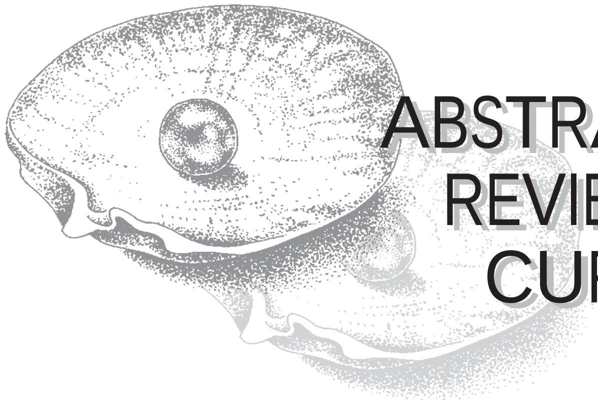

ABSTRACTS, REVIEWS AND CURRENT CONTENTS

World Aquaculture Society's WAS 2002, Beijing

by Wayne O'Connor
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The annual meeting of the World Aquaculture Society is one of the few truly international opportunities for those involved in pearls to gather and discuss trends and developments in pearl culture. This year the conference was held in Beijing, China, and, as in past years, it attracted a wide variety of participants from many regions.

As has been the case since 1994, a session devoted to pearl culture was chaired by Richard Fassler of the State of Hawaii Department of Business, Economic Development and Tourism, and this year was co-chaired by Yu Xiang-yong from Zhanjiang Ocean University, China. Talks and posters addressed a number of topics and because there was so much interest, many talks were forced into other compatible sessions. Several themes pervaded the conference; however, concerns of downturns in sales, particularly in black pearls, and the need to increase pearl quality dominated discussions. Student interest in pearl culture was high and both Anne-Michelle Lee and Josiah Pit from James Cook University are to be congratulated for receiving World Aquaculture Society student awards for the quality of their work. It is pleasing to see that their talents have been devoted to aspects of pearl culture.

China

Information on pearl culture in the host country was provided by a number of speakers. Yu Xiang-yong presented a brief history of marine pearl culture in China, describing some of the challenges facing the industry and outlining developments in Chinese research. Marine pearl culture began following the pioneering work of Professor Dalen Xiong in Zhanjiang, southern China. The first round cultured pearls were produced in 1958 and the industry has grown to an annual output of 25–30 t. Despite its successes, the industry also faces considerable challenges. There has been overfishing of wild stocks and little attention has been paid to the maintenance of genetic diversity in farmed stocks. Water quality is falling, farms are overstocked and mortality rates are high. When pearls are produced, nuclei rejection rates are high, pearl yields are low and pearl quality is frequently poor.

To address the problems facing the industry, Yu suggested that greater government involvement was needed to support research, monitor pollution and to regulate and educate its participants. Some research is underway. Studies are assessing genetic diversity and the potential for hybridisation in akoya oyster (*Pinctada martensii*) stocks using RAPD, isozymic and morphological measures. Other work has demonstrated the advantages of triploidy in *P. martensii*, such as accelerated growth, and attempts have been made to produce tetraploids for triploid production. Researchers are also attempting to diversify the industry by increasing the use of other Pteriids such as the silverlip pearl oyster, *P. maxima*, the blacklip pearl oyster, *P. margaritifera*, and the winged pearl oyster, *Pteria penguin*, which are all found in Chinese waters.

Professor Yu outlined the progress of nucleated pearl culture in the freshwater wrinkle comb mussel, *Cristaria plicata*. The technique is reportedly similar to that used in marine pearl oysters. A single nucleus, commonly 7–9 mm in diameter, is inserted in each mussel along with a piece of mantle tissue. The pearl is then cultured for between one and two years. Production of nucleated freshwater pearls in China is increasing and was just above four tonnes in 2001. Hua Dan, in a later presentation, elaborated on the developments across the industry. The increasing use of an alternate species, the triangle sail mussel *Hyriopsis cumingii*, was noted, and the techniques used to produce non-nucleated pearls were described. Hua reported that China now dominates the freshwater pearl market, producing between 800 and 1000 t of pearls annually. Of these, 400–500 t are exported to Asia, Europe, Africa and America.

As highlighted by Professor Yu, considerable effort has been made to improve growth rates in *P. martensii*. Professor Aimin Wang, formerly with Guangxi Institute of Oceanography and now with Hainan Ocean University, documented attempts to achieve faster growth through the production of tetraploid oysters, which would then be used to provide triploids for farming. Three techniques were described: 1) the inhibition of first polar body release from fertilised triploid eggs, 2) the inhibition of first and second polar body release from diploid eggs, and 3) the inhibition of first cleavage of diploid zygotes. Each of these techniques was capable of producing tetraploid trocophores; however, in all cases, subsequent larval survival was poor. In these trials, only the inhibition of both polar bodies was successful in producing tetraploid juveniles, although the percentage of tetraploid oysters was very low, 0.0625%. In addition, Professor Wang informally discussed his research using microsatellites to select oysters for faster growth and his attempts to revive *P. maxima* culture in Hainan, southern China.

Black pearls

Richard Fassler described the proliferation of black pearl culture through the Pacific and highlighted the benefits this might have for many island nations. However, Fassler noted the importance of the French Polynesian industry and its ability to dominate this section of the market. Here, production has increased rapidly, so much so that it has outpaced marketing efforts. As a result, Fassler and others reported substantial falls in black pearl prices. Anecdotal reports of large-scale layoffs in Tahiti's industry were also made.

Fassler also noted that falls in Tahitian pearl prices will assuredly dictate the prices achieved by other producers and that to avoid this, attempts must be made to differentiate their products. Emphasis needs to be placed on creating a unique product, perhaps through selecting for different colours or uniqueness in design, but above all quality not quantity must be paramount. He felt that some Tahitian lagoons had been overexploited and that this should serve as a cautionary tale for other emerging producers. Fassler's address was not meant as a requiem for the industry, but there may well be significant changes to the structure of the industry in coming years.

Bernard Poirine fleshed out the maladies of the Tahitian industry by providing an historical perspective on black pearl production and prices. Central to the problems experienced was the overexploitation of the available lagoon area. In 1972, 1.5 kg of pearls was produced. Since then, production has increased at a rate of 29 per cent a year to achieve a total harvest of 11,764 kg in 2000. This increase has had its corollary in falling prices, and now production is beginning to fall with indicators such as nuclei imports suggesting the fall will continue. This was described as a special case of 'the tragedy of the commons'.

Poirine described theoretical models of pearl production in which the dichotomy between the economic and the biological optima for pearl production was highlighted. In particular, he emphasised that the economic optimum for pearl production is achieved at stocking densities well below the maximum sustainable oyster density. Poirine discussed the merits of various regulatory frameworks in addressing the problems of overexploitation and made reference to quota systems in Australia, and fisheries cooperative management in Japan. Some discussion ensued, with contributions from Terii Seaman and Ben Ponia. A working group has been formed in French Polynesia, which will address issues such as export control, tighter control of pearl concessions, the maintenance of minimum standards for pearl quality, and the regulation of oyster stocking densities.

Consistent with increasing interest in pearl culture, in particular *P. margaritifera*, Ajai Sonkar spoke of the potential for culturing the species in the Andaman and Nicobar Islands. Falling within Indian's exclusive economic zone, this archipelago has a number of sites that have been identified as suitable for culturing *P. margaritifera*. Wild stocks of the oysters at most of these sites are low and thus hatchery production may be necessary.

In attempts to improve techniques for culturing of *P. margaritifera*, researchers at James Cook University, Queensland, Australia, have investigated several aspects of the oyster's production.

Josiah Pit has been evaluating tropical algal species as substitutes for more temperate species, which are commonly used in the diet of *P. margaritifera*. In particular, the inclusion of *Pavlova salina* in the larval diet was found to be of benefit to larvae. Hector Acosta-Salmon reported on a nondestructive technique for the collection of gonadal tissue from *P. margaritifera*. Using the relaxant propylene phenoxetol, a biopsy needle was inserted through a 10 mm notch in the oyster's shell to remove gametes from the antero-dorsal surface of the gonad. These samples could then be used to assess the reproductive condition of the oysters.

Pinctada maxima culture in Irian Jaya

In the past, details of on-farm research and development for *P. maxima* have been scant, however, this year marked what some hoped might be a watershed for future meetings. Joseph Taylor, Jens Knauer and Anne-Michelle Lee (Atlas Pacific Pty Ltd, Perth, Western Australia) presented several talks and a poster detailing attempts to improve the quality of South Sea pearls produced in Irian Jaya, Indonesia. Joseph Taylor reported that in Australia, recent sales of golden pearls have achieved prices well in excess of silver pearls and their talks documented the relative merits of attempts to increase the percentages of this colour variant. Taylor said the percentages of golden pearls in each harvest are higher in Indonesia than in Australia, and that selection for gold saibo (mantle tissue) donors was successful in increasing the percentage of gold pearls to 8.6%. However, he questioned the merits of this selection, as the proportion of cream-yellow pearls was correspondingly high (78.8%). In contrast, selecting for silver-nacred saibo reportedly produced over 98% silver-white pearls and that larger numbers of these pearls were in the preferred shape categories of round, drop and button.

In the past, one of the major impediments to the use of silver saibo in Indonesia has been a shortage of suitable donors. Jens Knauer noted that the percentage of silver-nacred stocks at various sites ranged between 0.3% and 8.9% and discussed strategies for increasing the pool of suitable saibo donors. This was achieved in the first instance by producing larvae from broodstock selected for their silver nacre. These stocks were then supplemented by additional silver-nacred stocks selected after examining 20–24-month-old oysters from routine production runs. Interestingly, both Taylor and Knauer reported differences in growth between silver and gold-nacred stocks with the latter growing faster.

To increase the efficiency of operations, Taylor and Knauer provided information on attempts to pre-operatively condition oysters and to develop methods to more accurately predict nuclei requirements. Comparisons of operative condition, post operative survival and nuclei retention were made between oysters placed on the seafloor or held in 1 mm mesh socks or rice sacks. Oysters from the seafloor had the highest proportions of operable stock; however, higher survival and nuclei retention has encouraged the use of mesh socks to condition stock. With respect to nuclei requirements, Knauer indicated that at AUD 88–165 per kg, nuclei were a significant cost, which tied up capital that might otherwise be used for farm development. Previously, nuclei purchases had been made on the basis of predictions from past experience and were approximately 60 per cent accurate. Studies have been undertaken to look at the relationship between the morphological characteristics of *P. maxima* (wet weight, shell height, width and length) and the size of nuclei that would ultimately be used. Knauer reported that oyster wet weight was the best predictor of nuclei size, but that the use of a single morphological characteristic did significantly increase predictive accuracy beyond the 60 per cent already achieved.

Atlas Pacific is continuing a programme of evaluating sites, and depths within sites, for growth of different size classes of pearl oysters. Anne-Michelle Lee has been monitoring various environmental parameters and relating these to oyster growth. While depth has not been found to be a significant factor, a picture of locational and seasonal changes in growth is emerging.

Akoya culture in Australia

The success of pearl culture over the past 15 years has encouraged a number of new entrants to pearl production. This year several talks were given concerning aspects of research aimed at producing akoya pearls in Queensland and New South Wales (NSW). Josiah Pit described results from two separate trials investigating the growth rates of *P. imbricata*. The first, Pit's own work at James Cook University, Orpheus Island Research Station and the second, my own research at NSW Fisheries, Port Stephens Fisheries Centre. Larval growth rates have been similar (approximately 20 days to settlement) at both locations, but the growth of oysters during the nursery and growout phases were faster in the warmer Queensland waters. In spite of the differences, oysters can be grown to a size of 50 mm or more within 12 months in both states.

Despite the growth rates achieved in Queensland, slow-growing oyster 'runts' were noted among the batches of *P. imbricata* produced. This raised the question of the efficacy of maintaining these oysters. Pit reported the results of trials in which the runts were separated and their individual growth rates compared with their larger siblings. Under these circumstances the runts grew at the same rate as their siblings, suggesting their initial poor growth was a result of environmental rather than genetic factors.

Simultaneous with our investigations into the farming potential of *P. imbricata* in NSW, we began to follow the reproductive condition of the oyster. These studies found that oyster reproductive activity was greatest from late spring to early autumn with oysters in poor reproductive condition during winter. Two annual peaks in condition were observed, the first in November and the second in March–April; however, microscopic examination of the gonad indicated differences between the two peaks. Gonad samples collected following the peak in November showed a high proportion were empty, consistent with spawning, while those taken in April–May suggested the oysters were resorbing the gonad rather than spawning. The number of spat settling has varied significantly between years but has been restricted to the summer months, December to February. This is consistent with November spawnings and further suggests that the second, autumnal peak in reproductive activity does not contribute to oyster settlement.

While to date, predators have not been a great problem in the culturing of *P. imbricata* in NSW, the occurrence of the flatworm, *Imogine mcgrathi*, in spat bags and cages was a cause for some concern. This flatworm was shown to eat pearl oysters at rate of approximately one per month and has been found sporadically in high numbers in other types of mollusc culture in NSW, such as mussel and edible oyster farming. If higher numbers of flatworms were found in pearl oyster culture, the efficacy of several treatments for flat worm control was evaluated. Salting oysters or dipping them in hyper- or hyposaline baths were all effective means of control. Currently, caged oysters are dipped in freshwater baths for 30 minutes to kill the flatworms, with care taken to ensure the salinity does not rise above 2.5 ppt.

Progress in Mexico

On several occasions during the discussions, Richard Fassler expressed his admiration for work undertaken in the Mexican pearl industry. It was, therefore, pleasing to have Carlos Rangel-Davalos and several of his colleagues give presentations at the meeting to provide further information on developments in Mexico. The industry is based on *Pteria sterna* and *Pinctada mazatlanica*, both of which can be hatchery produced. Rangel-Davalos described culture methods that have been evaluated in which the oysters are grown in 3.6 x 3.6 m plastic mesh enclosures. When they reach 70 mm, the oysters can be seeded and placed in 'folded' pocket nets. These nets are then placed on an iron framework on the seabed. The maintenance of this system was said to require three technicians for a period of 90 days for each 10,000 oysters. From spat to pearl harvest took three years.

In conjunction with their research into pearl culture, Rangel-Davalos et al. also described attempts to reseed wild oyster beds with hatchery produced juveniles. Mexican oyster beds have been heavily exploited in the past, which led to a fishery closure. A poster was presented at the meeting describing the successful re-establishment of a population at La Gaviota Island in La Paz Bay. The keys to this success were the use of mesh enclosures to protect oysters until they reached a size of 98 mm. Survival rates of between 8.3 and 21.2 per cent after 11 months were reported.

Abstracts[1]

Acosta-Salmon, H. and P.C. Southgate. Use of biopsy technique to obtain gonad tissue from the black lip pearl oyster, *Pinctada margaritifera.*

Du, X. and L. Lu. Comparison of proteins in extrapallial fluid of six species of mollusc.

Fassler, R.C. Recent developments in selected Pacific and Indian Ocean black pearl projects.

Hua, D. Freshwater pearl culture in China.

Knauer, J. and J.J.U. Taylor. Production of silver nacred 'saibo oysters' of the silver- or gold-lip pearl oysters *Pinctada maxima* in Indonesia.

Knauer, J. and J.J.U. Taylor. Assessment for external growth parameters of the silver- or gold-lip pearl oyster *Pinctada maxima* as indicators of the required nucleus size.

Lee, A.M., J. Taylor and P. Southgate. Comparative growth and mortality of silver-lip pearl oyster *Pinctada maxima* (Jameson) cultured at two sites in Irian Jaya, Indonesia.

1. Some of these abstracts appear on pages 29–35 of this issue.

O'Connor, W.A. and N.F. Lawler. Reproductive condition of the pearl oyster *Pinctada imbricata* in Port Stephens, NSW, Australia.

O'Connor, W.A. and L.J. Newman. Predation of *Pinctada imbricata* and *Mytilus galloprovincialis* by the Stylochid flatworm, *Imogine mcgrathi.*

Pit, J.H. and P.C. Southgate. Should slow growing pearl oyster spat ('runts') be discarded.

Pit, J.H. and W.A. O'Connor. Culture of akoya pearl oysters in Australia.

Pit, J.H. The use of tropical microalgae *Pavlova* spp. for pearl oyster *Pinctada margaritifera* larvae.

Poirine, B. Managing a common resource: Regulation of pearl farm industry in French Polynesia.

Rangel-Davalos, C., H. Acosta-Salmon, E. Martinez-Fernadez, A. Olivera, A. Romo-Pinera and H. Ruiz-Robio. Modelling pearl oyster culture in Northwest Mexico.

Rangel-Davalos, C., H. Acosta-Salmon, L. Hernandez-Moreno, E. Martinez-Fernadez, A. Olivera, A. Romo-Pinera and H. Ruiz-Robio. Further information on pearl oyster 'concha nacar' *Pteria sterna* repopulation in La Paz Bay, Baja California Sur, Mexico.

Sonkar, A.K. Potential of pearl culture in Andaman and Nicobar Islands.

Taylor, J.J.U. Production of golden and silver South Sea pearls from Indonesian hatchery reared *Pinctada maxima.*

Taylor, J.J.U. and J. Knauer. Inducing preoperative condition in silver- or gold-lip pearl oysters *Pinctada maxima* for pearl grafting.

Wang, A., Y. Bing, L. Ye and G. Lan. Comparative studies of three methods in the induction of tetraploidy of pearl oyster (*Pinctada martensii* D).

Yu, X. Pearl culturing in China present problem, countermeasure and new development.

Acknowedgements

My thanks to Richard Fassler and Xiang-Yong Yu for the time and effort put into coordinating and chairing the pearl session and my apologies to anyone whose presentation or abstract was related to pearls, that I have over looked. For those who have not had the chance to attend a WAS conference, WAS 2003 will be held in May in Salvador Brazil, followed by WAS 2004 in Hawaii. Details can be obtained from the World Aquaculture Society web site www.was.org.

Recent development in selected Pacific and Indian Ocean black pearl projects

Presented at the Pearl Session, World Aquaculture Society's Annual Meeting, Beijing, People's Republic of China, 24 April 2002.

Black pearl farming: a brief overview

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The good news

There is considerable good news in the farming of the black pearl oyster, *P. margaritifera*. Ten years ago, black pearl farming was almost exclusively in the domain of French Polynesia and the Cook Islands. Now, however, research projects are sprouting up throughout the Pacific Ocean and even into the Indian Ocean in Western Australia. Such places as the Solomon Islands, Tonga and the Federated States of Micronesia are pushing ahead with commercial farming and witnessing some successes.

And why not? Pearls have been identified by many economists as the ideal crop for small island nations, whose major economic activity has been traditional agriculture — copra or a variety of vegetables. As this paper will reveal, funding for pearl projects involving basic research for such necessities as a hatchery, and the training of the indigenous people, appears to be plentiful. Both American and Australian agencies are now heavily involved in this activity in the Pacific. Whereas pearl farming was once confined to those nations with the ability to capture spat in lagoons, French Polynesia being the prime example, the development of hatchery techniques has opened the door to pearl farming almost anywhere where there is clean water and a minimum of turbidity.

The bad news

But there is considerable bad news, too. For the most part, 'a black pearl, is a black pearl, is a black pearl.' Some experts might be able to tell the difference between a pearl that has been produced in the Cook Islands and a pearl that has been produced in Tahiti, but the buying public can not tell one from the other, and doesn't particularly concern itself with the origin of the pearl. This presents a dangerous marketing situation for a beginning nation, as prices will be dominated by the major player, and that major player is French Polynesia — the proverbial '500-pound gorilla in the middle of the living room.'

The Tahiti experience

By all accounts, the black pearl industry in Tahiti is in turmoil, due to vast production from 'industrialised' farms, many with an attitude that: 'The more we produce, the more quality we will produce.' There appears to have been little concern for the effects of one's production on the market as a whole. The bright spot has been a highly effective government marketing campaign, which has most fortunately resulted in the absorption of much product. But, unfortunately, high production has outpaced marketing efforts, resulting in too much product on the market and a consequent lowering of prices. The timing couldn't have been worse: at the moment when the industry was managing to convince the world that black pearls were a rare treasure, they suddenly emerged with such plentitude that swapmeet sellers and television hawkers were selling a low-priced product that even the most modest income could afford.

Fortunately, the very quality product seems to be holding its own, and this is the way the industry now appears to be turning. French Polynesia has taken steps to put more 'quality' than 'quantity' in its future by imposing quotas, encouraging farmers to leave pearls in the water longer, and so forth.

Lessons learned

What does this mean for the many incipient black pearl farmers scattered across the vast ocean? The first lesson will be that they must be extremely mindful of events in Tahiti (and, at present, it is the author's belief that not many of these new farmers are aware of that situation). Tahiti's low prices will most assuredly mean low prices for everyone.

The second lesson will be that all attempts must be made to make their product unique — through the development of colours, for example, and, above all, an emphasis on quality.

Oddly enough, as Tahiti turns back to small farms to cut costs, it may find itself in the position the industry was in some two decades ago: dominated by family members who are able to devote more care to each harvest. This is precisely where the beginning farms in other nations are: using family members, devoting much care to product.

And where Tahiti has been careless about the environment, pushing the limits of many lagoons, the new black pearl farmers must be aware that too much product could be disastrous. A major advantage that they have is clean waters. This is an advantage that must not be squandered.

The future

So, what is the future of black pearl farming in the Pacific? At the moment, it is very much in a transition stage. The 'old player', Tahiti, is falling, and the new players are wondering what is going on. It may be some years before things are sorted out. Above all, one thing will remain true: any attempts at rapid pearl farming development will result in an even further lowering of prices, possible pollution, a severe image problem for black pearls and, perhaps worst of all, a dampening of enthusiasm for an industry that could still make a strong contribution to the economies of small Pacific nations.

The following abstracts present some detail on black pearl projects in the Pacific/Indian Ocean region. Perhaps most useful are the contact numbers of the principal researchers and farm managers. The author would like to encourage a dialogue that will, hopefully, involve both conference participants and these farmers and researchers.

Abstracts

Production of silver-nacred 'saibo-oysters' of the silver- or goldlip pearl oyster *Pinctada maxima* in Indonesia

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The production of highly valued silver-coloured South Sea pearls is achieved by inserting a spherical nucleus and a piece of mantle tissue, the 'saibo' from a silver-nacred silver- or goldlip pearl oyster (*Pinctada maxima*), into the gonad of a recipient pearl oyster. Silver pearl production thus depends on a regular supply of silver-nacred *P. maxima*. In Indonesia, however, *P. maxima* predominantly have a yellow to gold-coloured nacre, and silver-nacred specimens are extremely rare. A sufficient supply of silver saibo to produce silver pearls therefore presents a continuous problem to *P. maxima* farms in Indonesia.

Consequently, at our Indonesian pearl oyster farm at Waigeo Island in Irian Jaya, we have implemented a strategy to ensure a regular and sufficient supply of silver saibo-oysters. There are two aspects to the strategy. First, we produce larvae using wild and hatchery broodstock specifically selected for their silver-nacre. Up to two such runs are attempted per hatchery season. Secondly, oysters resulting from other hatchery runs are examined after approximately 20 to 24 months of age and, if found to be silver-nacred, are put aside for use as a saibo-oyster. Data on the silver-hatchery runs and incidence of silver nacre in wild and hatchery-produced *P. maxima* are presented, and the implications for pearl oyster culture in Indonesia are discussed.

Producing golden and silver South Sea pearls from Indonesian hatchery reared *Pinctada maxima*

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Cultured South Sea pearls result from the surgical implantation of a shell bead nucleus with a section of mantle tissue (saibo) from a sacrificed donor *Pinctada maxima* into the gonad of a healthy host. The selection of saibo tissue is integral to the success of the operation and the quality of the resulting pearl. Pearl colour greatly influences value, golden South Sea pearls are the most valuable followed by silver-white pearls. Cream and yellow is regarded as an inferior colour and these pearls sell at greatly reduced prices. To determine the degree saibo affects the value of South Sea Pearls, two experiments were conducted using donor saibo tissue selected on the basis of observed nacre coloration.

In the first experiment, pearl colour and quality were compared between oysters seeded using saibo tissue cut from donor pearl oysters exhibiting either silver-white (silver saibo) or golden (gold saibo) nacre colour. The differences in pearl colour were highly significant ($P<0.01$) for the two treatments. Oysters seeded with silver saibo produced 98.2% silver-white pearls, no golden pearls and small numbers of cream / yellow pearls. By contrast, gold saibo produced 12.7% silver-white pearls, 8.4% golden pearls and 78.8% cream / yellow pearls. In addition, a significantly greater ($P<0.01$) proportion of pearls from silver saibo were in the better (more valuable) shape categories (round, drop and button) than for gold saibo.

The obviously large variation in colour from gold saibo prompted a second experiment using seven individual donor oysters (Gl - G7) exhibiting gold characteristics. The variation in colour was highly significant ($P<0.01$) between treatments. In pearls produced using saibo from four of the donor oysters (G2, G4, G5 and G6), more than 50% exhibited gold colour. One hundred per cent of the pearls produced by G5 were golden while G1 produced no golden pearls but did produce 43.8% silver-white pearls and 56.3% cream / yellow pearls.

The results indicate that it is easier, providing the appropriate oysters are available, to select donor saibo tissue for producing silver-white pearls than for the more valuable golden pearls. Furthermore, using tissue derived from pearl oysters with gold colour characteristics can lead to the production of large numbers of comparatively low value cream / yellow pearls lowering the overall value of the crop. Very careful selection of goldlip pearl oysters can, however, yield good numbers of golden pearls. In order to maximise pearl value, careful consideration must be given to saibo selection.

Inducing pre-operative condition in silver- or goldlip pearl oysters *Pinctada maxima* for pearl grafting

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The success of pearl oyster surgery is largely dependent on the pre-operative condition of the gonad in which the nucleus and donor mantle tissue (saibo) is implanted. Ideally, the gonad should be void of gametes that may limit space for pearl nuclei and obscure a technician's view during operation. Low metabolic activity also assists by reducing the strength of the adductor and foot muscles that can cause expulsion of pearl nuclei through the gonad wall. In Australian waters, this is achieved in silver- or goldlip pearl oysters *(Pinctada maxima)* naturally by choosing to operate only during the cooler winter months (June–August) when the pearl oysters are in a non-reproductive state. In equatorial regions such as Indonesia, which have little annual variation in water temperature, pre-operative condition must be induced.

On our Indonesian farm, three methods were assessed for inducing the pre-operative condition in 2.5 year-old hatchery-reared *P. maxima.* Oysters were either held in paired eight-pocket panels and covered with commercially available 50 kg capacity rice sacks (RS) or 1 mm nylon mesh socks (MS), or they were laid flat on the sea floor (SF). The covered oysters were suspended to a depth of 15 m from surface longlines. Those in the SF treatment were held at a depth of 8–10 m on a natural coral rubble bed. After 30 days the oysters were assessed for condition and either operated on or rejected. Significantly more of the

SF pearl oysters (P<0.05) were in operable condition (96.7%) than in either the RS (90.3%) or MS (85%) treatments, which did not differ significantly (P>0.05).

Six months post-operation, survival of MS conditioned pearl oysters was significantly higher (P<0.01) at 98.8% than in either the SF or RS treatments with pearl oyster survival rates of 97.8% and 96.1%, respectively. Surviving oysters were examined using x-ray equipment to determine whether or not they contained a growing pearl. There was no significant difference (P>0.05) in pearl retention between MS and RS with 66.4% and 66.5%, respectively; however, both had significantly higher pearl retention than SF (64.4%). Due to the high value of *P. maxima* (USD 1.00/cm DVL), using 1 mm mesh socks is favoured as this treatment resulted in the highest survival rates and pearl retention was not significantly different to pearl oysters conditioned using rice sacks.

Assessment of external growth parameters of the silver- or goldlip pearl oyster *Pinctada maxima* as indicators of the required pearl nucleus size

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Cultured pearls are produced by grafting a spherical nucleus and a piece of mantle tissue, the 'saibo' from a sacrificial pearl oyster, into the gonad of a recipient pearl oyster. Nuclei, which are crafted from a variety of freshwater mussel shells, constitute a major material cost in pearl culturing. It is therefore desirable to accurately order nuclei of the appropriate size, ahead of the operating season. However, the size of a nucleus that can be implanted into a particular pearl oyster can only be known at the time of operation, when the technician can get a measure of the available space within the pearl oyster's gonad.

In this study, we assessed whether easily measured growth parameters of the silver- or goldlip pearl oyster, *Pinctada maxima*, are suitable as indicators of the required pearl nucleus size. The experiment was done at Atlas Pacfic P/L's Indonesian pearling project at Waigeo Island, Irian Jaya. The relationships between wet weight (WW), antero-posterior shell length (SL), dorso-ventral shell height (SH) and shell width (SW) of *P. maxima*, and pearl nucleus size required during implantation of pearl nuclei was studied by regression analysis (n = 847). The highest coefficient of determination was found for WW (r^2 = 0.62), followed by SH (r^2 = 0.49), SL (r^2 = 0.48) and SW (r^2 = 0.24). The relationships between each of the growth parameters and pearl nucleus size were significant (P<0.05). The results of this study indicate that up to 62% of pearl nuclei sizes required for pearl operations can be correctly predicted based on WW measurements of *P. maxima*. The suitability of the growth parameters as indicators to accurately predict nuclei requirements ahead of the operating season is discussed.

Recent developments in selected Pacific and Indian Ocean black pearl projects

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For the past 20 years, black pearl farming has centred on French Polynesia, and to a lesser extent, the Cook Islands. Within the past five years, advances in technology have enabled black pearl farmers to increase production dramatically, to the point where black pearls have entered the mainstream global pearl marketplace at reasonable prices. Other improvements, such as the utilisation of pearl grafters from nations other than Japan, have decreased production costs and opened up the industry to new areas in the Pacific and Indian Oceans. Indeed, black pearl farming is no longer confined to one species of oyster: *Pinctada margaritifera.*

The goal of this paper is to present a number of new black pearl projects, briefly discuss production and marketing techniques, and offer comments on the challenges and successes of the ventures. These projects will include those located in the Marshall Islands, the Solomon Islands, Kiribati, Fiji, the Abrolhos Islands (Australia), the Andaman Islands (India) and Mexico. A discussion of the similarities and differences among the projects will be provided, together with observations on marketing strategies in light of the serious downturn in pearl sales following the tragic events of 11 September 2001.

Should slow growing pearl oyster spat ('runts') be discarded?

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Growth of cultured bivalve molluscs is highly variable during both hatchery and nursery culture and variation can occur among individuals of the same age reared under identical conditions. In this laboratory, pearl oyster spat are generally graded at 3.5 months of age when fast-growers (>10 mm shell height) are separated from normal growers (5–10 mm) and runts (<5 mm). Runts are often discarded because it is believed that they will remain slow growers for life. This study reports on two experiments that assessed the growth rates of different size classes of blacklip pearl oyster *(Pinctada margaritifera)* and Akoya pearl oyster *(P. fucata)* spat in northern Australia. Spat of the same age from three size classes (<5 mm, 5–10 mm and >10 mm) were individually glued into replicate plastic mesh trays (55 x 30 x 10 cm) and positioned on a surface long line at 6 m for four months.

At the end of the first experiment there were significant differences between mean dorso-ventral shell height (DVH) of *Pinctada margaritifera* spat from the different size classes ($F_{2.87}$ = 167.67, P<0.01). Mean (± SE) DVH was 24.6 ± 0.4 mm, 32.2 ± 0.4 mm and 35.6 ± 0.4 mm, for spat with initial DVH size classes of <5 mm, 5–10 mm and >10 mm respectively. Spat in the 5–10 and >10 mm size classes showed significantly greater growth during the experiment than those in the small size class ($F_{2.87}$ = 15.99, P<0.010). However, a number of individuals in the <5 mm size class grew very rapidly and were as large as some oysters in the larger two size classes at the end of the experiment.

At the end of the second experiment there were significant differences between mean DVH of *P. fucata* from the different size classes ($F_{2.267}$ = 140.39, P<0.001). Mean (± SE) DVH was 36.2 ± 0.3 mm, 42.3 ± 0.4 mm and 46.9 ± 0.4 mm, for spat in the initial size classes of <5 mm, 5–10 mm and >10 mm, respectively. Incremental growth in DVH was 30.0 ± 0.5 mm, 32.1 ± 0.4 mm and 30.3 ± 0.4 mm for spat in the initial size classes of <5 mm, 5–10 mm and >10 mm, respectively. Growth during the experiment was significantly greater in individuals from the 5–10 mm size class ($F_{2.267}$ = 7.05, P = 0.001) whereas those from the <5 mm and >10 mm size classes did not differ significantly (P = 0.903).

Results from these experiments show that small spat do not catch up to larger individuals within a cohort within four months from grading. However, the results also show that spat classed as runts are capable of similar growth rates to larger pearl oysters when provided with appropriate conditions. On this basis, it may be premature to discard runts at first grading.

Use of a biopsy technique to obtain gonad tissue from the blacklip pearl oyster *Pinctada margaritifera*

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Aquaculture research often requires samples of different animal tissues to be obtained for various analyses. An example of this is sampling gonad tissue to assess reproductive seasonality or the effectiveness of broodstock conditioning protocols. In many cases this process is destructive and involves sacrificing experimental animals. While this is not such a problem with lower value aquaculture animals such as rock oysters and mussels, it is often prohibitive with higher value animals such as pearl oysters, which have the potential to produce pearls worth many hundreds of thousands of dollars.

In order to carry out research into the reproductive biology of the blacklip pearl oyster, *Pinctada margaritifera,* a non-destructive method of obtaining gonad tissue using biopsy was assessed. Prior to biopsy, oysters were anaesthetised with 2 mL/L of propylene phenoxetol. Three different 9-cm-long biopsy needles (16, 18 and 20 gauge) with a 10 mm sample notch, were compared as a means of obtaining gonad tissue from 20 oysters. Samples were removed from each oyster using each of the three biopsy needles. Biopsy samples were taken from an antero-dorsal portion of the gonad. Following the biopsy procedure, each oyster was killed and the gonad sectioned for standard histological preparation. All samples were preserved with the formaldehydeacetic acid-calcium carbonate gonad fixative (FAACC), dehydrated in an alcohol series dilution, embedded in paraffin, sectioned and stained with H-E. Samples were observed microscopically to assess gonad condition and to compare samples taken using biopsy with those taken using destructive sampling.

The impact of the biopsy sampling technique on oyster mortality was determined using a second batch of 48 oysters. Three groups of 12 oysters were sampled with each of the 16 gauge, 18 gauge and 20 gauge biopsy needles; the remaining 12 oysters were kept as controls. Oysters were maintained under culture conditions to assess survival.

Preliminary results showed 100% recovery from the anaesthetic and biopsy procedure after two weeks. Results of longer-term survival and histological analysis will be presented. This study indicates that non-destructive biopsy sampling could be a valuable means of assessing gonad condition in pearl oysters.

Reproductive condition of the pearl oyster, *Pinctada imbricata*, in Port Stephens, NSW, Australia

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Pearl oysters form the basis of Australia's most valuable aquaculture industry and are the subject of considerable commercial interest. Largely the focus has been upon the silverlip pearl oyster *Pinctada maxima*, although increasingly interest is diversifying to include other endemic pteriids. Among these, *Pinctada imbricata* (Röding) is attracting particular attention, however, there is a paucity of information regarding the species in Australian waters.

Central to the development of a pearl industry is an understanding of the reproductive biology of the target species. This assists in timing various aspects of farming including the collection of wild spat, hatchery production and the timing of nuclei implantation. Regrettably, reproductive studies to date indicate that the behaviour of *P. imbricata* varies significantly according to location. Therefore, simultaneous with initial investigations into the farming potential of *P. imbricata*, studies also began to follow the reproductive condition of the oyster in New South Wales.

Beginning in May 1998 and continuing until August 2000, oysters were collected monthly from natural populations off Wanda Head, Port Stephens. These oysters were returned to the laboratory where both macroscopic and histological observations of reproductive condition were made. Oyster reproductive activity was greatest from late spring to early autumn with oysters in poor reproductive condition during winter. Two annual peaks in macroscopic condition occurred, the first in November and the second in March–April; however, histological examination of gonadal tissue indicated differences between the two peaks. Gonad samples collected following the peak in November showed a high proportion of voided follicles consistent with spawning, while those taken in March–April suggested gamete resorption.

In addition to reproductive monitoring, spat collector bags were deployed monthly to monitor natural recruitment. Spatfall has varied significantly between years but has been restricted the summer months December–February. This is consistent with November spawnings and further suggests that the second autumnal peak in reproduction does not contribute to recruitment.

Managing a common resource: Regulation of the pearl farm industry in French Polynesia

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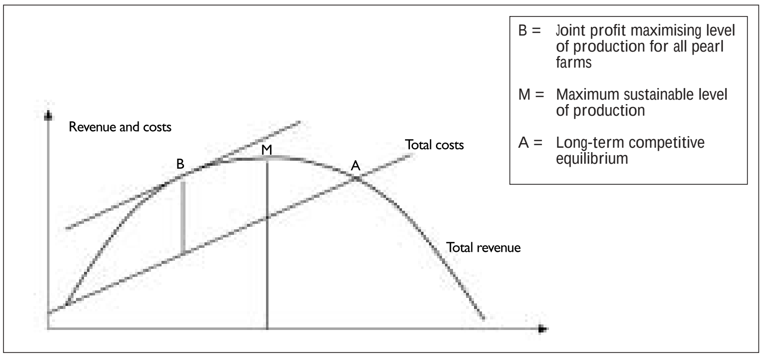
The first part of the paper presents the pearl farming industry in French Polynesia and its recent growth. The second part discusses the danger of overexploitation of the lagoons in some atolls, how the problem has been addressed (or not addressed), some examples of dystrophic crisis in French Polynesia and, recently, in Manihiki in the Cook Islands.

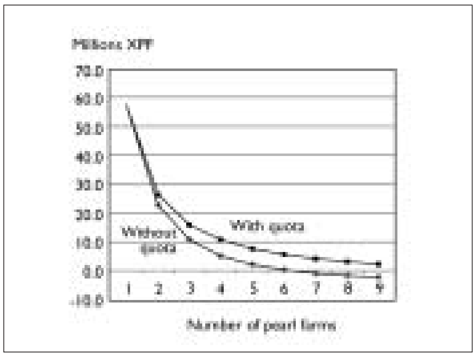
The third part reveals that the problem comes from the negative externalities in production relating to the use of a ‘free’ (almost free) use of a common resource, the lagoon. It is a special case of the ‘tragedy of the commons’.

The fourth part presents a theoretical model of a lagoon with ‘n’ pearl farms, each maximising profits, with negative production externalities in the production function for each pearl farm. The model shows how the competitive equilibrium is above the optimal level of production maximising joint profits for all pearl farms, and also above the maximum sustainable yield of the lagoon, the former being lower than the latter. The model also shows that profit per farm is higher if a quota system limits the number of shells in stock in the lagoon.

Finally the fifth part reviews the different regulation policies addressing the problem: the Japanese policy (decentralised regulation through village cooperatives), the Australian policy (quotas on grafted shells), and a 19th Century policy of ‘oyster banks auctions’ in Holland.



Revenue, cost and optimum level of production in a pearl farming lagoon



Profit per farm with or without quotas on grafted shells

Potential of pearl culture in the Andaman and Nicobar Islands

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The Andaman and Nicobar Islands form an archipelago consisting of more than 550 islands, islets and rocky outcrops in the Bay of Bengal, lying between 6°45'N and 13°41'N latitude and between 92°12'E and 93°57'E longitude. There is a limited land area of only 8293 sq km, but the islands have a total coastline of 1962 km, which is about one-fourth of the total coastline of India. Of the two million sq km of India exclusive economic zone, 0.6 million sq. km or 30% lies around the Andaman and Nicobar Islands.

The continental shelf around these oceanic islands is limited to about 16,000 sq km, as compared to the total shelf area of about 452,000 sq km for the entire country. With practically no continental slope, the land drops steeply to great depths not far from the coastline.

The blacklip pearl oyster *Pinctada margaritifera* is an important resource in the Andaman and Nicobar Islands. Havelock Island, Mayabunder, North Bay, Wandoor, Chiriatapu, Diglipur and several other spots have been identified for *P. margaritifera.* The background colours of *P. margaritifera* shells in the collections from several locations are dark green, bronze, brown or black. The shells show variation in form and outline. *P. margaritifera* generally occupies the intertidal reef flat and was observed up to a depth of about 10 m.

Although it is observed that the population of *P. margaritifera* at most of the places identified for the availability of the oysters is not very high, a hatchery could fulfil the requirements of a commercial venture.

Several other aspects of the potential of pearl culture in the Andaman and Nicobar Islands will be discussed in the paper.

Freshwater pearl culture in China

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Freshwater pearl culture started in China 2000 years ago and the bead-nucleated freshwater cultured pearls were produced at least as early as 1900. Commercial freshwater pearl culture, however, dates back only to the late 1960s and early 1970s, after the key technology had been developed, and when tremendous quantities of small, irregularly shaped rice-like freshwater cultured pearls from pearly mussel (wrinkle comb mussel, *Cristaria plicata)* entered the market. Although, these rice-like cultured pearls dominated Chinese production during the 1980s, in 1984 the importance of quality as well as quantity was realised. Pearl culture scientists made changes in technology and, most importantly, in the mussel used, which resulted in the production of greater quantities of larger and more lustrous round, near-round, and baroque cultured pearls having a variety of colours. The pearly mussel most used in pearl culture is the triangle sail mussel *(Hyriopsis cumingii).* Today, Chinese cultured pearls are in great demand throughout the world; 95% of the freshwater pearls in the world market come from China. China is producing an estimated 800 to 1000 t of freshwater cultured pearls annually, of which 400 to 500 t are exported to different countries in Asia, Europe, Africa, and America, such as Japan, Korea, India, Thailand, Britain, Germany, USA, Canada, Australia and South Africa. These exports include pearls larger than 8 mm.

This monograph includes the principles and techniques of freshwater pearl culture in China, viz Principles of Pearl Formation, pearl culture operation procedure and operated mussel culture.

Comparative effects of temperature on suspension feeding and energy budgets of the pearl oysters *Pinctada margaritifera* and *P. maxima*

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This study assessed the effects of seasonal temperatures on suspension feeding, related physiological parameters and energy budgets in two pearl oysters, *Pinctada margaritifera* and *P. maxima.* Pearl oysters that were acclimatised at approximately 19, 23, 28 and 32°C in the field were tested in the laboratory at these temperatures. Clearance rate (CR), absorption efficiency (ae), absorbed energy (AE), respired energy (RE), excreted energy (EE) and the value of (AE – RE) were significantly affected by temperature, usually increasing with increasing temperature. ae, RE, EE and the value of (AE – RE) differed significantly between the pearl oyster species. *P. margaritifera* had a significantly higher CR than P. *maxima* at 19°C. *P. maxima* had higher ae than *P. margaritifera* at 28 and 32°C. As a result, *P. margaritifera* had greater AE than *P. maxima* at 19°C, but the latter species had greater AE at 32°C. Temperature significantly affected the RE of *P. margaritifera* over a wider temperature range (19 to 32°C) than *P.* maxima (19 to 23°C). However, interspecific differences in RE were only significant at 32°C. *P. maxima* had significantly higher EE at 32°C than *P. margaritifera,* although this energy accounted for a very small portion of AE (<5%). *P. maxima* exceeded *P. margaritifera* in scope for growth [SFG = (AE – RE) – EE] at 32°C, but the latter species had greater SFG at 19°C. These results agree with observations of the occurrence of *P. margaritifera* at higher latitudes and lower temperature habitats. The temperature effects on suspension feeding, related physiological parameters and SFG indicate that there will be marked seasonal variations in growth in both species in environments where water temperatures vary seasonally. In bioenergetic terms, the optimum temperature ranges for these pearl oysters are approximately 23 to 28 and 23 to 32°C for *P. margaritifera* and *P. maxima,* respectively.

POIB's Pacific Pearl Seeding Technician Registry

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Alternative contacts :

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Past seeding experience:

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

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

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