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PEARL OYSTER

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INFORMATION BULLETIN

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From the Editor

On information flows...

Since Pearls '94...

It has been five years since Pearls '94: that seminal gathering on the shores of Waikiki that finally brought the pearling people of the planet—or at least, a large proportion of them—together for the first time. The interim period has been dramatic, with continued rapid growth in South Sea Pearl production, a bloom in promotional efforts, major shifts in wholesaling patterns, and the decline of the Japanese marketing dominance and the domestic Akoya industry. Pearls '94 was like most conferences—bringing people together with common interests, and letting them bounce ideas around, trade business cards, and cement friendships. These events are intense, educational and always enjoyable, and it was beginning to feel like we needed another such fest.

WAS '99...

In the absence of other Pearls events (Pearls '95 not being an event, really) the annual World Aquaculture Society meetings have proven to be a good source of information exchange for our industry. Since '94, WAS has grown in prominence in the pearling world, with the size and significance of pearl sessions increasing from year to year. This past April, a sizeable chunk of the Australian pearling community came out of the woodwork, to mingle with the other Pacific pearl participants at the Sydney WAS '99. There were some exciting revelations: George Ventouras of Paragon Pearling presented the first details on Bironite, the new nuclei material developed as a substitute for freshwater mussel shell. (Michael Snow of the Biron company also provides us with more details elsewhere in this issue). John Lucas reported on the ACIAR pearl seeding improvement trials, and an Australian group announced results of trials with non-toxic antifouling coatings for oysters to reduce *Cliona* infes-

Inside this issue

tation and other bio-fouling. Bob Rose provided analysis of harvests from hatchery-produced goldlips in Indonesia, and together with a number of the JCU /ACIAR fraternity, provided details on grow-out trials and nursery work for *maxima* and *margaritifera*. And more, and more …

We publish a comprehensive report in this issue summarising the papers and presentations from WAS. This was very kindly put together by Berni Aquilina (you will remember the review of Berni's pearl book last issue). I almost felt like a fly on the wall when reading Berni's account of the WAS sessions, but flies don't get to ask questions or swap stories afterwards, so I'm making sure I get along to the next one. We also present the complete abstracts from the pearling session. It is just all part of communicating, of information sharing, of the closer links that we try to promote.

POIB on the web…

Pearls '94 and WAS '99 are notable for the same reason we like to think that POIB is worthwhile—in the protective industry that we deal in, there is a tradition of suspicion and distrust, of insularity rather than integration. Most of us already live on geographical islands, and this is all exacerbated by the professional insularity of pearling. In a practical sense, both conferences and POIB facilitate the sharing of information. They are born out of the information vacuum and frustrations that hinder our work in remote locations.

The need for information exchange is ongoing, of course. Is there really anyone out there who thinks that they now know enough already? The POIB goes on, thanks again to the SPC support staff and the funding from the French Government. I've given up trying to predict when the constraints of my time and the workload of SPC's Information and Publication Sections will lift in the right sequence to provide a window for the next issue. We hope this might improve, but history proves otherwise.

But the information flow grows, and the latest POIBs have now become a little easier to tap into, through the wonders of the web. Look us up at http://www.spc.org.nc/coastfish, and pass it on to your friends. Of course, hard copies are always easier to read in a rocking boat, so we will continue to send them out.

Pacific Pearl Seeding Registry...

We would also like to propose one further small step in this direction: it has been drawn to our attention many times over the past several years that small, start-up pearl-farm ventures often have difficulties contacting seeding technicians. The difficulties seem to stem simply from a lack of information on who is out there, and which technicians are willing to travel and take a bit more of a risk. It is again part of the nature of the industry that technicians don't go around publicising themselves and their services (perhaps it is one part modesty, and two parts professionalism—it is, of course, only in the U.S. that lawyers and plastic surgeons advertise themselves). We have often been asked to link newly developing farms with seeding technicians who are willing to spend the travel time and take the risks to work in more remote, unproven and untrammeled areas. We are pleased to be able to do this, but it would seem that a sounder basis is needed for this service than our foggy recollections of names and e-mail addresses.

There is therefore, attached to this issue (p. 39), an information sheet for seeding technicians to register themselves under the POIB Pacific Pearl Seeding Registry (in formation). It provides a format for information on technicians who would be willing to work in the Pacific: names, contact details, past seeding experience, and references. We don't want to insinuate ourselves too deeply into other people's private business, so we will simply provide this basic information 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 here in Hawaii and at the SPC office in Noumea. Please fill this form out yourself, if you are a seeding technician, or pass it along to someone who is.

We are also sure that this is not the last good idea for furthering such links within the industry. We continue to actively canvas for more of the same. So the next brainwave you have, write it down on the back of the beer coaster or napkin, and send it across to us here. We can thereby all help build a better Bulletin, and a better industry.

Some information flows back …

One final point: Bernard Poirine of the French University of the Pacific in Tahiti was kind enough to cut off a large slice of humble pie for your editor. Bernard injected some reality and solid data into the levity of my earlier extrapolations regarding employment expansion for pearl culture in French Polynesia. Bernard's letter is reproduced here for all to watch me chew and swallow. I am ecstatic. It is nice when folk seem to tacitly agree with me—and I always infer your silence to mean tacit agreement—but it's a lot more valuable to have someone correct an error, and substantiate their position with real numbers. An honest, earnest sharing of information: we thereby all learn more.

Aloha all,

Neil Anthony Sims

RESEARCH NOTES AND REPORTS

World Aquaculture '99 Conference

by Berni Aquilina

The four-day World Aquaculture '99 conference, held in Sydney from April 26, was an eclectic gathering of scientists, owners, government workers and industry employees, representing all aspects of aquaculture. Of more than 800 papers about 30 were devoted to pearling.

George Kailis of Broome Pearls, part of the M.G. Kailis Group and the second biggest producer of pearls in Australia, opened the Pearl Oyster session with a broad overview of worldwide pearling trends including the Japanese downturn, increasing dominance of Chinese freshwater pearls, growth in Tahiti and Indonesia, and Australia's market niche for high-value pearls.

Managing the Australian industry

Australian Fisheries Department people spoke about the framework supporting the pearling industry in Australia based on *Pinctada maxima*. Talks by Peter Rogers, Heather Brayford (both from Fisheries Western Australia) and Chris Robertson (Queensland Department of Primary Industries) on industry management and development revealed the different positions in each state.

Western Australia has a long-established and highly regulated pearl culture industry, worth more than Au$ 200 million a year. The industry is co-operatively managed by Fisheries Western Australia in liaison with sixteen licensed pearl farmers through the Pearl Producers Association, and with advice from the statutory Pearling Industry Advisory Committee. Its wildstock fishery is controlled by licences, quotas, fishing zones and size limits; hatchery production is also regulated. A strategic planning process guides research and development. Overall, co-operative management is intended to help make policy and pass legislation that will develop the industry, stabilise the market and ensure a sustainable harvest of pearl oysters.

By contrast, the Queensland pearling industry, with production valued at about Au$ 1 million a year, is less developed and less regulated. It has also been hampered by a lack of wild pearl oysters, although a recently established hatchery promises future growth. Currently there are no quotas and no limit to the number of farms in Queensland. The Queensland Pearl Industry Association, representing 11 companies, is keen to see sustainable expansion. They have recently developed a 'draft strategic plan' which includes seeking protected areas for pearl oyster restocking, a code of practice for pearl farming, and investigation of a selective breeding programme to enhance the quality of pearls produced.

John Benzie from the Australian Institute of Marine Science reported on research into the genetic structure of pearl oyster populations in Western Australia, from which preliminary results indicate considerable genetic diversity.

Mexico

Mexico is a country with an ancient pearling history but which is just starting commercial pearl culture. Richard Fassler, from the State of Hawaii, described recent developments in the farming and marketing of Mexican pearls, including contributions made by University research institutes and individual efforts.

One self-taught enterpreneur is now producing and marketing (mostly *mabe*) pearls from *Pteria sterna* and *Pinctada mazatlanica.* Richard's advice to other nations wishing to begin pearl farming, based on Mexico's experience, is to start small, use available resources and knowledge, find a market niche, use jewellers to add value to the product, and build up through reinvestment.

In Mexico, wild oyster stocks have been overexploited in the past and are now insufficient to support a commercial industry. The Baja California Sur State University has been working since 1993 on research to promote commercial pearl enterprises. Héctor Acosta-Salmón described the procedures used for the first major hatchery production of *P. sterna* in Mexico and Erika Martínez-Fernández talked about creating pearl oyster beds in La Paz Bay using hatchery-produced spat.

Trials at various sites showed that protection from predators is essential but hard to achieve, maintenance of the beds is required, and calm oceanographic conditions will enhance results. It's a labour-intensive operation but one that might help to replenish Mexico's depleted resources.

Technician training and seeding techniques

Pearling has the potential to play an important part in the economic development of many nations, especially of the Pacific region. However a major problem confronting these nations is the high cost and limited availability of pearl-seeding technicians. One solution is to train local technicians. Maria Haws described a University of Hawaii Sea Grant Extension Program aimed at providing this kind of training on *P. margaritifera.*

The first phase of the programme, which was planned to begin in July 1999, will thoroughly document current technician practices with a manual and video showing pearl-seeding procedures. The video format is good for non-speakers of English and for people not used to written learning methods. An endoscopic camera was used to get close-up views of the seeding operation, which certainly gives a technician's perspective. It is not expected that the manual and video alone will suffice for training, but they will give an initial overview of grafting procedures. Aspiring technicians at the conference were keen to receive a copy of the video.

Pearl farmers also will benefit from familiarisation with seeding methods as this can help them monitor technicians' performances. The group's future work will attempt to improve seeding methods and to transfer this information to industry.

John Lucas, from James Cook University in Australia, spoke about work already done with John Norton and others in the Cook Islands, aimed at improving the percentage of gem quality pearls from *P. margaritifera* oysters. Treatments incorporating modern surgical techniques were applied to the seeding operation: oysters were relaxed using propylene phenoxytol, operation sites were disinfected using Betadine solutions, and incisions were closed with cyanoacrylate adhesives.

Very high mortalities occurred when the relaxant was used, the exact cause of which has not been established. Antiseptics gave no significant improvement over standard methods. Using an adhesive to close the incision did not significantly affect bead rejections, although it did reduce the percentage of pearls that initially had 'tails'. The adhesive produced an adverse effect on oyster tissue and there was a higher death rate, compared to the control, in the six weeks following the seeding operation.

Unfortunately running seawater or other facilities for cleaning technician's instruments was not available during this study, although in many places it is now a standard item.

Pearl oyster health

Australian Fisheries pathologists gave a couple of talks about pearl oyster health. John Humphrey reported the results of a national survey, conducted over a three-year period, which provides baseline data for future disease identification.

Overall, Australian pearl oysters are relatively free of serious pathogens. Brian Jones outlined the strict quarantine and inspection precautions that are used in Western Australian hatcheries and pearl farms to ensure that diseases do not establish or spread.

Interestingly, in a Mollusc Health session the previous day, Mike Hine had mentioned that an emerging disease has been confirmed in Akoya pearl oysters in Japan (details are yet to be published). Increasing attention is now being given to risks posed by the frequent movement of technicians and their instruments between and within countries.

Husbandry

Several people presented results of oyster growth studies. Mehdi Doroudi studied the effect of different densities of micro-algae on the growth of *P. margaritifera* larvae. He found that the food density for optimal growth was 20,000 cells per ml. Paul Southgate found in nursery grow-out trials that the best growth for *P. margaritifera* was obtained when oysters were held in 24-pocket panels, compared with using trays, mesh inserts in 8-pocket panels, or isolated mesh bags. Conventional 'ear hanging' was a close second for strong growth, although an audience participant suggested that this method could cause bacterial build-up if the shell is drilled so far in that the mantle is damaged.

Joseph Taylor reported that in suspended grow-out of *P. maxima* spat the lower the stocking density the better for growth, survival and the minimisation of deformities.

Of great interest was the news that Maxima Pearling Co has recently collaborated with the Centre for Marine Biofouling & Bio-Innovation and the Cooperative Research Centre for Aquaculture in successful trials for novel coatings to prevent biofouling in shellfish aquaculture. Patrick Moase, from Maxima Pearling Co, described the damage done to *P. maxima* shell by boring sponges (*Cliona* spp.), its associated deterioration of pearl quality, and its cost to industry.

Traditional treatments include freshwater immersion, formalin, high salinity water (45 ppt) and desiccation. Rocky de Nys, from the Centre for Marine Biofouling & Bio-Innovation at the University of New South Wales, presented results from the biofouling trials. A coating designed to kill *Cliona* spp. was 90% effective after two weeks, and after four months (including two cleans) no oysters had been re-infected. Another coating was designed to prevent settlement of barnacles and other fouling organisms.

Twelve weeks after large-scale application to one-year old pearl oysters the number of barnacles on each of the treated oysters averaged two, compared with around 30 on each of the control animals. The coatings are designed to be effective for up to six months and contain biodegradable, non-toxic antifouling compounds.

They will be available commercially under the names 'PearlSafe' for the *Cliona* dip (around August 1999) and 'PearlClear' (early 2000) for the biofouling spray. The distributors will be Colours & Chemicals Pty Ltd, Australia (a division of Wattyl Paints). Rocky de Nys (e-mail: r.denys@unsw.edu.au) can provide further information.

As yet, the effect of the coatings on growth rates and pearl quality has not been investigated.

Pearls

Bob Rose provided statistics on pearls harvested from hatchery-reared *P. maxima* oysters at an Indonesian farm. Results for shape were similar to those of Australian crops with 26% round, 14% semi-round, 27% drop, 13% button, 11% baroque and 9% circle. Colour, however, reflected the tendency for Indonesian pearls towards yellow and gold, compared with mostly silver and white for Australian pearls. Percentages by colour were 37% silver, 32% yellow, 13% cream, 9% gold, 7% other mixed, and 2% silver-blue.

Abalone pearls from *Haliotis* species are a new prospect, often with strong colour appeal. Efforts to culture abalone pearls are being made in Australia, New Zealand and Baja California, according to Richard Fassler.

Cultured *mabe* pearls are more common than loose pearls, which are unlikely ever to be 'round', given the active, muscular nature of the animal. Natural pearls from abalone are typically quite jagged and baroque, often with the appearance of sharks' teeth. In a panel discussion during the abalone session, Richard spoke with Mike McKenzie (NZ), Rod Ewing (NZ) and Derek Cropp (Aus) about their experiences growing abalone pearls. Mike has cut his production of *mabe* pearls by half this year because outlets to market them are not available.

Nuclei

Various substitutes for round pearl nuclei, presently made from threatened Mississippi River mussels, are being tested. George Ventouras from Paragon Pearling had samples of nuclei made from a processed material, called Bironite, that displays the basic characteristics of mussel shell. Bironite nuclei are white, with a uniform structure, and can be easily manufactured in large or small sizes (Editor's note: see contribution by Michael Snow, below).

In general

As is typical of conferences, World Aquaculture '99 was stimulating and exhausting. Apparently it was the biggest pearling turnout since Pearls '94 in Hawaii, and it was a great opportunity to talk with far-flung colleagues.

It was unfortunate that some of the scheduled speakers from overseas were unable to come to the Conference, so we missed perspectives from India,

Burma and the Philippines. Personally, I'd have preferred a greater opportunity for informal networking—if refreshments were provided just outside the meeting rooms, instead of several minutes walk away, this might have been easier.

There was evidence of the dissociation of academic research from farm-based research, fuelled in part by the secrecy that many pearl companies see necessary for their eminence.

Notwithstanding the several collaborative projects described above, there is still information being tied up for years that would benefit the pearling industry as a whole and its competitive position with respect to other jewellery industries.

Some academic research could benefit immediately from knowledge common among pearl farmers, and producers are only now coming to realise the usefulness of studies begun decades ago on the structure of nacre and the pearl formation process.

Bio-coated nucleus is a current hot topic (following Japanese studies reported ten years ago in the open literature), of which there was no mention at the conference, although many farms are trying out this approach. These illustrate the need for better exchange of information; a need only partially satisfied by WAS '99.

(*Abstracts from WAS '99 are presented on pages 24–36, in the Abstracts section, Ed.*)

Employment levels in pearl culture in French Polynesia: a correction

Dear Sir,

I read your article 'Pearls vs. Tuna' in the SPC Pearl Oyster Bulletin no. 11 from July 1998 with great interest. While the pearl culture industry is developing rapidly in French Polynesia, I feel that your figures concerning employment in this sector are, to say the least, optimistic, i.e. you spoke of 23,000 to 34,000 jobs created 'on the outlying atoll islands'.

Almost all pearl farms are located in the Tuamotu and Gambier island groups that only had 15,370 inhabitants at the time of the 1996 census. The labour force represents about 42% of this population, i.e. 6427 people, from which must be deducted all those who do not making a living from pearl culture as not all of the islands in these groups are suitable for this industry.

It is generally estimated that the number of pearl culture-related jobs is between 3000 and 4000. Your estimate seems to have been extrapolated from a 1989 figure to which you applied the production growth rate, but it seems that increased production was the result of very large pearl farms using increasingly modern methods which make possible scale economies and significant increases in productivity. Family production, which is more job-intensive, accounts for only 10 to 20% of total production.

It certainly is true that pearl culture has led to spectacular repopulating of these island groups. Between 1988 and 1996, the population increased 106% on Apataki, 80% on Arutua, 30% on Kaukura, 88% on Fakarava, 191% on Kauhei, 75% in the Gambier Islands, 57% on Makemo, 132% on Ahe, 79% on Manihi, 44% on Makatea, and 46% on Rangiroa. These figures, which are themselves remarkable, demonstrate the benefits of pearl culture for the islands concerned. But they only involve a small part of French Polynesia and I do not believe that indirect jobs are on the scale you suggest as storage and marketing of this lightweight product require a much less elaborate infrastructure and less manpower than is needed for the tuna industry.

Bernard Poirine

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Albina, margaritifera and Winged Pearl Oyster Conference in Perth, Western Australia, 1998[1]

by Dan Machin[2]

Executive summary

Workshop background

In recent years the development of the non-*maxima* pearl oyster industry in Western Australia has been impressive. This rapid expansion has brought about a genuine need to discuss research findings, market information and government policy to facilitate the industry's growth. Not since 1996 has the non-*maxima* pearl industry come together to discuss R&D matters, and hence the opportunity for this workshop.

Workshop objectives

The workshop was aimed to provide a forum to examine the research, development and policy needs of the emerging non-*maxima* pearl industry. The workshop objectives were to:

- Facilitate discussion between pearl farmers and government agencies.
- Collate and communicate research needs of industry.
- Provide a forum for discussion of hatchery technology, marketing, policy and industry development.

These objectives were achieved through the non-*maxima* pearl industry workshop that was held in Fremantle. Over 40 delegates, representing all industry sectors, attended the workshop which was held on the 31st October 1998 at Miss Mauds Function Centre.

Workshop outcomes

The main outcomes of the Workshop were:

- Research and development priorities identified by industry,
- Key issues identified for the future development of the industry,
- Results of recent research on hatchery technology and farm management,
- Increased communication and cooperation between the various members and sectors of the industry, and
- Formation of the Amwing research committee to facilitate the development of research needs identified.

The industry participants identified the following top six research and development priorities for Western Australian non-*maxima* pearl industry as a whole:

- Colour morphology of oyster and its relationship to pearl quality
- Disease profile
- Assessing the genetic differentiation of stocks
- Development of 'code of practice'
- Development of economic models
- Stock assessment survey

1. Editor's note: Another AMWing conference was recently held in Perth in October, 1999, and will be reported by Dan in the upcoming POIB.
2. Aquaculture Development Officer, WA Fisheries Department, P.O. Box 1171, Geraldton WA 6532

Akoya Research in NSW

by Dr Wayne O'Conner[1]

In July 1998, researchers at NSW Fisheries, Port Stephens Research Centre began investigations into the possibility of establishing a pearl industry in Port Stephens, an industry based on the Akoya pearl oyster, *Pinctada imbricata*.

Interest in the possibility of farming Akoya oysters in NSW has been shown for several years. However, extensive surveys of the NSW coast indicated that there were insufficient oysters to permit gathering from the wild. To overcome the shortage of oysters and to commence trial farming, NSW Fisheries signed a memorandum of understanding with a pearl farming company 'Australian Radiata', who have a wealth of farming experience in both Australia and Japan.

Port Stephens, 200 km north of Sydney, was chosen for farming because it is among the best waterways in Australia for temperate shellfish farming owing to its fortunate combination of a suitable temperature range, lack of pollution, and expanse of sheltered, well-flushed and relatively deep waters. Further, Port Stephens offered the facilities of NSW Fisheries, Port Stephens Research Centre, with its extensive experience in the production of new aquaculture species.

Together, scientists from NSW Fisheries and representatives of Australian Radiata devised a research programme with three major goals: first, to elucidate the biology of the Akoya oyster in NSW, focusing in particular on species distribution, growth rates in NSW estuaries and reproductive biology; second, to establish techniques for reliable hatchery production of spat in NSW to preclude the need for collecting oysters from the wild; finally, to construct experimental farms in Port Stephens so that the viability of farming can be tested and any potential environmental impacts can be assessed.

Within a year of the programme's inception, work is well under way. Four experimental leases with a total area of 28 ha have been obtained to allow farming in different areas of Port Stephens. Oysters have been deployed at these sites so that growth and survival can be monitored. Sampling to follow growth and reproduction in the wild Akoya population has been underway for 11 months and settlement collectors have been deployed in order that natural recruitment can be followed. In the hatchery, oysters have been brought into reproductive condition and induced to spawn. More than 2.5 million spat have been produced, enabling farming trials to begin.

Spat growth has been encouraging; the first oysters are expected to be large enough to allow pearl-nuclei implantation by the end of this year (1999). The quality of pearls produced will then be assessed in the hope that Port Stephens could become the centre of an Australian Akoya pearl industry, an industry that has a low environmental impact and complements other existing industries such as tourism.

Black Pearls of Micronesia: first pearl harvest, farm expansion plans to include additional local partners

Virgil Alfred, Farm Manager for Black Pearls of Micronesia Inc., reports that the company is looking to expand its activities in the Marshall Islands. Over the last few years of expansion on the farm, Virgil and his crew have been able to adapt the established pearl farming techniques to Republic of Marshall Islands conditions, and have trained over 15 Marshallese workers in the basics of pearl farming.

The company is now looking to set up joint-venture arrangements with local partner farms. Dr Dale Sarver, BPOM President said that the company's plans had always been not just to get their own operation up and running, but to also show the way for others to participate in this potentially lucrative industry in the RMI. 'As well as expanding BPOM's own "nucleus" farm', he said, 'we

1. Fisheries Scientist, NSW Fisheries Department, Port Stephens Research Centre, Taylors Beach, NSW 2316, Australia

would like to involve local Marshallese partners in developing "satellite" farms in the surrounding lagoons. We have now reached the stage where we would like to begin this expansion. These development plans have a long time horizon, and potential farmers must realise it involves a lot of hard work, significant investment, and a long payback period.'

The company's plan is to set up a demonstration 'satellite' pearl farm in Majuro lagoon, as a joint-venture partner with the larger 'nucleus' farm. This way the larger farm can provide all the technical expertise and management, as well as train the new workers at the existing farm site. BPOM could also provide advantages for smaller farms by bulk purchasing of equipment, assisting with obtaining seeding technicians to operate the oysters, and with marketing of the final crop. The BPOM hatchery would provide spat (young oysters) for the partner farm. The costs for spat and other operating expenses could be shared between the partners. 'BPOM would like to encourage local Marshallese participation in this venture in whatever way possible,' said Dr Sarver.

The company's pearl oyster hatchery in Woja has been increasing its production capacity over the last six months, with the appointment of a full-time hatchery manager from Tasmania. Mr David Wise was formerly Assistant Manager of the largest oyster hatchery in Australia. The hatchery has operated for the last year out of a containerised facility, but a permanent hatchery will be built in the near future. Four Marshallese staff are also currently employed at the Woja hatchery.

BPOM has moved its operations from the DUD area to Bikirin, near Enamanet. 'The new site has excellent water exchange with the ocean all along this northern edge of Majuro' said Dr Sarver. Other potential expansion sites are now being evaluated.

'Our last year's harvest has shown that this lagoon can produce superb pearls', he said. Size and shape of the pearls harvested were within expectations, but the most pleasing aspect was the colour. 'A striking gold colour was present in a good proportion of the crop', said Sarver. 'The strength of this colour, and lustre throughout the crop were all far better than we could have hoped.' A proportion of the better pearls from the harvest was sold to a distinguished jewellery house from 5th Avenue, New York.

'The RMI government, through the Marshall Islands Marine Resource Authority (MIMRA), has been very supportive of our early research and development efforts here. We continue to carry out joint R&D projects with MIMRA, and expect this cooperation to continue. It has taken a long time to bring our plans to fruition, and we would like to acknowledge the invaluable assistance we have received over the years from the government,' said Dr Sarver. The company also has prepared a plaque, containing a pearl from the first harvest and one of their hatchery-produced shells, which they intend to present to the RMI government as a token of their appreciation. US Government support has also been integral to the company's R&D efforts in the RMI. The initial support from NOAA/NMFS, through the Salston-Kennedy Program, was crucial to developing the first hatchery and nursery techniques, said Neil Sims, company Vice President. Ongoing support from USDA and SeaGrant's PADP has also enabled greater training and extension work.

In furthering the growth of the industry in the RMI, BPOM is also seeking Marshallese locals suitable as candidates for training as pearl-seeding technicians. The pearl-seeding operation requires very steady hands, and lots of patience. Currently, most of the seeding technicians in the black pearl industry are Japanese, Australian, or Tahitian. BPOM uses a Cook Islander to seed its oysters on its own farm. 'As the industry expands here in the RMI' said Sims, 'there will be a need for Marshallese seeding technicians to fill the growing demand'.

Further enquiries can be directed to Dr Dale Sarver or Mr Neil Sims through the BPOM Majuro office. Contact:

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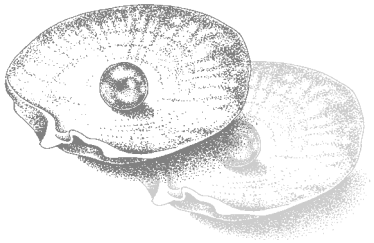
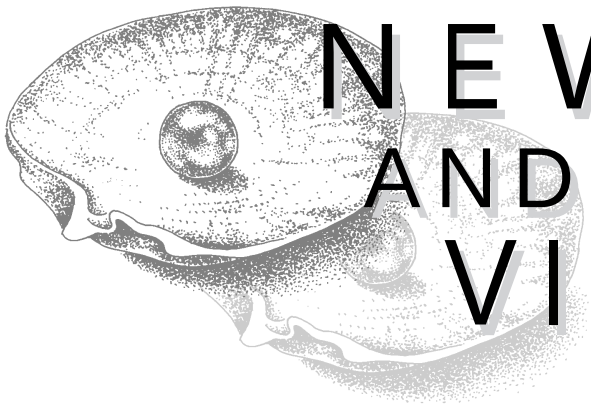




NEWS AND VIEWS

Black pearls cultured in the Solomon Islands

Solomon Islands have harvested 800 black pearls, a record number since the country started the aquaculture farming project.

The black pearl farm at Gizo in the Western Province is the first to successfully culture pearls since the project started two years ago. A pearl farmer from the Cook Islands was contracted to operate on oysters to produce pearls and recently returned to extract them.

Principal Farm Scientist, Doctor Johann Bell says another farm has been set up in Noro, also in the Western Province as a back up for the Gizo farm. The Solomon Islands Agriculture Ministry has not revealed the value of the 800 black pearls harvested this week. Dr Bell said the result of the research on black pearl farming is of great significance to the country...

Source: PACNEWS 2: Thurs. Apr. 15, 1999

Tonga's pilot pearl farming project begins

A Japanese pearl farming company has begun a pilot project in Tonga to determine the viability of producing black-lip oyster pearls in the Polynesian kingdom.

Secretary for Fisheries, 'Akau'ola, says the government is optimistic about the project undertaken by Japan's Tahiti Shinju Company.

A successful result, 'Akau'ola says, could lead to the establishment of Tongan pearl farming activities on the capital island of Tongatapu and in the Vava'u and Ha'apai island groups, Radio Tonga reports.

Meanwhile, Tonga's Ministry of Fisheries has embarked on another trial pearl project in Vava'u, using winged oysters, which already has shown some positive results.

A recent joint review of Tonga's fisheries sector by the UN's Food and Agriculture Organization and Australia's AusAID suggests that pearl farming is the country's most promising aquaculture development opportunity.

Source: - PACNEWS/Tohi: April 26, 1998

Cook Islands ideal for pearl farming

Pearl farmers in the Cook Islands say the wild seas that threaten the islands' isolated pearl farming atolls each hurricane season also are probably the best thing for the industry.

Small populations on scattered atolls in an unpolluted sea keep the pearl farms free of the diseases and problems that threaten the cultured pearl industry in Japan.

Meanwhile, because of the Asian economic crisis, pearl farmers report that demand for Cook Islands' and other South Sea pearls has decreased.

Dealer Trevor Bergman and pearl farmer Raymond Newnham said if Japan's economy does not revive, dealers may turn to buying pearls from China.

Source: Radio Australia, 14 September 1998

Cook Islands expanding black pearl industry

The Cook Islands government is planning to turn an isolated nature reserve atoll, into a major black pearl farming site.

The Cook Islands Investment Corporation, which handles all the country's state assets, reports it plans to have a review of Suwarrow Atoll's commercial pearl growing opportunities completed by the end of next June.

A Hawaiian company, Black Pearls, Inc., will carry out a project feasibility and environmental impact study on the huge lagoon. Suwarrow is an atoll made up of 15 untouched islets located in the clear waters of a 90 square kilometer (36 square mile) blue lagoon, 825 kilometers (495 miles) north of Rarotonga.

Source: Radio Australia, 10 October 1998

Pristine Suwarrow atoll targeted for pearl farms

By Florence Syme-Buchanan

Pearl farming proposals could threaten one of the South Pacific's last pristine atolls, Suwarrow, in the Cook Islands, environmentalists said Monday.

The atoll is the one of the areas largest bird nesting grounds, as well as an important breeding ground for green turtles and coconut crabs.

'The coral and fish in the lagoon are spectacular, the environment is pristine,' Save Our Suwarrow campaigner Anna Tiraa-Passfield told AFP.

Suwarrow is a national park atoll made up of 15 untouched, emerald islets nestled in the diamond clear waters of a 90 square kilometre (36 square mile) blue lagoon, 825 kilometres (513 miles) north of here. Only a caretaker and her family live on the atoll. Knowing that wild pearl shells grow in Suwarrow, government officials decided that Suwarrow was the most suitable place to farm.

Last month the Cook Islands Investment Corporation, which handles all the country's state assets, said a Hawaiian company, Black Pearls, Inc., was to carry out a feasibility and environmental impact audit (EIA) on the lagoon. Because of government's push for Suwarrow development, there were concerns the EIA would address the best way to utilise the Suwarrow environment to pearl farm rather than whether this should be done at all.

The Prime Minister's Chief of Staff Temu Okotai said the question was irrelevant. 'Pearl farming is farming in the lagoon. What is the concern of these extreme environmental groups?' asked Okotai.

Tiraa-Passfield said the government's history of disregarding advice meant their fight to keep Suwarrow a national park might be an exercise in futility. She said the government was seeing dollar signs.

Tiraa-Passfield said they were concerned whether the EIA would be made public. They also want consultation on who would protect the wildlife and the impact of the nearly 150 people that would be living there.

She said if people lived on the outlying islets, they would become like Anchorage island, the main atoll where 'very little wildlife breeds.'

Okotai said environmental groups 'jump on the bandwagon (and) it's not unusual for environmental groups to say "no development." I don't have much time for them.'

In the early 1980s, cabinet declared Suwarrow a national park. However, this was never legislated. Okotai said that in the 1980s pearl farming was not an important industry for the country. 'Do we lock it up, or do we look at developing it the right way ... the pearl potential should be developed. We are looking at the well being and aspirations of the people of the Cook Islands and these are the kind of things that environmentalists want locked away.'

He said the government would consider public concerns over the atoll. 'Whether it should be (developed) or should not be, is a question that should be addressed to politicians.'

Source: AFP, 16 November 1998

Environmental study favours pearl farming on Suwarrow atoll, Cook Islands

By Alex Sword

No construction of an airstrip on Suwarrow Atoll is among the recommendations of the just publicly released draft Environment Impact Assessment (EIA) report on the proposed opening up of the atoll for pearl farming development.

The report, made available for public scrutiny yesterday by the Cook Islands Investment Corporation (CIIC), in supporting controlled pearl farming development of the atoll as opposed to no action, says seaplanes or ships should be used instead.

It recommends, during initial development, the confinement of construction to the areas of human settlement on Anchorage Islet, the lagoon side of motus Tou and Manu, and one lagoon Kaoa.

All that withstanding, 'Minimal pollution will occur during construction, barring accidents,' says the report.

Hawaii's Black Pearls, Inc. prepared the EIA for the Cook Islands Government through the CIIC subsidiary, the Suwarrow Development Corporation. Hawaii's Michael J. Wilder Company and Analytical Laboratories also assisted. The draft EIA report is not 'an exhaustive study of the Suwarrow Atoll' as its drafters explain, but is under terms of the Phase I EIA required by government. Yet to be carried out, is the Phase II scope of work which will deal with an in-depth (baseline) study of Suwarrow's marine and land life.

During operation of the pearl farm development, the report says residence on the atoll should be restricted to a maximum of 100 farm workers and required National Park staff.

It says that economic impacts from the farm operation will be significant, with 100 persons directly employed and possibly another 100 secondary employment positions created.

As Crown property, lease or royalty payment would accrue to the Cook Islands Government, along with applicable taxes on payroll and corporate profits, and goods and services tax (GST), says the report.

Among its other recommendations and findings are that:

- Number of farmed oysters should not exceed 2 million, that figure including 500,000 virgin oysters seeded per annum. (Wild oyster collection is not feasible—low spat fall rates render impractical the use of artificial collectors to support farm operations).
- A single large farm is favoured (on which the draft EIA is based). However, if political considerations demand that some number of smaller farms is appropriate, then no more than three farms in total should be licensed.
- As Anchorage Islet is already impacted by human development, it should be used as the base for the farm(s) and pearl hatchery. Small islet bases could be built on the lagoon-side of motus Manu and Tou without significantly impacting the bird or vegetation life.
- A single kaoa be allocated for each farm as a lagoon base for cleaning and seeding.
- There be a maximum population on the atoll of 100 workers at any one time.
- A 'National Park Management Plan' be designed to promote the protection of the atoll's national park status, with regulations to be developed and monitored.
- Precautions be taken to prevent the loss of the Suwarrow pearl oyster gene pool and to minimise the risks of inadvertent pathogen or parasite introductions.
- Turtles could be negatively impacted if the increased human presence results in greater harvesting rates of adults and eggs. Some greater protection should be accorded turtles under the National Park Management Plan.
- While none of the birds are endangered, some are either few in number or susceptible to human habitation and may be impacted by a human population increase.
- Increased human impact on coconut crabs should be monitored and managed by park staff.

The draft EIA report can be viewed at the Cook Islands Library, Takamoa, until 5 March 1999, and public comments on it in writing should be delivered to the CIIC no later than that final date.

Source: *Cook Islands News*, 25 February 1999

Objections to turning Suwarrow atoll into pearl farms

The Cook Islands government is under increased pressure from environmental groups to halt plans to turn a remote, uninhabited atoll into a major pearl farming site.

The groups want Suwarrow Atoll, which is a breeding ground for several varieties of sea birds, the endangered green turtle and coconut crabs, kept as a national park.

The environmentalists have urged the government to commission an independent body to make the final assessment on the proposed development to ensure that the marine and wildlife will not be affected.

Although Suwarrow was declared a national park in the 1980s, government officials now say that action was overturned by a more recent cabinet decision. Under the plans, up to 100 people would be stationed on Suwarrow Atoll's tiny Anchorage Island.

Source: Radio Australia, 17 March 1999

How government and the private sector can work together to develop resources of the Pacific Islands

Keynote Address at the 8th Annual Maui Pacific Center Conference, Lahaina, Maui, Hawaii

By Hon. Sir Geoffrey Henry, KBE, Prime Minister of the Cook Islands, 13 October 1998.

The Cook Islands: opportunities for public and private collaboration

Aquaculture takes many forms. The one that we are most familiar with and are now skilled at is black pearl farming.

Years ago, every passing economist felt obliged to say that 'the Cook Islands has no natural resources.' Forgive the fact that he ignored the tropical weather that attracts every visitor. Forgive that the economists ignored 6,000 metric tons per year of sustainable fish catch.

Even forgive—though it is becoming more difficult to do so—that they overlooked billions of dollars of copper, nickel and cobalt embedded in the modules that pave our sea floor.

But, it is unforgivable that the so-called expert economists always overlooked the glory of our oyster-rich atoll lagoons as potentially one of the world's best sources of cultured black pearls. Already, French Polynesia generates over US$ 50 million in black pearl exports and we are approaching some 10 percent of that.

Our three largest lagoons contain together nearly 300 km^2 of pure, warm, sunlit waters. Just as petroleum was once though useless until someone invented the internal combustion engine, so were lagoons overlooked as economic resources before the culture of black-lip pearl oysters was refined and put into practice by a few hardy pioneers.

Where the Cook Islands has differed from French Polynesia in its pearl industry is that, thus far, ours are almost entirely family-owned farms while theirs are corporate with considerable foreign ownership.

We are about to change this by tendering the rights to just three corporate farms in Suwarrow's lagoon. Each will cost towards US$ 4 million before it sells a pearl but, once in full production, each will gross twice that and very profitably too, thank you very much! Here is an almost perfect example of a collaborative opportunity. In this case, the production technology is local, the technician skills are largely Japanese and the markets are increasingly North American and European.

Actually, my government can see no obstacle to several strong, international pearl farming partnerships emerging. We hope to have an environmental impact assessment (EIA) completed this year—incidentally by a team of scientists from Hawaii—and, then, will publicly tender the opportunity.

In making the tender, government is not seeking large up-front payments. Instead, we will be looking for the strongest business plans. Our goals include job creation, locally based supply purchases and, of course, tax revenue. We will achieve these by selecting only well-financed operators who know the business, leaving them free to do what they do best—but within the guidelines of the EIA.

Manihiki pearl farming under threat

By Florence Syme-Buchanan

If nothing is done quickly, the lucrative Manihiki pearl industry could be destroyed by over farming the island's 60 square kilometre (24 square mile) lagoon. Marine Resources says pearl farming there is approaching 'critical levels in all capacities.'

It's understood 80% of the lagoon is now filled with pearl farms. The lack of a proper management programme at the outset has been blamed for the threat now hanging over a national money spinner that's second only to tourism.

Two years ago it was estimated the pearl farming industry earned $4 million a year. That estimation has increased to between $5 million to $7 million each year—money that helps the country repay loans with the Asian Development Bank.

The ADB is concerned enough about the Manihiki problem to want effective management of the lagoon initiated.

The Cooks is to get two loans of US$ 200,000 this year and next to implement two phases of a 'regulation and management' programme of the island's pearl industry.

Farmers concerns

Ministry of Marine Resource's Director of Research Ben Ponia says Manihiki pearl farmers also share their concerns. He says government hasn't really made substantial input into a management process and 'farmers have been regulating themselves.'

'A lot of pearl farm operations realise they can only farm so many pearl shells before overstocking occurs.' That overstocking can be disastrous, says Ponia. 'The quality of the product goes down, it affects the health of the oysters and environmental consequences that can't be undone. It'll have a domino effect.' Ponia says people have only become concerned enough to take meaningful action now that the Manihiki situation is critical. He says 1994 management plans were adopted by the island, but weren't seen as essential then.

Ponia believes 'the pearl farming industry needs a higher body to control the industry at the production level.' Marine Resources is to carry out a survey of Manihiki lagoon next week.

Source: *Cook Islands News*, 16 April 1999

The Penryhn dilemma

by Florence Syme-Buchanan

Behind the mystique of black pearls are island families who work incredibly hard and long on their tiny atolls to produce these gems—but one third of their effort pays foreign pearl technicians, and now some farmers are crying 'unfair'.

The tiny atolls of Penryhn nestle in the second biggest lagoon in the Southern Hemisphere, and pearl farmers there believe this massive natural feature is the key to producing the best black pearls in the world. But four years after the island launched into pearl farming, some farmers are experiencing the same problems as their relatives in nearby Manihiki. The problems, they say, have been caused by greedy farmers, whose crafty behaviour has resulted in a payment system that has disadvantaged everyone and broken the very by-laws set up to stop foreigners farming in their vast lagoon. Through a lucrative payment system, foreign pearl technicians are ending up owning more pearl shells than indigenous Penryhn islanders, and many aren't happy about this.

Penryhn islanders are limited to 5,000 pearls shells each. Another island by-law restricts pearl farming in he 130 square kilometre lagoon to people of Penryhn descent. Despite the by-laws, about four technicians originally from Japan, have accumulated pearl shells well over the limit and have set up thriving farms. Minister of Marine Resources Tepure Tapaita admits the foreign technicians are technically farming without licences and a problem situation exists. But he, the Pearl Federation and concerned pearl farmers are stumped how best to resolve the problem. That's because farmers and author ties are in a catch-22 situation. The foreign technicians are needed to seed the pearl shells as just one local, John Lyons, is fully qualified. About six other locals are trainee technicians and farmers are reluctant to use them because mistakes are costly. No one sees a way around the problem, caused mostly by some dishonest farmers who made the original percentage of harvest payment too risky for technicians to accept anymore.

Technicians are now demanding one shell out of every three they seed for a farmer. It used to be a percentage of proceeds, or harvested pearls, which sometimes runs up to 60 per cent of a harvest. A technician used to be paid one pearl out of three that were harvested. That system went out over the reef when Penryhn farmers began stealing their own pearls so they wouldn't' have to share them with the technicians.

Big time pearl farmer Peter William says technicians are seeding up to 30,000 shells at a time and, from this, earn themselves 10,000 shells after delicate operations. 'A lot of farmers disagree with the payment system, but have no alternative, otherwise they wouldn't get any shells seeded', says William. But the other side of the coin, says William, is that a few technicians have been burnt by dishonest farmers, 'So their trust has gone—they prefer to have payment in (seeded) shells'.

'What has happened, says William, is that we've condoned farming by a non-Manihikian islander, a non-Penryhn islander, and that leaves a bad taste in my mouth'.

Marine Resources minister Tepure Tapaitau is talking about standardising rates, but says this would need pressure from the Pearl Federation and farmers themselves to enforce. Tapaitau says he's told technicians that 'the farmers are missing out. It's the farmers' shells, it's the farmers' lagoon, it's the farmers' accommodation they are living in. Let's be fair.' The minister says 'Penryhn farmers are in a desperate position'.

Tapaitau says 'technically' the foreign technicians are bigger farmers than the Penryhn islanders and this isn't conductive to growing the industry for the islanders. Pearl Federation member and farmer Glenice Lyons says technicians get an alloted area for their shells, then pay a local to look after the farm.

'The point really is other Cook Islanders can't do it, unless they have Manihiki or Penryhn blood', says Lyons. She says 'Cook Islanders must be asking: if a Japanese can do it, why can't I?' Lyons says eventually the technicians will get companies behind them and 'move in, what's stopping them from doing that?' She says another payment method must be used, but is unsure what the Pearl Federation is doing, if anything to address the problem. Minister Tapaitau has disputed Lyons claims that a Japanese/Australian pearl technician was granted a license to farm pearls by the Penryhn island council. He says it is not true.

Another problem being faced by big farmers such as Peter William is the ban on importing shells from nearby Manihiki or anywhere else. The island council has fears that imported shell will bring disease. William says Penryhn lagoon's wild shell stocks are fast being depleted and they want to bring in smaller younger shells from Manihiki that produce better quality black pearls. The Marine Resources hatchery can't keep up with the demand William family has for new stock.

As for talk about diseased Manihiki pearl shells, William says he 'wouldn't have a clue' what the island council is basing that theory on. The William family have been pearl farming in Manihiki for almost 20 years and regularly have the biggest harvests. Minister Tapaitau says it's probably time the Penrhyn limit of 5000 pearl shells per farmer was done away with.

But he wants to discuss shell importation with pearl farmers in French Polynesia first before lifting the ban. While the minister talks, the pearl farms of foreign technicians get bigger in Penryhn—with farmers virtually held to ransom by the critical need for the expertise and skill of pearl seeders from outside the huge lagoon.

Source: *Pacific Islands Monthly*, October 1998

Big export potential for *paua* pearls

Efforts to establish export markets for New Zealand's firs national gem are making headway, with a recent cover story on *paua* pearls in the American jewellery trade publication *Gem and Gemology*. Christchurch entrepreneur Liz McKenzie has trademarked the name Empress Pearls for the gems her company, Empress Abalone Limited, is growing at a farm on Stewart Island. The *paua* are fed farmed kelp, which New Zealand has in abundance. The pearls grow around implants attached to the shell and when harvested fetch up to $US 1000 each. There are also ready markets for *paua* meat and shells.

Source: Neill Birss, in *The Press* (16 January 1999)

Cellular differentiation during pearl sac formation

by Belinda Hui[1]

Since graduating last academic year with a pre-doctoral diploma (DEA) in 'Knowledge and Management of Coral, Coastal and Oceanic Environments' from the French University of the Pacific, Mrs. Belinda Hui-Tchung has been preparing a thesis on cellular differentiation during the development of the mantle graft and the pearl sac in the Pinctada margaritifera *(Mollusca lamellibranchiata) pearl oyster. She is carrying out her research as part of a partnership agreement funded by the (French) Development Contract and the European Community (7th EDF) and implemented by EVAAM*[2] *in co-operation with the French Polynesia University Centre (CUPF).*

Christian Herbaut (CUPF), professor of animal biology, is the scientific supervisor for this thesis, whose subject and objectives were jointly determined with EVAAM. Further research will be carried out in France, at Caen University, in conjunction with Professor Eve Boucaud (Marine Biology and Biotechnology Laboratory).

During seeding, a mantle graft and then an aragonite nucleus are implanted into the pearl pouch of a mother pearl oyster. Ideally, after a few days, the mantle graft cells proliferate and cover the entire cavity wall to form the pearl sac, which will secrete nacre around the nucleus. In order to explain the mechanisms involved in the formation of the nacre coating, it is important to determine the origins of the cells composing the pearl sac and how they develop. Such observations could make it possible to establish a relationship between the pearl sac's characteristics and the quality of the pearls produced. (The pearl pouch and the pearl sac should not be confused. The pearl pouch, which is also called the gonad, is the organ in which the nucleus is implanted, whereas the pearl sac is formed of a layer of cells from the graft's nacre epithelium, which surrounds the nucleus and secretes nacre (for more information, see *Te Reko Parau*: *Les mécanismes de formation de la perle*).)

Activities carried out and initial results obtained

Work began in October 1996 with a seeding programme at the EVAAM station in Rangiroa. The pearl oysters were sampled successively 1, 2, 4, 7, 10, 15, 20, 25, 30, 45, 50, 100 and 250 days after implantation. Implantation was again carried out in September 1997 on another batch of pearl oysters, some of which were grafted with coated (yellow) nuclei. Pearl pouches which showed flaws (e.g. constrictions, pitting, waste material, blistering) were also sampled in order to try to establish a correlation between the observed flaws and the way the corresponding pearl sac cells functioned. These samples are being processed and analysed at the CUPF Animal Biology Laboratory and Caen University's Marine Biology and Biotechnology Laboratory. Initial results show that, beginning on the 10th day after grafting, organic material is deposited around the nucleus, mainly at the grafting point. By the 50th day, the nucleus has been completely covered by a layer of nacre, which thickens steadily over time.

Source: *Te Reko Parau*, January, 1998

Takapoto: A lagoon under intense surveillance

by Jean-Marc Zanini[3]

Since March 1997, the natural stock of pearl oysters in the Takapoto Lagoon, in French Polynesia, has been the subject of long-term scientific monitoring at four test sites surveyed on a regular basis in various lagoon locations. The study aims at understanding changes in this resource over time and detecting any abnormally rapid variations in the stock.

An assessment of the natural pearl oyster stock in the Takapoto Lagoon was jointly conducted by EHPE and EVAAM in October and November 1995. It showed that Takapoto Lagoon contained between 4 and 5 million natural pearl oysters on coral structures, generally at depths between 30 and 40 meters.

1. Doctoral candidate at the French University of the Pacific
2. EVAAM- *Établissement pour la Valorisation des Activités Aquacoles et Marines* , became *Service des Ressources Marines* (department of marine resources) in 1998.
3. Student at the Tertiary School of Practical Education (EPHE)

These data were gathered as part of the General Pearl Oyster Research Programme (PGRN).

In the strictest sense, this stock assessment was only valid at the moment it was made. It could be compared to a 'snapshot' of the lagoon taken at a specific instant, which does not show what happened before the study or how the stock has evolved since the end of 1995. In fact, we know practically nothing about the natural stock's mortality or regeneration rates or about the average life span of pearl oysters in the lagoon.

The life and death of pearl oysters: a year-long study

In order to better understand changes in the natural stock, EPHE has been carrying out a project to monitor pearl oysters over time in the Takapoto Lagoon with the support of EVAAM.

In early 1997, four 200 m^2 sites were marked out with buoys and ropes. All the pearl oysters at 20-35 meters of depth inside these limits were then counted. These four sites were again visited in early June 1997 and then once every three months for a year.

This study aimed at establishing an initial estimate of the renewal rate for the natural stock of pearl oysters as well as discovering the mechanisms affecting that rate (mortality and the arrival of young spats at the site).

This study also constituted the first deep lagoon surveillance station ever established in French Polynesia, allowing the detection of events which could otherwise go completely unnoticed.

After three months: the initial results

The first tagging operation in March 1997 had already revealed a worrying situation: Site 2 near the village, which had been chosen for its abundance of pearl oysters, as noted during the 1995 sampling, now offered only a bleak landscape scattered with empty oyster shells. At a spot where, in late 1995, more than 50 pearl oysters had been counted for each 200 m^2, it was no longer possible find a single live specimen. This situation was a cause for concern, but the location of the dive did not allow any conclusions to be drawn, other than this simple observation.

On the other hand, the second site observation programme did reveal a clear problem: while Sites 3 and 4 in the northern lagoon, only witnessed minor changes to their populations (one oyster died and two spats arrived), Site 1 near the village had experienced a high rate of mortality. Of the 23 pearl oysters tagged at that site, 13 were dead. As their shells were still at the site, oyster diving was eliminated as the cause of mortality. This mortality rate (i.e. over 50% in less than 3 months) was, to say the very least, very worrying and undoubtedly indicated that the seabed had experienced a crisis situation.

Is this a cause of concern for pearl oyster farming?

The mortality problem only affected a small portion of Takapoto Lagoon and was not actually observed on natural stocks at depths of between 20-30 metres. The high mortality rates observed at these sites for other species such as Chama sp. and Arca sp, led us to suppose that this was not a disease specific to pearl oysters. However, after investigation, it appeared that some limited mortality was also observed in a few pearl oyster farms in March and April.

This alarm signal should not be ignored and vigilance is, more then ever, essential.

Call for vigilance by pearl oyster farmers

For the moment, the causes of this mortality are not known. There is, however, one common-sense measure which can be recommended to oyster farmers: verify and, where necessary, bring back up to their proper level any oyster lines which have sunk to the bottom.

For while these instances of mortality only affected the natural stock and spared oyster farms, this was probably because environmental conditions are more unfavourable on the lagoon bed than they are near the surface.

This measure, which, in any case, is important even during normal conditions, may allow farmers to limit damage if, unfortunately, this problem should spread.

In order to try to be better prepared for such occurrences, it is very important that everyone be careful and verify their lines on a regular basis so as to detect any possible appearance of abnormal mortality. This information must be shared with pearl oyster farmers and also the scientific community by means of EVAAM's Takapoto Station.

Understanding what is happening today may perhaps prevent it from recurring tomorrow, and that, in any case, is everyone's business.

Source: *Te Reko Parau* n° 8, September 1997

GIA's Course Development editors experience pearl farming first-hand

Contributions to the Gemological Institute of America's *Vision 2000* campaign funded staff members from GIA's Course Development department to travel to Japan and Tennessee in July to increase their first-hand knowledge of Japanese akoya pearls and freshwaters pearls.

The information and experience gleaned from these trips will be incorporated into the new assignment Pearls course to be offered in April 1999. Hundreds of photographs and video footage of various pearl manufacturing and farming operations were also acquired during the trips and will be included in the new course material.

Dean Stevens, editorial manager of GIA's Course Development department, travelled to Japan with GIA chief Development officer Jim Littman, who directs the Vision 2000 campaign. Japan Pearl Exporter's Association hosted Stevens and Littman while in Japan. They visited two pearl farms, a hatchery, and attended a meeting with The Japan Pearl Exporters' Association, all operations of Tasaki Shinju Co.

Stevens said he gathered invaluable information about the nucleation, farming and research of akoya pearls for the Far East and Akoya assignment of the Pearls course.

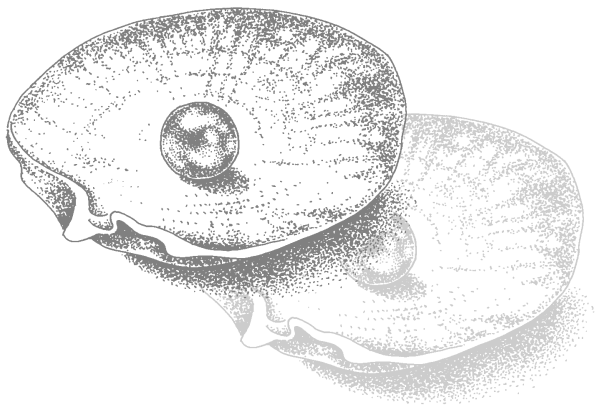
GIA staff was hosted by American Pearl Company, producer of freshwater pearls, in Nashville and Camden, and Tennessee Shell Company in Camden, the largest supplier of shells for the production of beads which are used for pearl culturing. They also visited other pearl-related sites in Tennessee.

In October, GIA staff travelled to freshwater pearl farms near Shanghai, China, where they were hosted by Mansang, producer and wholesaler of freshwater and saltwater pearls, to conduct further research on freshwater pearls and visit farms near Shanghai, farms and processing facilities near Shantou, and wholesalers in Hong Kong.

After China, the group travelled to the Philippines Islands to gather the information and to shoot still photos and video footage on the island of Palawan at the site of their host, Jewelmer, producer and wholesaler of South Sea cultured pearls.

For more information about the Pearls course, please call Education Services representatives at GIA Carlsbad, at (800) 4217250, ext.: 4001 or (1 760) 6034001 outside the US or fax : (1 760) 6034407.

Source: *The Loup*, Fall 1998



'Bironite™': A new source of nuclei

by Michael Snow, Biron Corporation

Introduction

Many different nucleus materials have been used in pearling, both natural and synthetic, but shell material is predominantly the material used for round pearls.

Patents have been granted for many materials including glass ceramics, various compressed calcium carbonates materials and some mineral powder/resin composites. Lead, silver and gold were used in the early Japanese experiments and several stone materials have been employed experimentally.

Nacre will grow on nearly any solid material; indeed plastics are used for mabe production. However with round pearls where the nucleus remains, it must have a comparable coefficient of expansion to the nacre. Resins and plastic have very high coefficients leading to flaking nacre with these nuclei.

Nuclei properties

Three key properties need to exist in a round pearl nucleus:

- They must have a very similar density to the mussel shell near 2.80 g/cc for commercial weight reasons.
- They must be stable over time and capable of taking a good polish.
- They must drill well without excessive drill wear and with drilling speeds near that of mussel shell so that they can be drilled with the same drilling equipment.

Less critically the thermal coefficient of expansion must be compatible with pearl nacre. This was a major issue when the Japanese industry started to use epoxy resins filled with shell powder. The thermal expansion coefficient was far too high and the nacre flaked off.

Finally the industry strongly prefers white nuclei and so the material must be colourless. Indeed the mussel nuclei grading system is based on the degree of colour evident in the nuclei. This especially important for Akoya production where the nacre is thin, but less so for *Pinctada* pearls.

Mussel shell suffers from several disadvantages for use as nucleus material:

- It is a layered material, often colour banded and in manufacture, drilling and use it is possible for the layers to split apart. This is common in the manufacturing lapidary and it is not uncommon when drilling the final pearl.
- The hardness and drilling speed differ in the directions into and along the layers.
- It is hard to get sufficient shell to afford enough beads in the larger sizes, with the result that these are expensive and some sizes not available.

Also, mussel shell has a major disadvantage as a nucleus. It is a material that has directional properties. There is about a 2:1 variation in property values measured into and perpendicular to the shell layers. The shell layers are bound together by an organic matrix and the layers can part during bead manufacture and during drilling of the finished pearl.

We have focused on natural dolomite as a stating point for our nucleus development. Dolomite has major drilling deficiencies as a pearl nucleus. The main one is that the material is too hard for easy drilling. Materials we have tried will drill slowly, but also cause rapid drill wear. This in turn can lead to rapid over heating of the nucleus and possible cracking of the structure.

We are aware that some Korean and Japanese firms are offering dolomite to farmers as nuclei at discount prices to shell. We find this material very slow drilling giving rise to excessive drill wear. The farmers that use this material will face possible rejection of their pearls crops by processors due these very hard nuclei causing drilling problems and possible pearl failure.

An additional problem is that dolomite has euhedral (block like) crystals that do not bind together tightly. While some materials do hold together well enough others do not.

In other respects dolomite is acceptable as it does not have directional properties, polishes, has a density slightly above 2.80 at 2.84, it can be obtained white and has an acceptable thermal coefficient of expansion inside the range of mussel shell.

Bironite

In 1995 Biron, a created emerald manufacturer and gemstone distributor in Perth, was approached by the industry to develop a new nucleus material. The material had to be less expensive and readily made, to be white and have properties similar to mussel shell especially in regard to its ability to be drilled by the traditional steel spade ended pearl drills.

Biron is grateful to the Commonwealth Government for recognising the merit of the project and providing an IR&D grant over 3 years to pay half the expenses of the work. Dr. Michael Snow, a professional chemist and Director of the company led the development work.

With Mr. Artur Birkner, Dr. Snow has been able to develop selected dolomite mineral material as an ideal alternative to mussel shell. It is white and it is not colour banded nor does it have directional properties like mussel shell. This means it does not split in the lapidary or on drilling.

Bironite is a natural dolomite that has been modified by a patented process to overcome these deficiencies. It remains mineralogically very similar to the original material except that its drilling properties are substantially improved. See the table of propertiesdown below.

The Bironite nucleus has been trialed by the Australian company Atlas Pacific Limited in Indonesia and is to be trialed by three Australian groups starting this year. Atlas Pacific by the way is stock exchange.

We are also grateful to Paragon Pearling and South Pacific Nucleus for lapidary work. Pearlautore and Linneys at Broome and in Perth helped us with drilling tests. The S.A. Museum gave advice on minerals.

Frequently asked questions

Why use Bironite when mussel shell is so well established?

Bironite has a distinct advantage over mussel shell in drilling. It is a uniform natural material specifically modified for the purpose. It is able to complement the availability of mussel shell that is not always procurable in larger sizes. The taking of live mussel shell is now banned on environmental

Table 1: Properties of different materials used for nuclei

	Dolomite	Bironite	Mussel shell
Density, gm / cc	2.82 to 2.87	2.84	2.8
Hardness, (Vickers)	172 to 250	176 to 192	135 to 223
Linear Expansion Coefficient (Parts per C°)	15 to 25 x 10^{-6}	22 x 10^{-6}	14 to 35 x 10^{-6}
Appearance	Pearly lustre	High polish, icy	High polish, glassy
Colour as graded	White to black	Pure white	White to banded
Workability with pearl drill	Poor, excessive drill wear can cause cracking	Excellent, regular very low drill wear	Excellent, variable low drill wear
Relative drilling speed*	0.4 to 0.6	0.9	0.5 (±) to 1.0 (±)

grounds in many states of the USA. The mussel species has been overfished and the supply is no longer sustainable. The very slow growing times of between 40 and 80 years to maturity and zebra mussel predation suggest that the shell may not be replaced when the old shell is exhausted. Past experience has shown that the supply of shell can be erratic. Farmers commonly stockpile nuclei to ensure that this critical supply item is always available. Check the following internet site for more information: http://www.sdafs.org/meetings/98sdafs/mussels/mussels.htm

Why are the drilling properties of a nucleus important?

The industry has evolved around mussel shell. The drills used are primarily the traditional pearl drills. This drill is made of mild steel and has triangular section and chisel pointed end. While fluted and diamond drills are also used, the traditional drill is still widely used for pearl drilling. This drill is very sensitive to the hardness of the nucleus material, too hard and it will wear quickly, overheat and possibly become stuck in the pearl. If the nucleus material is too soft then it will be subject to excessive wear in use. Bironite has been specially developed to work well with the agoya drill. Bironite is a more uniform material with a relative drilling speed of 0.9 units/s where mussel varies from 1.0 down to 0.5 units/s depending on orientation.

Why not use other shell materials?

Many have been tried including giant clam and pearl shell. The former grows quickly and is very hard to drill and it is also subject to splitting. The drilling rate is about 10% of the rate of Bironite and this leads to over heating and possible rupture of the pearl. Pearl shell appears to be a good material and it is still used for buttons. The costs of using it are much greater than with mussel shell or Bironite.

Will nacre grow as well on Bironite?

Yes, our trials show nacre growth at the same rates as mussel shell. Over the last 100 years many materials have been trialed for pearl nucleus. They all grow nacre, even plastics and resins; however, the nacre tends to flake off these materials due to their large thermal expansion coefficients. Bironite on the other hand has a coefficient of expansion within the range of mussel shell and the pearl itself.

Can other natural materials be used for pearl nucleus?

Yes, in principle but no others seem to be satisfactory in practice. It is necessary to have all the properties correct such as density, drilling properties, white colour, ability to polish, and thermal expansion. This and being readily available rules other natural materials out.

Is Bironite a stable material?

Bironite is made from dolomite, a calcium magnesium carbonate formed in ancient seas. It is transformed over time with increasing temperature and pressure to a mineral stable on the geological time scale.

Are Bironite nuclei in any way artificial?

No. The pearl culturing process always involves the insertion of a bead nucleus or a tissue nucleus. Bironite is a bead nucleus of natural origin.

Can you reconstitute shell material into nuclei?

This seems an attractive idea that is not easy to realise commercially. The difficulty is in achieving the original density and polish. Cements even under high pressure yield materials with lower density and poor polish.

Is Bironite synthetic?

No. It is a natural product that has been modified and refined for its drilling ability.

Does Biron have a lapidary to process Bironite?

Yes, we have a fully equipped lapidary in Perth to produce finished nuclei.

Why does Bironite not have as high a polish as mussel shell?

Mussel shell will take a high polish, as it is a very fine-grained material although it can have several types of physical defects. Bironite is composed of crystals about 1 mm across and it will sometimes have very fine pits near these junctions. We are still developing techniques to reduce this, but we believe that this is not important for pearl development provided that these fine pits are not sources of infection. To avoid this problem the nuclei are washed in deionised water then with acetone and dried at 120°C. They are then packed hot and heat-sealed into a vacuum pack bag.

Will Bironite wear as well or better than mussel shell in necklace strings?

The wearing ability will closely follow the hardness of the material. Mussel shell varies with a range from 135 to 223 Vickers hardness that parallels the drilling results. Bironite has a hardness of 190 Vickers. Hence in a string of mussel shell pearls, some will wear at a faster rate than others will. The Bironite string will wear uniformly. In practise both nuclei will be acceptable, as it is the string itself that is the weak link in the pearl strand. Jewellers recommend that pearls be restrung regularly.

For more information, please contact Dr. Michael Snow of Biron Corporation Limited (ACN009 087 469) on 08 83447728 to discuss trials or to learn more about Bironite®.

Pearl Development Group announces first nucleus coating: 'P.D.G. Alpha™'

'Better science, better quality, better price... for better pearls.'

Pearl Development Group, L.L.C.—an U.S.-based pearl science biotechnology consortium—is pleased to announce that our first nucleus coating—P.D.G. Alpha—is fully tested and is now available to nucleus suppliers and farmers. P.D.G. Alpha coating provides both antibiotics and other proprietary materials to improve healing after surgery, promote better pearl sac formation, and enhance pearl quality.

In our controlled experiments, PDG Alpha™ resulted in 29% greater retention over control uncoated nuclei (average retentions increased from 56% to 85%, see table below).

More than just an alternative to other coatings, however, PDG is able to offer three distinct advantages to the pearl farmer: better price, better quality, and better science.

Better quality

PDG is the only company in the world today that is focussed specifically on researching and developing innovative materials and methods for improving the natural pearl formation process in the oyster. We represent a consortium of Pacific pearl farming and investment companies, together with leaders in U.S. biotechnology applications to aquaculture, New England's biomedical expertise, and university affiliates and researchers in materials science, marine biotechnology and bone and shell formation from around the country.

PDG also guarantees the potency of our coatings. Each batch is packed immediately after coating and stamped to certify the technician and the date when it was coated. This ensures coated nuclei do not sit around in warehouses or refrigerators beyond the date of maximum effectiveness.

Better price

PDG Alpha is offered at a significant cost saving over other products on the market. We offer a simplified price structure for coating any grade of nuclei, any size: US$ 50 per 100 momme bag, or part thereof (FOB, Portland, Maine). Ship us the nuclei, we will coat them in our state-of-the-art lab facility, and then will forward them—at your expense—to anywhere in the world. This price also includes all handling charges in Portland, quality-assured packaging, and affixing of labels or brand names of your choice at no added cost. We will provide this flat-fee service for any size of order from 100 momme upwards.

Better science

What would your doctor think if you were taking the same drug day-in, day-out, year-in, year-out, just in case you might get sick? Why should the standards you set for your oysters' health be any different to your own?

Modern medicine is all too well aware of the potential for rapid development of resistant bacteria from overuse or repeated use of the same antibiotic. We believe that it will become increasingly important for pearl farmers to have available

Table 1: Increase in retention of nuclei using PDG Alpha™ over uncoated nuclei

Nuclei	Seeder # 1	Seeder # 2	Seeder # 3	Average
Uncoated	54%	57%	57%	56%
PDG Alpha™	96%	90%	70%	85%
Increased retention	42%	33%	13%	29%

Retentions calculated from catch-bag data collected at 28 days post-seeding, for three different seeding technicians. Results from Pinctada margaritifera seeding trials at PDG experimental farm site, February, 1999.

a wide range of various antibiotics and other coatings, to ensure that each treatment remains effective. Prudent pearl farmers would then rotate their nuclei coatings either from day-to-day or month-to-month.

To support this end, PDG is developing several other coatings—both antibiotics and other materials. PDG Beta and PDG Gamma are currently in the latter stages of testing, and will hopefully be available on the market in the near future.

PDG's ongoing investment in improved nucleus coatings and pearl seeding materials ensures that further developments will be brought to market once they have been fully proven. We plan to offer a range of coatings, materials, scientific support and consultative services to our clients. With PDG in their pockets, the world's most astute and innovative pearl farmers will have a wealth of research expertise working for them, guaranteeing that their pearls continue to attract attention, and exceed all expectations.

For more information, please contact :

Pearl Development Group, L.L.C.
Neil Anthony Sims, M.Sc., Dr Dale Sarver, Ph.D.
P.O. Box 525, Holualoa, HI 96725, USA

Ph : (808) 331 1188 Fax: (808) 325 3425
Email : konalab@aloha.net or : nasims@aloha.net

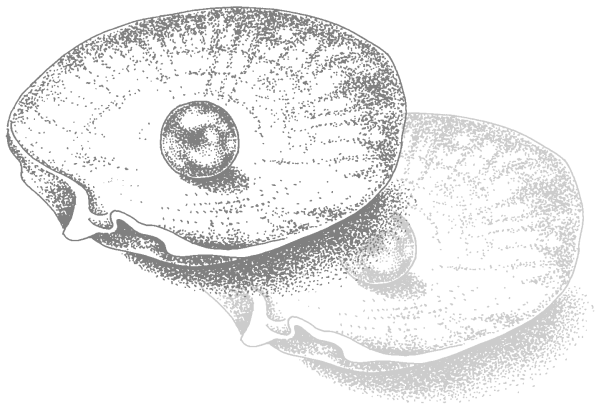
Situation wanted

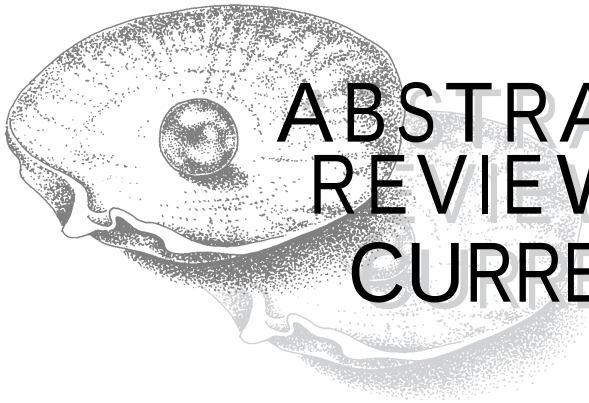
A 36 year old Pathology Laboratory Technician with a burning ambition to secure a position within the Pearl Oyster industry. Having recently completed a Diploma of Aquaculture at the Fremantle Maritime Centre in Perth Western Australia, I am eager to hone my newly acquired skills.

I can offer my prospective employer over 15 years of experience in diagnostic disease testing including microbiology, histopathology, and necropsy techniques.

With the knowledge gained from my aquaculture course and my extensive analytical skills I believe a supportive role in the field or a hatchery technician's position would allow my abilities to be fully exploited.

Mr Peter Hall
Unit 60, 46 East Street
East Fremantle, WA 6158, Australia
Tel: (+61) 08 9431 2455
E-mail: pahall@bigpond.com





ABSTRACTS, REVIEWS AND CURRENT CONTENTS

World Aquaculture '99 abstracts

Nuclei alternatives — the future for pearl cultivation

George Ventouras
Paragon Pearling Pty Ltd, O'Connor, Western Australia

One of the most important items used in the process of cultivating pearls is the nucleus. The nucleus is the base on which the nacre forms and can often dictate the quality of the finished pearl. Historically, the material used in the manufacturing of the nuclei has been the freshwater mussel shell originating from the Mississippi River system. This material has usually always been available in large quantities for the world's pearl producers. In recent times with an increasing number of farms being operated and larger nuclei sizes demanded (above 14–15mm), this source of raw material is being over-utilised to dangerously low levels. When one considers that the larger shells required for larger nuclei can be over 40 years old, the replenishing of stocks is not a short-term option.

Because of this substitutes are needed to fulfil current and future demand. There have been several attempts made to unearth a suitable alternative that conforms in all respects to mussel shell currently being used. Parameters which must be met include ready availability, low relative cost, thick profile, white base colour and composition similar to mussel shell. Alternatives that have been touted as being acceptable include Mother of Pearl shell, clam shell, various minerals and manufactured substances. The problems that have been encountered include extreme hardness, problems with drilling using current techniques, fractured material structures that may cause breakages, unsuitable colouring, low cost efficiencies, unacceptability by pearl growers or wholesalers, etc. While several farms have experimented with some of these substances, none are yet to prove conclusively that they are accurate substitutes for mussel shell.

Characteristic	Bironite	Mussel	Clam	MOP
Density	2.84	2.8	2.72	2.71
Hardness	172–204	135–223	237–283	181–209
Expansion	21.6 x 10	17.2 x 10	15.4 x 10	15.0 x 10
Appearance	Icy	Glassy	Glassy	Glassy
Colour	White	White/Brown	White	Brown
Drillability	Good	Excellent	Good	Good

Tests that have been undertaken to date that have shown some results that include the use of Mother of Pearl shell (problems have arisen with dark colour, relative high cost, thin shell which reduces yield on larger nuclei sizes) and clam shell (higher hardness than mussel shell, problems with cracking and fracturing). In experimenting with the natural materials that compose the mussel shell, a manufactured alternative has been discovered which is currently in the process of being tested at various locations. This material named Bironite, displays the basic characteristics of mussel shell and as it is a processed material, it can be made available in large quantities of both small and large sizes. It also is characterised by a more uniform structure thus reducing chances of breakage in normal use.

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

Joseph J. Taylor[1,2], Paul C. Southgate[1] and Robert A. Rose[2]
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2. Pearl Oyster Propagators Pty. Ltd., 4 Daniels St., Ludmilla, N.T. 0820, Australia

A comparison was made of the growth of one-year old silver-lip (or gold-lip) pearl oysters, *Pinctada maxima*, cleaned every 2, 4 or 8 weeks or after 16 weeks. The diversity of fouling animals was recorded and their dry weight (DW) estimated. Survival was 100% in all treatments, with the exception of a single death in one replicate cleaned every 4 weeks. The DW of fouling animals increased steadily over the first 10 weeks of the experiment before declining during weeks 10 to 16. Significant ($P < 0.05$) differences in the DW of fouling animals between treatments was observed and pearl oyster growth was affected by fouling. The wet weight, shell height and shell length of pearl oysters cleaned every 2 or 4 weeks was significantly greater ($P < 0.05$) than that of pearl oysters cleaned every 8 weeks or after 16 weeks.

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

Cleaning	Wet weight (g)	Hinge length (mm)	Shell height (mm)
2 weeks	72.51 t 1.53[a]	82.4 ± 1.1[a]	83.1 ± 0.8[a]
4 weeks	72.14 ± 1.74[a]	84.3 ± 1.1[a]	84.7 ± 1.0[a]
8 weeks	66.40 ± 2.06[b]	78.3 ± 1.2[b]	79.9 ± 1.3[b]
16 weeks	66.24 ± 1.57[b]	78.1 ± 1.1[b]	80.3 ± 1.1[b]

Mean (± s.e.) wet weight, hinge length and shell height of *P. maxima* from which fouling organisms were removed every 2, 4, and 8 weeks and after 16 weeks. Means in columns with shared superscripts are not significantly different ($P > 0.05$).

Growth and survival of juvenile *Pinctada maxima* stocked at different densities in suspended nursery culture

Joseph J. Taylor[1,2], Robert A. Rose[2], Paul C. Southgate[1] & Claire E. Taylor[2]
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2. Pearl Oyster Propagators, 4 Daniels Street, Ludmilla, Northern Territory 0820, Australia.

Growth and survival of juvenile silver-lip (or gold-lip) pearl oysters, *Pinctada maxima*, re-settled onto PVC slats (75 **x** 500 mm) were examined at four stocking densities: 10 juveniles slat^{-1} (1.3 juveniles.100 cm^{-2}); 50 juveniles slat^{-1} (6.7 juveniles.100 cm^{-2}); 100 juveniles slat^{-1} (13.3 juveniles.100 cm^{-2}**)** and 150 juveniles slat^{-1} (20 juveniles.100 cm^{-2}**).** After six weeks in suspended culture, best survival was recorded at a stocking density

of 10 juveniles slat^{-1} (80 ± 4.36%: mean ± s.e.) which was significantly higher than at the other densities tested (P <0.05). Survival did not differ significantly between the other densities tested (P >0.05). Best growth measured as wet weight, shell length and shell height was shown at a density of 10 juveniles slat^{-1}, where wet weight and shell length was significantly greater than at any other stocking density (P <0.05) and shell height was also significantly greater, with the exception of those stocked at 50 juveniles slat^{-1}. Spat were significantly (P <0.05) smaller with each increase in stocking density from 50 juveniles slat^{-1} to 150 slat^{-1}. The incidence of growth deformities increased with increasing stocking density. These increases were significant (P <0.05) between all densities apart from the 100 juveniles slat^{-1} and 150 slat^{-1}, where the difference in the number of deformed animals was not significant (P >0.05). The ratio of shell height to shell length was also influenced by stocking density. Differences between the shell height: shell length ratio were significant between all stocking densities (P <0.05) except 100 juveniles slat^{-1} and 150 juveniles slat^{-1}, where there was no significant difference (P >0.05). Advantages for both low and high density culture are evident. Reduced stocking densities would optimise growth and survival where spat numbers are low. Alternatively, heavier densities may be appropriate when there are large numbers of spat. In this case, an operation may be able to select the best animals from a given collector for on-growing and return the 'graded' collector to the nursery for future use if required. In this way, collectors remain a useful and valuable source of future seed.

Pearl oyster resource development in the Pacific Islands

Paul C. Southgate
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The blacklip pearl oyster *Pinctada margaritijrera* has a wide distribution from the south Pacific to the Red Sea. This species supports cultured black pearl industries in French Polynesia and the Cook Islands which generate incomes of approximately US$ 130 and US$ 5 million, respectively. These incomes are very significant amounts in terms of the budgets of these small Pacific nations and understandably, the success of these industries has aroused considerable interest from other countries in the Pacific.

James Cook University is collaborating with The Ministry of Natural Resource Development (Fisheries Division) and Abaiang Island Council, Kiribati, the Ministry of Agriculture, Fisheries and Forest (Fisheries Division), Fiji, the ICLARM Coastal Aquaculture Centre, Solomon Islands, and the Ministry of Marine Resources, Cook Islands in a project funded by the Australian Centre for International Agricultural research (ACIAR). The project has the following major objectives:

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

This Project is particularly focused on the Republic of Kiribati where a pilot hatchery facility was developed at Tanaea on Tarawa atoll (2°N). Five cohorts of hatchery produced spat have now been produced and transferred to the neighbouring atoll of Abaiang for nursery culture studies. Early results suggest promising growth rates of oyster juveniles held on sub-surface longlines; however, mortality of juveniles as a result of predation from ranellid gastropods *(Cymatium* spp.) has been evident.

Growth data for *P. margaritifera* juveniles held in nursery culture at Abaiang atoll, Kiribati, and preliminary results from spat collection studies in Fiji will be presented.

Pearl oyster propagators—leaders in pearl oyster aquaculture technology; bridging the gap between old and new with research and development

Robert A. Rose and staff
8 Kelat Court, Bayview, NT, 0820, Australia.

Pearl Oyster Propagators presents a poster displaying the aspects of farming artificially propagated *Pinctada maxima* for pearl cultivation. Also a pamphlet detailing aspects of the evolution of south sea pearl production, from past to present and future pearl cultivating systems. During the early to mid 1980's, hatchery produced oysters began to replace wild stock used for pearl production. One of the first Australian pearl oyster hatchery specialist companies, Pearl Oyster Propagators, began designing, constructing, training and managing hatcheries in Western Australia, Northern Territory, Indonesia and Thailand.

Hatchery-produced oysters may very well increase the annual supply of cultivated South Sea pearls in the future, but may not adversely affect market conditions. Success may be patterned after that of the edible oyster, prawn and salmon industries. That is: although the price may decrease, the market could very well expand, as more consumers could afford to purchase the product. Hatchery technology in Australia is still in its infancy. Pearl Oyster Propagators is dedicated to the research and development of a 'Emerino' pearl oyster and has been involved in research projects with Commonwealth Research Centre for Aquaculture (CRC) and Commonwealth Fisheries Research Development Corporation. During the course of this research, Pearl Oyster Propagators trained and supervised two PhD and three MSc students.

Development issues in the Queensland pearl farming industry

Chris H. Robertson[1] & John Saltmarsh[2]
1. Queensland Department of Primary Industries, Northern Fisheries Centre, Cairns, Queensland, Australia
2. President, Queensland Pearl Industry Association, owner Roko Pearls Pty Ltd, Roko Island, Torres Straits, Queensland

The Queensland Pearl farming industry has a long history in early pearling for mother of pearl shell, and has played an important role in the initial development of farming technology for production of round pearls from wild shell. During the 1940's and 1950's a fleet of up to 400 Tuggers at times supplied more than 10,000 tons of shell per year to the world button trade. During the 1890's William Saville-Kent was the first to investigate the pearl nucleation technique during trials at his pearling operation at Albany Island, northern Queensland.

The current pearl farming industry is based on approximately 100,000 *Pinctada maxima* and minor numbers of *P. margaritifera* shell held on farms in Torres Straits and the north eastern coast of Queensland. The value of pearl sales in 1996/97 was estimated to be approximately Au$ 1 million p.a. In the 1970's the pearling industry in Queensland collapsed due to a shortage of wild shell stocks. Suggested causes for this collapse include: the effects of overfishing for shell, the influx of prawn trawling in to pearling grounds, and reports of pollution from a oil tanker wrecked in the vicinity of Torres Strait pearling grounds. Although the Queensland pearling industry has traditionally used wild shell, the use of hatchery spat is increasing steadily with new entrants to the industry wanting to adopt technology that has proven so successful in Western Australia and the Northern Territory. The Queensland Pearl Industry Association has recently developed a draft strategic plan for the future development of the industry. Issues relevant to increasing the sustainability of the industry and expanding production include: the seeking of protected areas for pearl oyster restocking, a code of practice for pearl farming, and the investigation of cross breeding and genetics technology to enhance the quality of pearls produced.

Cliona—an enemy of the pearl oyster, *Pinctada maxima* in the west Australian pearling industry

Patrick B. Moase, Alan Wilmont & Scott A. Parkinson
Maxima Pearling Co. Pty Ltd, Broome, W.A., 6725, Australia

With the next millennium fast approaching, and an ever-increasing change in aquaculture technology, there are many issues that affect the successful operation of pearl oyster farms, and pearl production in the Southern Hemisphere. One such issue, facing the future of most, if not all farms, is a substantial

increase in the presence of *Cliona* (phylum Porifera), a boring sponge which penetrates the outer prismatic and inner nacreous layers of the pearl oyster *Pinctada maxima*, resulting in high mortalities over a relatively short period of time.

The term 'parasite' is used frequently to illustrate the lifestyle of *Cliona*, however, its structure and physiology is consistent with all other free-living sponges.

Visual evidence indicates that *Cliona* displays a preference to infestation of larger pearl oysters, many of which have entered the operation phase of their lifecycle on the farm. However, due to the rapid growing phase of juvenile oyster shells, the sponge may still be present, but not appear to have penetrated its host. Once mature, the shells growth decreases, with the sponge continuing development at a faster rate.

The result of infestation is discernible both internally and externally. Externally the shell becomes excavated with holes forming a 'honeycomb' pattern, often bright red or orange in colour. Internally, the shell deposits thickened nacre around visible darkened lesions beneath nacreous layers where penetration into the muscular cavity appears inevitable. As *P. maxima* concentrates its energy on fighting the sponge, it neglects to deposit nacre on the previously inserted nuclei. From this stage forward the pearls display physical imperfections and discoloration, resulting in a substantial decrease in quality. Often *P. maxima*'s own method of defence becomes futile, as infestation of the shell reaches a capacity far greater than it can handle. At the stage, the shell becomes weak, brittle, its mantle retracts, and the animals dies.

Considering that colour, shape, and weight determine the value of a pearl, *Cliona* infestation on a large scale within a farms lease (and even from wild caught shell) can cost a pearling company millions of dollars each year.

Maxima Pearling Co. is an Organisation, which places enormous emphasis on providing the best environmental conditions in order to produce potentially the world's finest South Sea Pearls. Ongoing experiments relating to *Cliona* infestation have shown that 'suffocation' of the sponge appears to halt its growth and cause its eventual death. Various techniques have been trialed with some astonishing results.

Creating pearl oyster beds in La Paz Bay, Baja California Sur, Mexico.

Carlos Rangel-Davalos, Erika Martinez-Fernandez, Hector Acosta-Salmon, Omar Hirales-Cosio, Salvador Valdéz-Murillo & Luis Herndndez-Moreno
Universidad Autonoma de Baja California Sur, Laboratorio Experimental de Maricultura, P.O. Box 819, La Paz 23000 B.C.S., Mexico

Exploitation of pearl oysters in the Gulf of California dates from antiques times, being the XVI century when formerly commercial fisheries were established, at the arrival of Spanish conquerors. By the beginning XX century populations showed severe detriment, and in 1940 fisheries of both species of pearl oysters *(Pteria sterna* and *Pinctada mazatlanica)* were prohibited. There have been some attempts to recovery natural beds, with unsuccessful or limited results.

The Baja California Sur State University started a Pearl Oyster Research and Development Program in 1993, to promote establishment of commercial enterprises. Lines of this program are: Reproduction (hatchery seed production), Pearl Production (implantation of half and round nucleus) and actually Creation of Pearl Oysters Beds.

By November 1997, the Mexican National Council for Knowledge and Use of Biodiversity (CONABIO) support a project, in the aim to create three Pearl Oyster beds of 'concha nacar' *(P. sterna).* Organisms were produced in laboratory, and were seeded in the vicinity of 'La Gaviota' and 'San Juan Nepomuceno' islands in La Paz Bay. Project consisted in SCUBA seeding a total of 30,000 concha nacar. In every bank, 10,000 organisms of different sizes were seeded in 4 seed times, and covered with plastic mesh structures, to protect juveniles against predators.

For the first seed time structures were made with black plastic mesh (16 x 8, 12 x l2 or 22 x l9 mm) knitted to elaborate a protection device, 20 cm in height, 10 meters long and 7.5 meters wide. Pearl oysters were bottom seeded, where they attached to rocks, corals and themselves. The structure was intended to protect this sowing against the main predators associated, i.e. fishes (Balistidae, Diodontidae, Tetraodontidae,

Scaridae), and molluscs (Octopodidae). However structures demonstrated to be non-effective; total mortality occurred as well as in non-protected seeded controls. Structure were improved by adding bottom flaps, covering them with rocks and attaching buoys the roof of the structure to maintain a regular rectangular shape.

It is expected to reach an average of 15,000 adult concha nacar attached to substrate in the 3 beds, at then end of the experiment (one year after the first sowing), when the plastic mesh cover will be retired off the water.

Oyster (*Pinctada maxima*) genetic variation in Western Australia

John A.H. Benzie, Carolyn Smith & Kate Wilson
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Australia is the source of the finest white south sea pearls derived from the pearl oyster, *Pinctada* maxima. The bulk of the industry is situated in Western Australia, although the species is distributed over much of northern Australia where there is suitable habitat. Allozyme studies have demonstrated that stocks of *P. maxima* in eastern Australia (Northern Great Barrier Reef-Torres Strait), the Gulf of Carpentaria, Northern Territory, Joseph Bonaparte Gulf and Western Australia were significantly differentiated genetically, and clearly belonged to different stocks. In contrast, the several sites sampled in Western Australia, covering more than 800 km, showed no genetic differentiation, suggesting they all belong to one stock. However, some evidence for different recruitment dynamics in some of these sites has raised the question of whether dispersal is as free among all these sites as suggested by the allozyme data.

The present paper reports the development of microsatellite loci for *P. maxima,* and preliminary data on the genetic structure of.the Western Australian populations. Microsatellites proved to be rare and the isolation of approximately 130 putative positive clones required screening of 55,000 clones derived from several libraries. Of the 130 putative positives, primers that gave consistent and reliable results were designed for about 15 loci. Collections of some 1200 oysters, including random samples of the adult population, and samples of up to 100, year O+ and year 1+ individuals are being assayed to determine the extent of gene flow among populations. Preliminary results indicate considerable genetic diversity within all the Western Australian populations, with some indications of minor shifts in microsatellite variants. The extent to which these reflect real differences in dispersal among populations as opposed to genetic drift must await the results of analysing larger numbers of animals, but at this early stage appear to suggest that gene flow among some sites is more restricted than others.

First massive hatchery production of the pearl oyster *Pteria sterna* (Concha nacar) in Mexico.

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The Mexican Pearl Oysters *Pteria sterna* ('concha nacar') and *Pinctada mazatlanica* ('madre perla') have been considered as gem quality pearl producers. As natural resource is scarce due to overfishing up to 1940, to start a commercial venture it is necessary to produce enough juvenile supply in laboratory.

In the Laboratorio Experimental de Maricultura, Baja California Sur State University, a project is carried out to establish procedures to obtain Pearl Oyster spat since 1993.

A small parental stock, obtained from nature by placing artificial collectors, was used to produce 1,700 *Pteria sterna* spat in laboratory (F1) in 1994. Three years later 60 of them were used as parental stock. Organisms were induced to spawn with thermic stimulation (19–30°C). Fertilisation was carried out immediately after sex was determined. Embryos were placed in 1800 or 400 litres fibreglass tanks filled with UV irradiated, 1µm filtered seawater and aeration. 48 hours later density was adjusted to 10 larvae / ml; by Day 5 larval density was 5 / ml; by Day 11 it was lowered to 2 larvae / ml and finally by Day 15 and up was maintained at 1 larvae / ml.

Every 2 days, contents of tanks were drained through a bottom valve. A sieve retained larger larvae and let pass small larvae and debris. Normal larvae were placed in a recent filled tank. Food consisted in a mixture of 4 microalgae species (*Isochrysis galbana (aff. Tahiti), Chaetoceros gracilis, Monochrysis (Pavlova) lutheri* and *Nannochloris* sp.). Microalgae were added in enough quantity to reach a final density of 30,000 cells / ml for the first 10 days, from Day 11 to Day 14 density was augmented to 50,000; from Day 15 to Day 25 it was 80,000 cells / ml and from Day 26 and up density was 100,000 cells / ml. By Day 40, larvae were placed in 500 litres tanks, aeration and continue flow were provided. Flow in the tanks was enriched with the same microalgae mixture. Plastic material (vexar, fishing nets, polypropylene rope, plastic garden mesh) and empty shells were supplied in abundance as substrate for settlement of larvae.

In May 1997 a total of 70,000 *Pteria sterna* spat (F2) were successfully obtained; by this date they measured 6.7 mm height average. One year later the cultured organisms measured 44.5 mm height average. For this area, hatchery produced juveniles are the only source to obtain enough organisms to begin a commercial venture, as large number of seed is needed for a given time. Cost of experimental production was US$ 0.10 / piece and can be lowered as production increase.

Studies to improve the percentage of gem quality pearls

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The surgical technique for producing cultured round pearls in *Pinctada* species was developed by Japanese biologists early this century and is used by most pearl technicians. However, this method of cultured pearl production is inefficient. Only a small percentage of the operated produce gem-quality pearls. There may be some intrinsic problems with the technology and we are testing the applicability of modern surgical methods for improving the efficiency of round pearl production. These methods include using a relaxant and antiseptics for surgery, and suturing the incision.

Thirteen potential relaxants were evaluated on *P. albina* and propylene phenoxetol at 2 to 3 ml/L was found to be effective. However, when propylene phenoxetol was used as part of bead insertion operations on 768 *P. margaritifera* on a commercial farm in the Cook Islands, the higher mortality rates outweighed the lower bead rejection rates (see Table).

Percentage mortalities, bead rejections and total failures (deaths and bead rejections) in Pinctada margaritifera six weeks after the bead insertion operation. ns = not significant; **P <0.01 (arcsin transformations used in statistical analyses of % data of each treatment versus no treatment).

Treatment	% deaths	% bead rejections	% total failures
Relaxant	18	8	30
	**	ns	**
No relaxant	1	14	18
Antiseptic	7	9	21
	ns	ns	ns
No Antiseptic	7	13	26
Adhesive	11	12	28
	**	ns	**
No adhesive	4	10	20

Betadine (povidone iodine) solution was found to be an effective antiseptic and non-irritant to pearl oyster tissues. Its use on the operation site lowered the percentages of bead rejections and total failures compared to untreated oysters, but these were not significant effects. A further experiment is in progress to evaluate the use of Betadine solution on the instruments, graft mantle, cutting board, etc. These surfaces may be

more crucial for introducing bacteria into the wound. A flexible cyanoacrylate adhesive was used for incision suturing. It reduced the percentage of pearls that initially had 'tails' or defects. Because of some adverse tissue reaction to this adhesive, work is in progress to use fine nylon sutures to close the incision.

The improved production of gem quality pearls may require that each step in the bead operation is insertion operation is based on sound surgical principles, while being compatible with rapidly processing oysters in field environments.

World pearling—managing success

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Pearling has spread well beyond its traditional home in Japan and now forms substantial industries in Australia, Tahiti, Indonesia, China and the Philippines. There are increasing attempts to spread pearl production to new areas and a number of countries wish to enter the industry and commence substantial production.

The pearling industry covers a wide range of species, farming methods and pearl products. The different types of pearl and their place in the market will be distinguished, from inexpensive freshwater pearls to highly desirable South Sea Pearls. In addition the general characteristics of the production systems of the principal pearl producing nations will be outlined along with the differing technologies used, from wild collection to hatchery production.

Broad trends in pearl production will also be presented. For a variety of reasons pearl production from the traditional source, Japan, has fallen rapidly. Outside Japan many producers are planning to significantly increase their production of pearls. Increasing production brings concerns common to other aquaculture industries; such as access to suitable grow-out areas, conflicts with other uses of marine environment and disease. In addition pearl industries face difficult marketing issues with pearls constituting part of the luxury jewellery market rather than the food market. Co-operative and legislative measures have attempted, with varying degrees of success, to resolve these issues.

In summary the world's pearl industries are diverse, but as a long established aquaculture species pearlers have a lot to learn from each other's approaches as the industry grows.

Relationship between the clearance rate of the black-lip pearl oyster *Pinctada margaritifera* (L) and its weight and size

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The clearance rate (CR, l.h-1) of black-lip pearl oyster *Pinctada margaritifera* was estimated by following the rate of removal of algae *(Isochrysis* aff. *galbana)* in a known volume. A flow-through system was used under laboratory conditions close to the lagoonal environment: water temperature ranged between 27.8°C and 28.8°C, salinity averaged 36 ‰ and total particulate matter never exceeded 1 mg dry weight.l-1. Algal concentration was monitored in the inflows (C1) and outflows (C2) of 4 experimental chambers by continuous measurements of fluorimetry. Data were recorded every 5 seconds and analysed to provide mean values for each individual. The clearance rate CR (l.h-1) was calculated by means of the equation: $CR = Fx (1-C2 / C1)$, where F is the water flow in the chamber (l.h-1).

Assessments of clearance rate were performed on 41 individuals ranging from 4 to 15 cm (shell height) and from 0.19 to 7.40 g (dry weight of flesh). The clearance rate (CR, g) was expressed as a function of dry weight of flesh (W, g) and shell height (H, cm) according to the allometric equation: $Y= aXb$ where Y is the clearance rate and X the shell height or the dry tissue weight. Statistical estimation of the parameters by mean of exponential regression led to the following equations:

$$(1)\ CR = 21.52\ W^{0.63}\ (r = 0.95;\ n = 41)$$

$$(2)\ CR = 0.87\ H^{1.66}\ (r = 0.94;\ n = 41)$$

A 1 g dry-flesh pearl oyster cleared 21.52 $l.h^{-1}$. This value of clearance rate is one of the highest known among the bivalves. Such high values may have implications on the nutritional behaviour of the species which are discussed in terms of oligotrophy among lagoonal environments.

Pathogens, parasites and diseases of pearl oysters *Pinctada maxima* Northern Australian waters

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A health survey, based primarily on gross and histopathological examinations of pearl oysters *Pinctada maxima*, was undertaken between 1994 and 1997 from Queensland, Northern and Western Australia. The study included 4767 mature animals with no history of disease from wild harvest and pearl culture farms, together with batches of spat for interstate movement and cases of diseased mature and juvenile oysters.

The study was undertaken to improve knowledge on diseases confronting the pearl oyster industry, to facilitate regional and national quarantine, to enhance diagnostic capabilities and to identify pathogenic agents for further investigation. The study established the occurrence, prevalence and distribution of a taxonomically diverse range of microbial, protozoan and metazoan agents associated with pearl oysters and evaluated the pathogenic significance of these agents. Over 57% of the mature oysters were normal and free from infectious agents, whilst many carried agents not considered significant pathogens.

Pathogenic or potentially pathogenic agents identified in apparently normal *P. maxima* included a papova-like virus of the palp, viral-like inclusion bodies in the digestive gland epithelium, rickettsiales-like agents in the digestive gland and gill, enigmatic protozoan-like bodies in the digestive gland, metazoa including copepods in the digestive gland, a copepod *Anthessius pinctadae* in the oesophagus and a *Haplosporidian* sp. in the digestive gland. Bivalve molluscs, sponges and polychaetes commonly invaded the shell matrix. *Vibrio* sp., the enigmatic protozoan-like agent and sub-optimal environmental conditions were associated with mortalities in mature and juvenile oysters. Differences in regional occurrence were evident with some agents, providing a basis for implementation of quarantine.

Normal histological criteria for *P. maxima* were established and host responses to injury described, providing a basis on which the normal structure of the pearl oyster may be differentiated from the structure altered by disease.

The study indicates that Australian *P. maxima* are relatively free of serious pathogens. At the same time, a need exists to clarify the taxonomic status and establish the pathogenic significance of a number of the agents recorded. The study provides baseline data on the occurrence and prevalence of potential pathogens and provides a basis for the diagnosis of infectious and non-infectious diseases of *P. maxima.*

An educational module for training grafting technicians for the black pearl culture industry

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Current methods of performing the grafting procedure, which initiates cultured pearl development, are a key constraint in the pearl industry. Development of a training program for grafting technicians will promote increased industry efficiency in established pearl farming areas, new industry development in the Western Pacific Region and Hawaii, and provide high-paying jobs for youth and women. Formal training will improve grafting capability, increase farm revenues and encourage transparency and competition in this secretive field.

The technicians of choice in the black pearl industry are Japanese-trained technicians capable of consistently producing large, high quality pearls. Success rates of trained technicians range from 60% to 80% nucleus retention at 30–40 days post-implantation, with a final production of 5% to 10% grade A round pearls. Hiring Japanese-trained technicians is expensive, involving payment of expenses and a share of up to 25% of the harvested pearls. Demand for the services of these technicians currently exceeds availability.

Producers are increasingly turning to the small pool of technicians trained outside of Japan, who generally demonstrate less consistent results. Hiring these technicians is riskier for the producer and has a direct effect on farm revenues. Consequently, new technicians often have difficulties establishing themselves in the field.

Entry of qualified grafting technicians into the industry to meet the growing demand is slow. Most technicians learn through limited opportunities to observe technicians, then painstakingly perfect their skills without guidance. This keeps the skill level of most technicians at sub-optimal levels. For the industry to grow, and to improve pearl quality, a larger pool of more qualified technicians must be available to producers. Technicians need opportunities to refine their methods to provide better services and be competitive in the field.

The first phase of the grafting training program is thorough documentation of current grafting practices through production of an education module consisting of a video and manual. These provide an initial overview of the procedure for aspiring technicians. Producers will also benefit from familiarisation with methods so that they may monitor technician performance.

The video and manual present basic concepts in grafting for production of high quality pearls. Best practices in grafting are described and demonstrated in detail, including the following critical steps: 1) selection of host and donor; 2) preparation of mantle tissue graft; 3) surgical procedures for insertion of nucleus and tissue graft; 4) post-grafting inspection and care; and 5) methods for improving grafting success. Techniques for avoiding common errors in grafting are also described.

Recent developments in the farming and marketing of Mexican pearls

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Mexico has a long history of pearl oyster fisheries, dating back to the year 800. The goal of the Indian tribes in the Baja California and Sonora areas was to produce food, with shells pearls as occasional highly desirable by-products.

With the arrival of the Spanish in the 16th Century, the fishery greatly heightened as the Spaniards heard tales of Indians adorned with pearls. By the end of the 16th Century, English and Dutch merchants had established a trading relationship with the Indians resulted in the colonisation of the arid and inhospitable peninsula, Baja California Sur.

First attempts at pearl culture were carried out by the Frenchman Gaston Vives on the Island of Espiritu Santo at the beginning of the 20th Century. This bold, and apparently successful effort to produce pearls in the open ocean, ended in 1914 during the Mexican Revolution, when a mob destroyed the company's operation and Vives barely escaped with his wife.

The two species of oysters that constitute the Mexican pearl industry are the Panamic Mother-of-pearl oyster, or 'Madre perla' *(Pinctada mazatlanica)* and the Western Winged Pearl Oyster, or 'Concha-Nacar' *(Pteria sterna).*

Given the rich oyster beds lying off the coasts of southern Mexico, and the advances being made in pearl oyster culture in other parts of the world, it was natural that Mexico would turn its attention to the development of pearl farming. This effort was initiated in the early 1990's by three groups of scientists: two at La Paz and one at Guaymas. The three, not always working together, nevertheless started on the same journey: to achieve the commercial feasibility of producing pearls from *P. mazatlanica* and *P. sterna.* University research institutions were to play an important role through their support of the projects.

One of the operations is now successfully marketing product and looking to expand. This paper will examine the development strategies that were adopted, the role the institutions played in the research efforts, and current attempts at entering the domestic and world marketplaces. It is hoped that other nations wishing to develop pearl farming will be able to learn much from Mexico's experience.

The effect of micro-algae density on growth and survival of black-lip pearl oyster, (*Pinctada margaritifera* L.) larvae

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This paper reports an experiment to determine growth and survival of *Pinctada margaritifera* (L.) larvae fed a 1:1 mixture of *Isochrysis* aff. *galbana* clone T. Iso and *Pavlova salina* at six different densities (1, 2, 5, 10, 20 and 30 x 103 cells ml^{-1}). Larval growth and survival were assessed every 4 days over a 20-day period. Exponential and logistic regression models were fitted to the growth and survival responses, respectively. Overall growth of larvae fed > 5 x 10^3 cells ml-1 was significantly greater ($p < 0.01$) than those reared at other algal densities. Growth of larvae fed 30,000 cells ml^{-1} was similar to that of larvae fed 5 x 10^3 cells ml^{-1} up to Day 16. However, beyond Day 16, there was a rapid increase in the growth of larvae fed 30 x 10^3 cells ml^{-1} relative to other food concentrations. The optimal food ration for maximum larval growth was 20 x 10^3 which resulted in larvae with antero-posterior shell length of 230 µm after 20 days. Larvae fed 20 x 10^3 cells ml^{-1} were significantly larger ($p < 0.05$) than those in all other treatments at the end of the experiment. Survival of larvae fed 0,1 and 2 x 10^3 cells ml^{-1} was significantly lower than that of larvae in all other treatments at the end of 15 days ($p < 0.01$). Maximal survival over the 20 day period was shown by larvae fed 10 x 10^3 cells ml^{-1} (8%) while lower survival was shown by larvae fed 2 x 10^3 cells ml^{-1} (2%) and 1 x 10^3 cells ml^{-1} (0%).

Larval culture, spat collection and juvenile growth of the winged pearl oyster *Pteria penguin*

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Increasing interest in the culture of winged pearl oysters, *Pteria* sp., has focused on the eastern Pacific species, *Pteria sterna*, however, the western Pacific species, particularly *P. penguin* remain relatively unstudied. This paper reports on larval culture, spat collection and juvenile growth of *P. penguin* in north Queensland.

Broodstock were collected in Pioneer Bay, Orpheus Island, Queensland, and placed in an onshore race-way, Spawning was spontaneous and 1.62 million eggs were collected from three females. Eggs were incubated at 3.25 ml^{-1} with 10 $mg.l^{-1}$ streptomycin sulphate for 24 hours with a 36% 'hatch' rate. D-stage larvae were initially stocked at 1.18 ml^{-1} and cultured in a 500 l tank with water changes every three days. Water temperature ranged from 26.9° to 29.5°C. Larval development was similar to that described for *P. sterna* (Araya-Numez *et al.* 1995) although *P. penguin* were significantly larger at each development stage. Eyed larvae were first seen on Day 20 and on Day 23 and 25, larvae caught on a 150 mm sieve were placed in a settlement tank. Larval survival to Day 25 was 16.3%. Spat collectors consisted of teased poly-ethylene ropes enclosed in mesh bags. Spat were transferred to suspended nursery culture at 6 m on Day 30. On Day 70 (45 days post settlement), when mean (±SE) dorso-ventral shell height (DVH) was 11.95 ± 0.34 mm, the protective bags were removed and mortality due to fish predation was severe. Remaining juveniles were grown in situ on the spat collector ropes for 15 months when mean DVH was 100.02 + 1.71 mm. Growth of *P. penguin* larvae and spat is presented in the table below.

Age (Days)	Stage	Mean (±SE) DVH (µm)
0	Egg	52.10 ± 0.52
1	D stage	80.76 ± 0.74
5	Prodissoconch II	107.71 ± 2.55
10	Umbo(rounding)	140.06 ± 4.09
15	Umbo(hooked)	171.09 ± 6.75
20	Eyed	251.94 ± 6.92
30	Spat	708.10 ± 12.55

During a 15 month spat collection study, *P. penguin* proved easy to catch, hardy and displayed rapid growth. Spat collectors made of 50% shade cloth within a mesh bag were deployed at 2 m and 6 m on the suspended longline. Spat settled between March and May as water temperature decreased from 29.3°C to 26.8°C. Settlement density was significantly greater ($p > 0.05$) at 6 m and there were significantly more spat on the outer bag than on the internal shade cloth. After 4 weeks at a mean (±SE) DVH of 4.85 ± 0.12 mm, spat were removed from collectors and placed in 3 mm mesh inserts within 8 pocket panel nets. Spat growth was not as rapid (3.44 ± 0.09 mm per month) as shown by hatchery bred spat suspended on rope, suggesting this method of nursery culture, whilst protecting the spat from fish predation, was unsuitable.

Growth of blacklip pearl oyster (*Pinctada margaritifera* L.) juveniles using different nursery culture techniques

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The cultured black pearl industry of the South Pacific has traditionally relied on collection of pearl oyster (*Pinctada margaritifera*) adults and spat from the wild and hatchery techniques have only recently been developed. As a result, there is little published data on the growth rates of hatchery reared *P. margaritifera* juveniles. This study assessed growth and survival of *P. margaritifera* under different nursery culture conditions.

Eight month old hatchery reared *P. margaritifera* juveniles with mean (± SE, n = 40) dorso-ventral height (DVH) and wet weight (WW) of 41.5 ± 0.3 g, respectively, were held for five months in suspended culture using five culture techniques: (1) 24-pocket juvenile panel nets with 25 mm mesh (PN24); (2) enclosed in plastic mesh (5 mm) inserts within 8-pocket adult pocket nets (PN8); (3) in 5 mm plastic mesh inserts without being placed into pocket nets (INSERT); (4) in plastic mesh (10 mm) trays (55 x 30 x 10 cm) with lids (TRAY); and by 'ear' hanging (EAR).

Survival was high and ranged from 100% (PN24 and PN8) to 90.6% (INSERT). Juveniles held in 24 pocket nets (PN24) and ear hung juveniles showed greatest growth during the experiment and had significantly greater DVH and WW than oysters in all other treatments ($P < 0.05$). Pearl Oysters held in inserts (INSERT and PN8) showed the lowest mean DVH and WW probably as a result of heavy fouling and predation were considered with growth and survival, the five nursery methods were ranked in descending order as follows: PN24 > EAR >TRAY> PN8 > INSERT.

The important factors—that effect the quality of nacre

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A cultured nucleated pearl forms when grafted mantle tissue at the gonad reason of the Oyster/Mussel envelops the nucleus and secrets the pearly components all around the nucleus, but chances to finding a perfect round lustrous pearl without no impurity is one in a twenty or more. After the studies it is found that there are several other factors besides perfect nucleus and good surgery that effect the quality of pearl sac. The experiments to determine the same will be discussed in the paper.

Energy budget of the black-lip pearl oyster, *Pinctada margaritifera*, in the Lagoon of Takapoto

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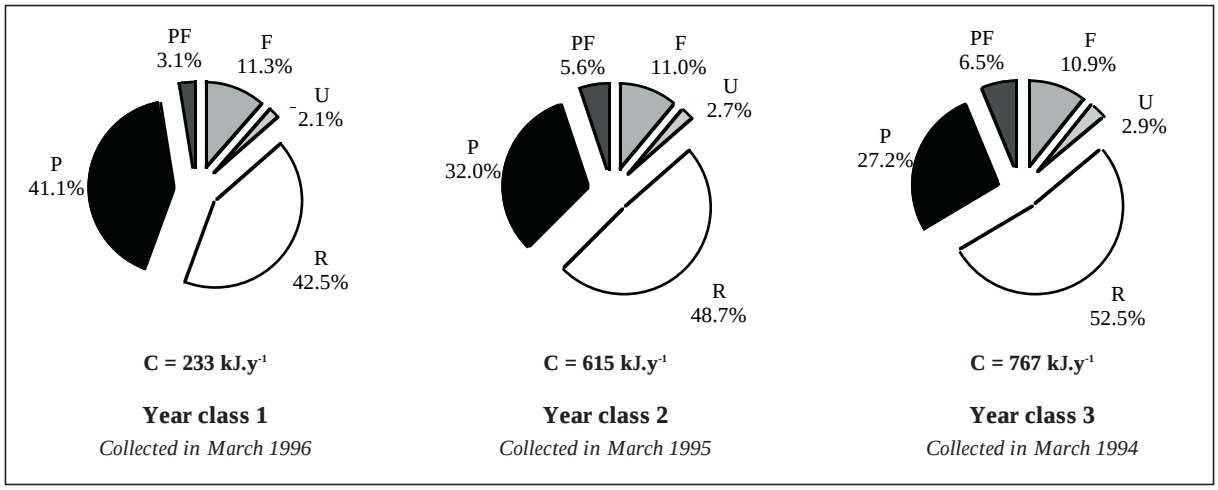
Physiological functions of the pearl oyster, *Pinctada margaritifera*, were estimated between 1996 and 1998, either during field experiments or under laboratory conditions, close to those encountered in Takapoto lagoon. Retention efficiency (RE, %) varied from 10–15% for 1 µm particles to nearly 100% for 5 µm particles. Therefore particulate matter (> 1µm) could not be directly retained by pearl oysters. Clearance rate

(CR, $l.h^{-1}$) was assessed by several methods, and yielded a value of 60 $l.h^{-1}$ for a two years old oyster, the highest encountered. Pseudofaeces production (PF, $mg.h^{-1}$) was noticeable while the total particulate matter (> 1.2 µm, TPM, $mg.l^{-1}$) was poor. The faeces (F, $mg.h^{-1}$) had a low organic content due to a high absorption efficiency (AE, %), averaging 90% of the organic ingested ration. The three functions, CR, PF and F, were related to the flesh dry weight (W, g), to particulate organic (POM, $mg.l^{-1}$) and inorganic matter (PIM, $mg.l^{-1}$):

$$CR= 26.96\ PIM^{-0.42}\ POM^{0.96}\ W^{0.61};\ PF =32.6\ (POM-0.28)\ (PIM-0.17)\ W^{0.77};\ F= 20(1-e^{-0.66\ TPM})\ W^{0.49}.$$

Oxygen consumption (R, mg $O2.h^{-1}$) was measured in situ during two surveys in fresh and warm season. Nitrogen excretion (U, µmol $NH3.h^{-1}$) was mainly composed of ammonia (laboratory experiment). They were related to the flesh dry weight, according to the equations:

$$R= 0.84\ W^{0.72} \text{ and } U=1.64\ W^{0.78}.$$



Energy budget of pearl oysters for 3 age classes from March 97 to March 98 in the Takapoto lagoon

From these relationships, an energy budget was computed from the TPM concentrations, weekly sampled during one year, for 3-year classes. Food consumption (C, kJ y^{-1}) of year classes 1, 2 and 3 reached respectively 233, 615 and 767 $kJ.y^{-1}.ind^{-1}$. Pseudofaeces production (PF) varied from 3 to 6.5% of the total consumption C, while faeces production (F) represented ~ 11% and excretion (U) ~ 2,5%. Oxygen consumption (R) increased with increasing ages from 43% to 53% and total production (P) decreased from 41.5% (year class 1) to 28.2% (year class 3). Field measurements were performed between March 1997 and March 1998 to assess the actual production of the three years classes (somatic growth, Pg + reproduction effort, Pr + shell growth Ps). A good correlation observed between the computed production P and the field measurements suggests that the water energy content (POM > 1.2 µm) was sufficient to explain the growth rate of oysters in an oligotrophic lagoon.

Other abstracts

Growout of blacklip pearl oysters, P*inctada margaritifera* collected as wild spat in the Solomon Islands

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This study assessed growth and survival of juvenile blacklip pearl oysters (*Pinctada margaritifera*) in a number of intermediate culture systems: lantern nets, panel nets, perforated plastic trays, and attached to ropes enclosed by mesh. Juveniles with initial dorsoventral measurements of 8.3 to 51.5 mm increased in size by 20.4 to 24.5 mm in 3 months, and 30.7 to 36.5 mm in 5 months. Growth rates of juvenile *P. margari-*

tifera cultured in the open reef systems of the Solomon Islands compared favorably with those reported from the established pearl culture operations in French Polynesia and the Cook Islands. Initial experiments showed that survival of oysters in lantern nets in shallow reef areas was poor as a result of predation by fish and invertebrates. Siting of culture potential problem. In general, there were no significant differences in growth or survival between juveniles held in lantern nets and panel nets; however, lantern nets were more difficult to clean and inspect for predators. Juvenile growth and survival did not differ significantly ($p > 0.05$) between panel nets and trays after 5 months, although the rigid trays were easier to clean of fouling organisms. Juveniles placed loosely into trays tended to aggregate, and rates of growth and survival of oysters glued separately into trays were significantly greater ($p < 0.05$) than those for oysters placed loosely into trays. There was no significant difference in growth between oysters glued into trays and those glued onto ropes and enclosed behind plastic mesh. Overall, this study shows that important criteria of the growout units needed for the intermediate culture of *P. margaritifera* in the Western Pacific include ease of cleaning and access for regular inspection and removal of predators.

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Growth of *Pteria colymbus* (Röding, 1798) in suspended culture in Golfo de Cariaco, Venezuela

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Over a 10-month period, we examined the growth of shell height and width, and of mass of the shell and tissues, of juveniles of *Pteria colymbus* (initially measuring 13.5 mm in shell height) placed in a suspended culture at 8 m depth at Turpialito in the Golfo de Cariaco, Venezuela. A high growth rate was observed for all body parameters. Shell parameters increased rapidly during the first 5 months and then at lower rates until the end of the study, and total tissue mass increased at a rapid and almost steady rate throughout the study. Mortality during the study was negligible. The maximum size predicted by the von Bertalanffy growth equation ($L\infty = 71$ mm) was near the maximal size observed in natural populations. *P. colymbus* seemed little affected by marked changes in environmental conditions during our study, because it showed continuous rapid growth rate. The rapid growth, low mortality, and availability of natural spat indicate that *P. colymbus* could be an excellent species for aquaculture in this region.

Source: *Journal of Shellfish Research*, Vol. 18, No. 1, 155–158, 1999.

National strategy for the conservation of native freshwater mussels

Prepared by the National Native Mussel Conservation Committee, 1 June 1997.

History of this document

On April 1995, representatives from several federal and state natural resource agencies, the commercial mussel industry (Shell Exporters of America), academia and The Nature Conservancy met to discuss freshwater mussel declines and gather information on freshwater mussel trends, research, and recovery activities. As a result of the magnitude and immediacy of the nation-wide threats to the freshwater mussel fauna, the group agreed that coordinated effort of national scope was needed to prevent further mussel extinction and populations declines.

To address this need, the group decided to (1) draft a National strategy for the conservation of Native Freshwater Mussels (National Strategy) and (2) establish a national ad hoc committee with broad-based representation from state, tribal, and federal agencies, the mussel industry, private conservation groups, and the academic community to help implement mussel conservation at the national level. A draft National Strategy was presented at the second Symposium on the conservation and Management of Freshwater Mussels organised by the Upper Mississippi River Conservation Committee, in St. Louis, Missouri in October 1995. Comments received at and subsequent to the symposium were incorporated into another draft dated 16 September 1996. The September 1996 draft was presented at a February 1997

meeting of the newly formed National Native Mussel Conservation Committee in St. Louis, Missouri. Comments from the February 1997 meeting have been incorporated into this current document.

Status and role of native freshwater mussels

The world's greatest diversity of freshwater pearly mussels, nearly 300 species, reside in the continental United States (Turgeon *et al.*, 1998). However, within the last 50 years this rich fauna has been decimated by impoundments, sedimentation, channelisation and dredging, water pollution, and, more recently, the non indigenous zebra mussel (*Dreissena polymorpha*) (Neves, 1997). Approximately 67% of freshwater mussel species in the United States are vulnerable to extinction or are already extinct; more than 1 in 10 mussels may have become extinct during this century (Williams *et al.*, 1993; Master *et al.*, 1998).

Freshwater mussels are a renewable resource, providing significant ecological and economic benefits to the nation. They are ecologically important as a food source for many aquatic and terrestrial animals; they improve water quality by filtering contaminants, sediments, and nutrients from our rivers; and because they are sensitive to toxic chemicals, they serve as an early-warning system to alert us of water quality problems. In recent years the annual value of shells to the mussel shell industry has been estimated at US$ 40–50 million. The mussel shell are used in the cultured pearl and jewellery industries, and the shell harvest provides employment to about 10,000 residents, primarily in the Mississippi River basin.

Conservation strategy goals

The goal of this National Strategy is to conserve our nation's freshwater mussel fauna and ensure that the ecological and economic values to society are maintained at a sustainable level. Specifically, the purposes of this document are to (1) identify the research, management, and conservation actions necessary to maintain and recover the mussel fauna; (2) increase government and public awareness of the plight of these animals and their essential ecosystems, and garner support for species and habitat protection programmes; and (3) foster creative partnerships (working and funding) among federal, state, tribal and local governments and the private sector to restore the mussel fauna and environmental quality to our rivers.

[*The remainder of the paper is devoted to 'Identification of specific problems, goals and strategies', and includes the references that could not be listed here (Ed.)*]

Source: *Journal of Shellfish Research*, Vol. 17, No. 5, 1419–1428, 1998.

Iridescent colour of a shell of the mollusc *Pinctada margaritifera* caused by diffraction

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Shells and pearls often show iridescence colour. The cause of this phenomenon has been attributed to diffraction, both diffraction and interference, or interference alone. We used a shell of the mollusc *Pinctada Margaritifera*, which shows very strong iridescence colours, to study how this colour is produced in the layers of nacre in shells. From observations with a scanning electron microscope (SEM), this particular shell exhibits a very fine-scale diffraction grating structure. This suggests that the iridescence colour is caused by diffraction, which was demonstrated by an experiment using an argon ion laser illuminating the shell to produce a distinct diffraction image. The strength of the iridescence colour can be correlated to both the groove density of the diffraction grating formed by the shell, and the surface quality of the grooves themselves. A shell with a high groove density and a smooth groove surface produces a strong iridescence colour.

Source: *The International Journal of Optics*, vol. 4, No. 5. March 19999. p. 177.

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Alternative contacts :

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Fax: Country Code first (. . . . .) . . . . . .
E-mail: . . . . . .

Past seeding experience:

Species	Country/Region	No. years
. . . . .	. . . . .	. . . . .
. . . . .	. . . . .	. . . . .
. . . . .	. . . . .	. . . . .
. . . . .	. . . . .	. . . . .

References:

Name	Company	Contact (Phone, Fax, E-mail)
. . . . .	. . . . .	. . . . .
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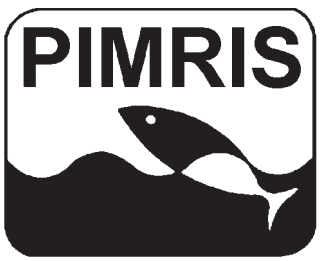

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