energy and Q10 coefficients for temperature were calculated. One-way ANOVA was applied to determine differences in these two physiological parameters as a function of temperature.

All physiological parameters yielded highly significant differences with increasing temperature, suggesting that an adequate metabolic temperature range may lie between 23–28°C. Within this range, a combination of active respiration and low ammonia excretion, together with Q10 coefficients near 2, suggest compensatory mechanisms that allow the species to perform physiological seasonal regulation during moderately warm temperature fluctuations. In contrast, 18°C and 33°C represented marginal temperature conditions close to the tolerance limits of the species, but clearly are not the limits. In particular, 33°C was a stressful temperature because of low respiration values and high ammonia excretion values. More studies under conditions of satiation and hypoxia, as well as experiments testing lower and higher lethal temperatures are needed to understand the energy budget of the species. The effect of temperature on respiration and excretion rate in *Pinctada mazatlanica* is charted.

Microscopic anatomy of gonadal tissue and specialised storage cells associated with oogenesis and spermatogenesis in the pearl oyster *Pinctada mazatlanica*

by Pedro E. Saucedo, Carmen Rodriguez-Jaramillo, and Mario Monteforte
(see previous contact data)

This study characterised the microscopic anatomy of gonadal tissue and storage cellular elements involved with oogenesis and spermatogenesis of *Pinctada mazatlanica*.

Tissue samples were collected every 15 days over an annual cycle and stained histologically and biochemically with hematoxylin-eosin (for general description of tissues and cells), Blue Alcian-PAS (PAS) for identifying neutral-acid mucopolysaccharides and carbohydrates, and Black Sudan (BBS) and Oft Red (OR) for identifying lipids. Seasonal variations in the sex ratio and sex of specimens were also analysed. Gonadal tissue developed synchronously over time at the expense of a dense matrix of inter-connective tissue (ICT) and reserves stored in the adductor muscle and digestive gland. ICT connects gonadal tissue with the digestive gland, and serves as substrate for the differentiation of two kind of nourishing cells: vesicular connective tissue cells (VCT cells) and auxiliary cells (AC).

VCT cells, very abundant surrounding excretory conduits of acini and adenomeres, were highly PAS++ and moderately BBS+ and OR+. AC were usually attached to developing oocytes (previtellogenic and vitellogenic oocytes). The endogenous synthesis of lipids during vitellogenesis was associated with the Balbiani body, a storage compartment in the oocyte ooplasm, not previously described for any species of pearl oyster.

The typical female/male sex ratio is 0.35:1 when specimens were obtained under culture conditions, but females outnumbered males when collected from the wild. Examples of photomicrographs of accessory tissues and cells associated with oogenesis and spermatogenesis in *Pinctada mazatlanica* will be presented. Several cases of protogenic specimens and a few functional hermaphrodites were also seen throughout the year.

Differential gonadal development of grafted and ungrafted specimens of the pearl oyster *Pinctada mazatlanica*

by Pedro E. Saucedo, Ilie S. Racotta, Humberto Villarreal, and Mario Monteforte
(see previous contact data)

This study evaluates whether there is differential gonadal development between grafted and ungrafted specimens. Oysters were collected as spat and extensively cultured until they were suitable for keshi pearl induction. A mantle allograft was placed within the gonadal tissue and the treated oysters were maintained under the same culture conditions as untreated oysters. After a year of pearl formation, samples of gonadal tissue, digestive gland, and muscle were excised from each oyster and used for histological and biochemical analyses. The histological examination of gonads was supported with measurements of oocyte frequency and diameter, and the use of gonosomatic and muscle performance indices.

For biochemical analyses, the concentration of carbohydrates, proteins, lipids, and triacylglycerides was measured. Two-way ANOVA was applied for determining differences in the oocyte diameter, index values, and biochemical composition of specimens during maturation and experimental treatment.

All histological and biochemical results showed that grafted oysters achieved greater reproductive condition than the controls, since they presented higher gonosomatic index values and lower muscle performance index than untreated specimens. Grafted oysters showed higher concentrations of lipids and triacylglycerides in the gonadal tissue and lower concentrations of proteins in the muscle than ungrafted oysters. Apparently, the mantle allograft promotes redirection of energy flows toward gonadal development.

The muscle and digestive gland, particularly the former, are the main sources of this energy-demanding process. A neuroendocrine control involving the formation of a "mantle-gonad" living complex is suggested.

More studies of the biochemical and ultrastructural composition of the mantle, together with comparisons of the physiology and endocrinology of grafted and ungrafted specimens are required to confirm these findings. Examples of temporal variations in the mean concentration of carbohydrates, proteins, lipids, and triacylglycerides of gonadal tissue of grafted (G) and ungrafted (UG) specimens of *Pinctada mazatlanica* will be presented.

Economies of scale in pearl farming in French Polynesia: The influence of pearl farm size on average cost per pearl and of cultural practices on the quantity and quality of pearl harvest

by Bernard Poirine and Sylvie Kugelmann
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A survey of 40 pearl farms in French Polynesia has shown significant cost variations among farms. The total average cost per pearl decreases as the size of the farm increases.

For small pearl farms with a stock of less than 25,000 oysters the average cost per pearl is twice as high as for pearl farms with a stock of more than 200,000 oysters. Economies of scale seem to take place between 25,000 to 100,000 oysters. Beyond 100,000 oysters in stock, scale economies are less significant.

Regression analysis has been used to show how farm practices affect the percentage of rejects (pearls with no commercial value). Higher oyster density on the lines and larger oysters when grafted, yield higher reject rates. On the contrary, when grafted oysters are left longer in the water before harvest and cleaned more often, the reject rate is lowered. Regression analysis is also used to show the determinants of the average selling price of pearls. A higher price is obtained when grafting larger oysters, when the mortality rate after grafting is lower.

Population genetics of the blacklip pearl oyster *Pinctada margaritifera*

by Teresa Lewis, Candace Martin, Cameron Muir, Maria Haws, Simon Ellis, Matang Ueanimatang, Donald David and Manoj Nair
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Pearl production is an important industry that promotes sustainable economic development and provides export income for various Pacific Island nations. Empirical evidence points towards a significant difference between pearls produced by different stocks of pearl oysters. For example, the island of Manihiki in the Cook Islands produces recognisably distinct pearls with unique coloration. Pearl buyers in French Polynesia noted that before large-scale pearl oyster transfers took place between the dozens of atolls in the Tuamotu Islands chain, atolls tended to produce pearls with recognisable differences in colour, lustre, and orient, critical factors in establishing price and a competitive niche.

After massive stock transfers of spat between islands occurred, these island-specific differences disappeared. There is a need to develop sensitive, and accurate genetic fingerprints to facilitate monitoring and development of appropriate management practices in blacklip pearl oyster aquaculture.

Hatchery operators require information to formulate strategies that will allow them to supply stakeholders with the requested spat while protecting biodiversity and the potential economic value related to genetic difference between stocks. We are seeking to address this issue through the use of two DNA marker systems: amplified fragment length polymorphism and analysis of microsatellite DNA. Samples included in our analyses were collected from hatcheries in Hawaii, the Federated States of Micronesia, and the Republic of the Marshall Islands, as well as from natural stocks.

Results from the combined outcomes of these two avenues of research will be presented.

Is juvenile pearl oyster growth and survival affected by culture unit mesh size?

by Josia H. Pit, Antoine Teitelbaum and Paul C. Southgate
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Culture method has been previously described as a contributing factor to growth and survival of bivalves. Previous studies have outlined that culture unit construction, particularly shape and size, can affect the growth and survival of commercially important bivalves.

In this paper we report on two experiments carried out to determine pearl oyster growth and survival when cultured using pearl nets and panel nets with different mesh sizes. In experiment #1, hatchery-produced *Pinctada fucata* with a mean (± SE, n = 90) dorso-ventral shell height (DVH) of 36.2 ± 0.1 mm were placed into pyramidal pearl nets of varying mesh sizes (1, 4.5 and 9 mm square mesh pore size) for three months. At the end of the experiment there were significant differences between DVH of *P. fucata* cultured in the different mesh size nets ($F_{2, 177} = 385.5$, $P<0.001$).

Mean (± SE, n = 60) DVH was 37.8 ± 0.4 mm, 48.4 ± 0.4 mm and 51.7 ± 0.4 mm, for juveniles cultured in mesh sizes of 1, 4.5 and 9 mm, respectively. Survival was 100% in all treatments except for one replicate of the 1-mm mesh nets, which had 92% survival. In experiment #2, hatchery-produced *P. fucata* with a mean (± SE, n = 90) DVH of 49.6 ± 0.4 mm were placed into panel nets and pearl nets of varying mesh sizes. Four methods were used: 1) panel nets with 5 mm mesh; 2) panel nets with 15 mm mesh; 3) pearl nets with 4.5 mm mesh; and 4) pearl nets with 9 mm mesh.

Mean (± SE, n = 90) DVH of *P. fucata* after 11 months was greatest (73.8 ± 0.9 mm) in oysters cultured in panel nets with 15 mm mesh but was not significantly different ($F_{3,116} = 10.66$, $P<0.001$) to that of oysters cultured in pearl nets with 9 mm mesh (71.9 ± 0.8 mm). Oysters cultured in pearl nets with 4.5 mm mesh had a mean (± SE, n = 90) DVH of 70.0 ± 0.7 mm but did not vary significantly from oysters cultured in pearl nets with 9 mm mesh. Lowest mean (± SE, n = 90) DVH (67.0 ± 1.1 mm) was observed in oysters cultured in panel nets with 5 mm mesh. Survival for all treatments ranged from 95–100% and was not significant among treatments ($p>0.05$).

It has been suggested that decreased growth observed with decreasing mesh size is due to a combination of increased fouling and decreased water flow resulting in lower food availability and decreased water quality.

The farming of and pearl cultivating of wing oyster *Pteria penguin* in Southern China

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The wing oyster, *Pteria penguin*, is distributed along the coast of Hainan Island, Leizhou Peninsula and other maritime regions in the South China Sea. It is a kind of large-sized and fast growing bivalve species. Trial farming of and pearl cultivating of this species was conducted about five years ago. At first, natural shells were captured mainly for half-sphered pearl culturing, then mature wild individuals were chosen as parents for seed producing.

After a series of trials, the processes of stock shell selecting and cultivating, induced spawning, larval rearing, spat collecting, nursing out, and growing to mature adults were successfully developed. In this discussion, the whole procedure from zygote to adult will be discussed.

Sufficient proliferation, primarily from wild shells and then from farmed stocks, provided enough oysters for trials in pearl producing. Cooperating with our research group, two companies in Hainan Island and one in Leizhou Peninsula, have developed the technology of producing mabes profitably. Recently, round pearls were produced successfully from this species. Cultivation of half-sphered and round pearls from the wing oyster is also described generally.

Mantle regeneration after saibo excision in pearl oysters

by Hector Acosta-Salmon, Erika Martinez-Fernandez and Paul C. Southgate
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Contrary to most bivalve culture industries where the best individuals are maintained as broodstock, the pearl culture industry sacrifices the best individuals for pearl production.

Recently, a new approach to pearl oyster broodstock management was proposed where oysters used to provide grafting material for pearl production ("saibo") were kept alive and may be used as broodstock or for future saibo production. We recently reported that pearl oysters survive the excision of a large piece of mantle and completely regenerate this part of the mantle and all its internal structures. This follow-up work reports in more detail on the regeneration process after mantle excision in the akoya pearl oyster, *Pinctada fucata*, and reports for the first time on mantle regeneration in the blacklip pearl oyster, *P. margaritifera*.

Prior to excision, oysters were anaesthetised with 500 mg L^{-1} of benzocaine. Saibo tissue was excised from 65 anaesthetised oysters. Oysters were relaxed and sacrificed on days 3, 5, 10, 15, 20, 30, 45, 60 and 90 after excision; regenerating mantle tissue was obtained and sectioned for standard histological preparation. All samples were preserved in 10% formaldehyde, dehydrated in an alcohol series dilution, embedded in paraffin, sectioned to 5 µm and stained with H-E, Masson trichrome or Alcian blue-PAS. Pearl oyster shells were kept for further analyses of nacre laid by regenerating mantle. After excision, all oysters were returned to culture conditions on a longline at Magnetic Island, North Queensland, Australia.

Preliminary results showed oyster recovery from the excision procedure. Macroscopic and histological analysis of shells and mantle are presented. This study gives an insight into in vivo mantle regeneration in pearl oysters and provides more information of importance to improving pearl oyster broodstock management techniques.

Progress towards development of a cultured pearl industry in Kiribati, Central Pacific

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In 1993, James Cook University and the Ministry of Natural Resources Development (MNRD) in Kiribati began a collaborative research project towards development of a cultured pearl industry in Kiribati. The project is funded by the Australian Centre for International Agricultural Research (ACIAR). The major impetus for this project was the lack of export opportunities for Kiribati and the well-documented success of cultured pearl production in eastern Polynesia.

Initial survey work in the Gilbert Islands of Kiribati showed very low numbers of blacklip pearl oysters (*Pinctada margaritifera*). This, together with low recruitment of spat to collectors, indicated that any development towards a cultured pearl industry in Kiribati would have to be based on hatchery production. A hatchery was established on the island of Tarawa in 1995 and a nursery culture area established at the neighbouring island of Abaiang. Both facilities have developed considerably over the last few years. The hatchery routinely produces large numbers of *P. margaritifera* spat and, for example, two hatchery runs in the first half of 2003 produced a total of 6.1 million spat. Larval survival in the Tarawa hatchery is also very high and is usually between 30 and 50% during larval culture. The nursery and grow-out facility has now expanded to contain around 80,000 juvenile and adult pearl oysters, and functions as a "demonstration farm" for training fisheries personnel A trial pearl seeding was conducted at Abaiang in 2001 and the first pearls were harvested in 2003.

A second seeding of 10,000 oysters was undertaken in August 2003. Project activities were recently extended to other sites within Abaiang lagoon and to other islands within the Gilbert Group. Development of a cultured pearl industry in Kiribati will be facilitated through the formulation of a Development Plan and establishment of a Pearl Oyster Coordinating Committee (POCC). The plan provides a framework for industry development with broad community involvement. It addresses both technical and political issues and will be amended on the basis of project findings. The POCC brings together representatives of relevant government ministries and other agencies and advises the government on industry development.

Pinctada margaritifera hatchery development and technology in Hawaii and Micronesia

by Maria C. Haws, Simon C. Ellis, Eileen Ellis, S.W. Quentin Fong, Donald Hess, Matang Ueanimatang, Neil A. Sims and David Wise
(see previous contact data)

Hawaii and the Central Pacific Islands possess stocks of blacklip pearl oyster (*Pinctada margaritifera*) but conditions are not conducive to feasible spat collection as the basis of pearl industry development. Initial establishment of pearl farms relied on collection of adult and juvenile pearl oysters from reefs, but farming quickly stagnated without an abundant supply.

A private pearl oyster hatchery operated on Majuro, Republic of the Marshall Islands (RMI) from 1998 to 2001, temporarily supplying two commercial farms. Critical bottlenecks in hatchery and nursery technology were soon apparent. After the demise of the private hatchery, the public sector in the Federated States of Micronesia (FSM) and RMI established three hatcheries of various scales and for a variety of purposes, including research. Hatcheries now function at the Ponape Agriculture and Trades School, College of Micronesia Land Grant Program (Pohnpei, FSM) and the College of the Marshall Islands (Majuro, RMI). The private RMI hatchery is being restarted as part of a public-private partnership. A commercial/research hatchery operates at Kailua-Kona and a research dedicated hatchery at the University of Hawaii-Hilo, Hawaii. Infrastructure and basic culture technology are the least of many challenges facing the effective operations of these hatcheries.

The Collaborative Alliance, a network of aquaculture professionals working together as part of the USDA/Small Farms project, "Bridging Gaps to Ensure the Viability of Small Scale Tropical Mariculture Ventures in Hawaii and the U.S.- Affiliated Islands" has undertaken a regional analysis of hatchery tech-

nology designed to identify and address key obstacles to continued success of pearl oyster hatcheries and nursery operations.

The partners involved in this endeavour are also conducting research and developing new methods to overcome the challenges. Basic pearl oyster hatchery technology has been successfully developed and now supports pearl farm development in the Pacific. Some obstacles still exist, however. Research is underway to improve and refine larviculture and nursery grow-out to increase efficiency and reliability of hatchery operations and the farms they serve. Spawning seasonality of blacklip pearl oysters in the Central Pacific stocks is being documented to enhance reliability of induced spawning.

Metamorphosis in pearl oysters is prolonged, and timing is unpredictable. Mortalities occurring in the early stages are sporadic and contributing factors unknown. The nursery stage is plagued with high mortalities, largely due to predation by *Cymatium* spp. snails, and is labour intensive. Work is underway to improve ocean-based and land-based methods. Cost-effectiveness of hatchery and nursery stages is being analysed as part of a bioeconomic study of Micronesian farms and hatcheries. Preliminary findings of these research initiatives will be presented.

Economic feasibility of small-scale, commercial culture of black pearls in rural communities in the Central Pacific

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Traditional revenue sources for island nations in the Central Pacific such as copra have diminished significantly. Further, many high value natural resources such as wild groupers for the live fish markets and sharks for their fins for the Asian markets, particularly Hong Kong, are being exploited and over-harvested by foreign fleets, using foreign labour with little economic benefits to the local population.

With the dwindling of such natural resources, aquaculture development in the Pacific Islands is accelerating and being implemented at a variety of levels ranging from outer island high schools to large-scale commercial projects as a means to improve the economic viability of outer island communities throughout Central Pacific.

Culture of black pearls produced by the blacklip pearl oyster (*Pinctada margaritifera*) has been found to be among the most promising forms of small-scale commercial aquaculture in the Central Pacific. Currently pearl culture is generally practised as a form of supplemental economic activity for outer island communities in nations such as the Republic of the Marshall Islands and the Federated States of Micronesia.

This work provides an analysis of the economic feasibility of small-scale pearl culture operations. Specifically, projections of financial performance of a small-scale farm with 25,000 seeded pearl oysters using the Tahitian longline method were conducted. Estimates of initial capital investment and annual operating costs were formulated. An annual cash flow and enterprise budget were developed.

Preliminary results show that initial capital investment is approximately USD 203,030. Annual operating costs are about USD 221,212. Net returns over a 20-year farm horizon average USD 128,223 per year, based on the most conservative price data from published sources.

The results of sensitivity analysis on profit due to the variability of market price, survival, and cost of seed and other inputs will be presented.

Management of the western Australian pearling industry

by Robin Clark
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The Western Australian South Sea pearling industry produces pearls from the oyster *Pinctada maxima*, from wild captured and hatchery produced oysters. Production was valued at USD 126 million in

2001/2002. Management of the pearl oyster fishery is undertaken through a quota management system. This system focuses on ecologically sustainable development principles to ensure:

- a sustainable catch from the wild;
- minimal impact of pearling on the marine environment; and
- optimum returns to the State through management of hatchery production, thereby maintaining market confidence in Australian South Sea pearls and thus high pearl prices.

There are currently 16 pearling licensees, who collectively hold 572 units in the wild stock fishery and 350 hatchery units and employ approximately 1500 people in the remote Kimberley region of northwest Australia. The Pearling Program of the Western Australian Department of Fisheries is responsible for the development, implementation and review of management of the industry. The Program is responsible for management of the wild capture fishery and hatchery sector; research and monitoring of the wild pearl oyster stocks; disease management, compliance and education; and pearl farm lease and licence assessment and administration.

The Pearling Program also provides executive support to the Pearling Industry Advisory Committee, a statutory Management Advisory Committee established under the Pearling Act 1990. The Program also maintains strong linkages with the peak industry representative body, the Pearl Producers Association. The pearling industry has experienced challenging times in the past few years. The global decline in pearl prices has resulted in a degree of rationalisation within the industry. The allocation of water and the seabed for pearl farms has also become an issue of concern to some other users of the Kimberley region. Introduction of new environmental legislation, the Environmental Protection and Biodiversity Conservation Act 1999, has required the industry to undergo an environmental assessment of fishing practices to ensure continued export approval for pearls. Though not required by legislation, the industry has been pro-active in preparing environmental management systems for its farming operations.

The paper outlines the current issues facing the pearling industry and the management responses to address those issues.

Seasonal changes in the histological and biochemical profile of the gonad, digestive gland, and muscle of the pearl oyster, *Pinctada mazatlanica*, associated with gametogenesis

by Pedro E. Saucedo, Ilie S.Racotta and Humberto Villareal
(see previous contact data)

The relationship between the energy storage cycle and gametogenesis of the pearl oyster *Pinctada mazatlanica* was studied over an annual cycle (January–December 1999). We performed histological analysis along with examination of oocytes and determination of carbohydrate, protein, lipid, and triacylglyceride levels in gonadal tissue, digestive gland, and adductor muscle. One-way ANOVA was used for assessing differences in the size of oocytes over time. Two-way ANOVA was applied for differences in the biochemical composition of specimens over time and by sex.

The gametogenic cycle was affected by the presence of a La Niña cold event during the first half of 1999. Gametogenesis commenced early in February and occurred synchronously throughout the annual cycle. There were two reproductive peaks, one in spring (March to May) and the other in summer (July–September). A massive spawning was observed in September–October when water temperatures were 29–29.5°C. Carbohydrates, either stored or obtained from ingested food, were used as an immediate fuel for the production of oocytes, which grew and increased their protein content during the first half of the year. Lipids and triacylglycerides also showed two important peaks in female gonadal tissue and the digestive gland, corresponding to the same peaks described histologically. Reserves stored in the muscle and digestive gland were actively used for gametogenesis.

A graph will be presented depicting temporal and sexual variations in the mean levels of carbohydrates, proteins, lipids, and triacylglycerides in the gonadal tissue of *Pinctada mazatlanica* over an annual gametogenic cycle. Bars will denote standard deviation.

Muscle proteins were mobilised to the gonad during the first half of the year, while carbohydrates were used during the second half. The digestive gland acted as a short-term storage site for carbohydrates and lipids during gonad development.

Is there potential for akoya pearl culture in Australia?

by Josiah H. Pit and Paul C. Southgate
(see previous contact data)

World akoya pearl production has slowly decreased over the last few years. This is mainly due to the downscaling of the Japanese pearl industry resulting from overpopulation and diseases, which have decimated a large proportion of their oyster stocks. As a consequence, there has been increasing interest in research and development of akoya pearl production in other countries, particularly China and Australia.

The Australian pearl industry is currently based on the production of pearls from the silverlip pearl oyster *Pinctada maxima*. However, there is increasing interest in pearl production from two other species, *Pinctada margaritifera* and *Pinctada fucata*, which are abundant in Australian waters. This paper reports on research carried out into the feasibility of akoya pearl production in northern Queensland, Australia.

The objective of this study was to gather baseline data on growth and survival during larval rearing and nursery culture. Aspects of interest included determining optimal rearing conditions for larvae (i.e. water quality, larval density and diet) and also optimal nursery conditions (i.e. type of culture apparatus and stocking densities).

This was the first successful hatchery production of *P. fucata* in Queensland. General methods employed to culture *P. fucata* during this study were adopted from methods used in the same hatchery for *P. margaritifera*. Over 48,000 3.5-month old spat with a mean (± SE, n = 50) DVH of 12.5 ± 0.4 mm were produced during the first year of this project. Results to date indicate that *Pinctada fucata* in northern Queensland should be cultured at a depth of 2 m when first transferred from the hatchery to the ocean. Once oysters are graded (at 3.5 months of age), they should all be kept and stocked at 20–30% of total available culture area into either pearl nets or pearl nets with net inserts until they attain a DVH of 50 mm. After they attain 50 mm in DVH, oysters should be transferred to panel nets or culture units with large mesh and nets should be changed or cleaned approximately every eight weeks. Additionally, oysters which are restricted from clumping (growing together) tend to show greater growth.

The culture of *Pinctada fucata* in Northern Queensland is very promising. To date we have cultured animals to over 100 mm in DVH and 100 g in wet weight within 24 months. At present we are conducting selection trials on the basis of size and early results suggest a very promising future for *P. fucata* culture in Australia.

Metabolic rate of *Pinctada margaritifera* during gametogenesis

by G. Cuzon, C. Soyez and G. LeMoullac
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The *Pinctada margaritifera* pearl is cultured extensively in French Polynesia and research on environmental rearing conditions was conducted in Tahiti (Ifremer, Service de la Perliculture and UFP) during a multidisciplinary programme named PGRN (1993–99), which led to a comprehensive approach of trophic level in lagoon waters, feeding habits, carrying capacity, etc.

Research for the control of spat production in hatchery is conducted at Ifremer/COP/Tahiti. One of the preliminary steps was the maturation of the broodstock under laboratory conditions and the results presented here provide information on the nutrition and physiology aspects of the problem. Some tools (respirometer, analytical procedures) provide physiological measurements (respiration, excretion) taken from animals maintained in the laboratory. Adults were placed in raceways with a flow-through system (0.5 m^3 $hour^{-1}$) and compared in two situations. Animals received unfiltered lagoon water or the same water plus a regular supply of algae (*Chaetoceros* or T-*iso* or *Pavlova*) at a concentration of 20,000 cells ml^{-1} for a period of 8 weeks at 27°C.

A graph depicts oxygen consumption recorded on adults placed in a microcosme for 20 hours and reflecting two different nutritional status (seston or seston + algae). Oysters without additional food respired at a lower1evels (4 µmoles O_2 day^{-1} $individual^{-1}$) than animals with supplemental algae ration (14 µmoles O_2 day^{-1} $individual^{-1}$). Additional measurements of ammonia excretion and a calculation of feed intake helped

to produce a scheme of energy partition during the gametogenesis period; moreover, it was possible to calculate an O:N ratio which differed between the two conditions of acclimation. Then, energetic substrate changed. By and large, oysters received a net energy (NE) of 1.5 kJ oyster^{-1} day^{-1} versus 5.0 kJ oyster^{-1} day^{-1} in a situation with additional food. Nutritional status for animals placed in a raceway with a high renewal water and micro algae distributed daily is significantly improved. Animals with supplemental food produced higher indices of gametogenesis (gonadic indices). A benefit through the supply of essential nutrients such as DHA, EPA, arachidonic acid, sterols, phospholipids needed during this phase of gametogenesis is probably part of the explanation of the results from a nutritional point of view, and this needs further analytical work.

Other abstracts

Variation in clearance and ingestion rates by larvae of the black-lip pearl oyster (*Pinctada margaritifera*, L.) feeding on various microalgae

M.S. Doroudi, P.C. Southgate and J.S. Lucas

Source: *Aquaculture Nutrition* 9(1):11–16

Clearance rate (CR) and ingestion rate (IR) of different sizes (89, 125 and 188 µm shell length) of *Pinctada margaritifera* larvae were determined when feeding on various microalgae. The microalgae tested were the diatoms, *Chaetoceros muelleri* and *C. simplex*, and flagellates, Tahitian *Isochrysis* aff. *galbana*, *Pavlova lutheri* and *P. salina* at 5 or 10 cells µL^{-1}. Both CR and IR of microalgae tested in this study increased with increasing larval size; but at all larval sizes, diatoms resulted in lower CR and IR. Of the microalgae tested, *P. margaritifera* larvae showed greatest CR and IR with the two *Pavlova* spp. Maximum CR for *P. salina* was 10.5, 21.2 and 29.7 µL h^{-1} for larvae with shell lengths of 89, 125 and 188 µm, respectively. The highest IR values for *P. margaritifera* larvae with shell lengths of 89, 125 and 188 µm were 8.7, 81.0 and 165.7 cells larvae-1 h^{-1}, respectively. CR and IR of *P. salina* were approximately five times higher than those recorded for *C. muelleri* and *C. simplex*.

Microtopography and antifouling properties of the shell surface of the bivalve molluscs *Mytilus galloprovincialis* and *Pinctada imbricata*

A. Scardino, R. de Nys, O. Ison, W. O'Connor and P. Steinberg

Source: *Biofouling* 19(1): 221–230.

Fouling organisms, like seaweed, sponges and barnacles, rapidly cover most things placed in the ocean. Cultured shellfish are no exception and this can cause problems for them because fouling may compete for available food or smother them. This problem is greater for some shellfish than others because some species foul faster than others. This study investigated the amount of fouling on the shells of blue mussels and pearl oysters and looked at why there are differences in fouling between them. In particular, we looked at the role of the periostracum in preventing fouling. The periostracum is the thin outer layer of the shells of pearl oysters and mussels and we measured the thickness, coverage and structure of this layer and how fouling interacted with it.

The periostracum of mussel shells is thicker than that of pearl oysters and does not vary as mussels grow larger. In contrast, the periostracum of pearl oyster shells wears away as they grow to become thinner and cover less of the shell. Using an electron microscope, the surface of the periostracum of mussels was seen to have a fine-ridged structure, while the surface of the pearl oyster periostracum showed no particular pattern.

When shells of mussels and pearl oysters of different sizes were held in the ocean for six months, mussels fouled much less than pearl oysters and small pearl oysters fouled less than large pearl oysters. The periostracum is thought to help prevent fouling in both these shellfish, but the ridged structure, extra thickness and greater coverage of mussel periostracum gives greater protection from fouling.

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PIMRIS

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. . . . . (Zip code) (Country)

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Email: . . . . . .

Alternative contacts :

Phone: Country Code first (. . . . . .) . . . . . .
Fax: Country Code first (. . . . . .) . . . . . .
Email: . . . . . .

Past seeding experience:

Species	Country/Region	No. years
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References:

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I hereby request that my name, contact information and other professional details shown above be placed on **POIB's Pacific Pearl Seeding Technician Registry**. I understand that this information will be provided to people who represent themselves as bona fide pearl farmers, for the purposes of increasing my professional contacts. I do not hold SPC or BPI, or any of their employees liable for any misuse or abuse of this information.

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This registry is designed to facilitate links between newly developing farms and seeding technicians. This basic information will be provided to bona fide Pacific pearl farmers who request it. It is then up to the individuals to pursue the matter further. Copies of this registry will be held both by the Editor of this bulletin in Hawaii and by the SPC Fisheries Information Section in New Caledonia. Please fill this out yourself, if you are a seeding technician, or pass it along to someone who is, and send it back to one of the addresses indicated on the form. Thank you.