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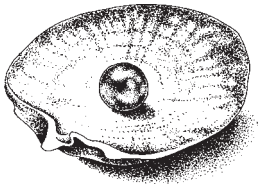

PEARL OYSTER

INFORMATION BULLETIN Number 8 — April 1995

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NOTE FROM THE EDITOR

It has been a while since the last *Pearl Oyster Information Bulletin* hit the news-stands, and quite a lot has happened in the interim. POIB #7 probably reached your mail box about this time last year. I should therefore begin with a humble apology, but I am also going to indulge in some gentle cajoling as well.

The apology is for all of you who feared that you had fallen off the mailing list. No, you haven't fallen: we have just slipped. Nevertheless, while we have always aspired to being a biannual publication, we have clung tenaciously to the prerogative of a flexible publishing schedule.

The timing of any POIB depends on several factors – time available to your Editor, the schedules of the SPC presses, and of course, the amount of topical material on hand.

While the last year has been one of exciting events in the wider pearl industry, there has been a dearth of information coming out of the islands, and out of the rest of our readership.

The careful reader will notice that this issue is, in essence, an amalgam of extracts from various sources — both the obscure (the French Journal *La Recherche*, *Hawaiian Shell News* and a UN report) and the obvious (*The Journal of Shellfish Research*, *Austasia Aquaculture Magazine* and, of course, *Pearl World*). (cont'd page 2)

Inside this issue

PIMRIS is a joint project of 4 international organisations concerned with fisheries and marine resource development in the Pacific Islands region. The project is executed by the South Pacific Commission (SPC), the South Pacific Forum Fisheries Agency (FFA), the University of the South Pacific's Pacific Information Centre (USP–PIC), and the South Pacific Applied Geoscience Commission (SOPAC). Funding is provided by the International Centre for Ocean Development (ICOD) and the Government of France. This bulletin is produced by SPC as part of its commitment to PIMRIS. The aim of PIMRIS is to improve the availability of information on marine resources to users in the region, so as to support their rational development and management. PIMRIS activities include: the active collection, cataloguing and archiving of technical documents, especially ephemera ('grey literature'); evaluation, repackaging and dissemination of information; provision of literature searches, question-and-answer services and bibliographic support; and assistance with the development of in-country reference collections and databases on marine resources.

PIMRIS

Pacific **I**slands **M**arine **R**esources **I**nformation **S**ystem

This compilation and reprinting is, in itself, a service to the reader. We all have better things to do with our time than pouring over 'Current Contents', running literature searches or sending off requests for reprints. And despite all the recent improvements in the availability of fisheries information, these tasks are still doubly challenging for our principal constituency, working in the Pacific Islands.

Nevertheless, copyright laws and common sense mean that we cannot reprint all that is newsworthy. We cannot — and should not — seek to repeat verbatim articles from the most 'obvious' publications listed above. We will publish reviews, titles, abstracts and extracts, from these. If you are further interested, then you can chase up the reprints. In the case of *Pearl World*, you may even be inspired to subscribe.

We must remember that POIB is meant to be a newsletter for all of us, and by all of us. To harken back to the editorial of POIB No. 1, this 'newsletter is the medium, catalyst and standard-bearer for the Pearl Oyster Special Interest Group'. We are an information-sharing network, and we would like to have whatever you are able to share.

Many of us may be somewhat constrained in what we can publish. Pearl culture is, after all, a very lucrative industry, and where there is not proprietary protectiveness, there is often simply good business sense.

One area where there might be more sharing, however, and where everyone stands to gain, would be in an exchange of names and addresses of suppliers of pearl farming equipment and services. We have therefore set up a separate section in this issue, entitled 'People, Products and Processes'. We will include that which we are able to glean, but it would be most valuable if the information were to come from you, the users. Comments on the range of supplies available, prices, quality of material and contact numbers for each source would add to its usefulness.

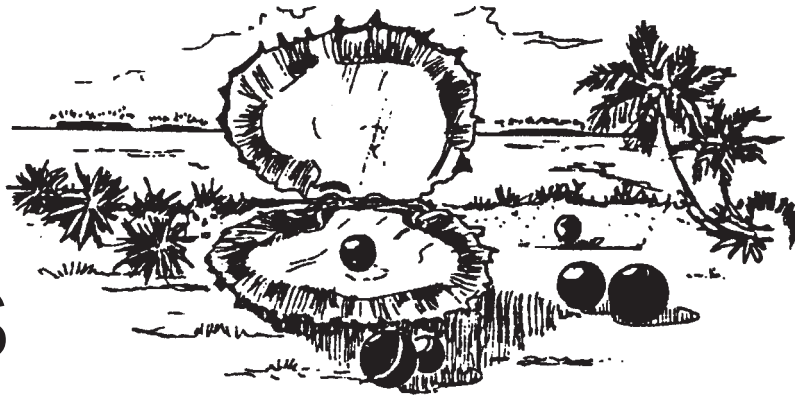
We would also be willing to publish short informative notes from the suppliers themselves – the more overt advertisements may be toned down, but it is an open opportunity for self-promotion. If this proves useful we may at some later stage compile all the notes into a separate reference list of suppliers.

The cajoling for news and views is, I suppose, something that every newsletter editor has to do every so often. I have, up to now, tried to limit most of my gentle nudging for news to my personal correspondence. By muttering away in an editorial, however, it is less personal. I'm therefore not having to wear out the warmth of my welcome from those stalwarts I usually turn to when I'm planning to pull another issue together. Also, you can readily choose to ignore the request, and I won't be offended.

Still, it would be good to hear what you are up to. Be part of the process. Be one of the stalwarts. Build a better POIB. Drop us a line.

Neil Anthony Sims

NEWS AND VIEWS



Pearls '94 in the Press

Pearls '94 — *Excerpts from an article by Ed Rampell, published in* Pacific Islands Monthly, *July 1994, p. 24.*

Pearls '94 marked the 100-year milestone of a gem stone that represents a viable and sustainable form of alternative economic development for the Pacific Islands. The largest 'International Pearl Conference and Exposition' ever took place in Hawaii from 14 to 19 May 1994.

Five hundred participants, from around Oceania and the world, participated in the International Pearl Association-sponsored event at the Sheraton Waikiki Hotel hosted by the State of Hawaii's Aquaculture Department. Dozens of exhibits, displays and speakers' forums paid homage to the 'Queen of Gems' in an effort to unify and direct the US$ 2 billion-plus per year pearl industry, which is marking the centennial of pearl cultivation.

Special attention was paid to 'perle noire', poe rava — the black pearl — hailed as a low-polluting, alternative form of economic development for small South Pacific Islands with the potential to alter Island economies. French Polynesia, the Cook Islands and Australia played leading roles in Pearls '94. As befits a jewellery convention, booths in the ballroom and foyer of the Sheraton Waikiki were highly decorated and colourful.

The stand from the French Polynesia volcanic island of Tahaa was composed of bamboo and palm thatch. Tahiti Pearls had a spacious area with stunning photo murals and a video room. Cook Islands stands exhibited wood carvings of Tangaroa, the Polynesian god of the sea, with his prominently exposed fertile phallus. Australian Netmakers exhibited samples of their pearl nets clasping oysters at the Paragon Pearling booth.

Tahiti Minister of Sea Resources Edouard Fritch said French Polynesia has 26 atolls under cultivation and is second behind Australia in supplying pearls to Japan, the top importer. Tahiti earns US$77 million annually from the gems, the Territory's top export product. White pearls have become a US$101 million a year industry in Australia. And with only about three atolls farmed, black pearls are the Cooks' top export, earning US$4.5 million a year. But as Pearls '94 forums revealed, along with the industry's potential, there could also be trouble in the pearl paradises.

The Cooks played a leading role in Pearls '94 with a sizeable contingent that included several private, as well as government, booths.

Prime Minister Sir Geoffrey Henry delivered a poetic keynote address, noting that 200 years ago, children of Manihiki Atoll played marbles with black pearls, which are today a mainstay of the Cooks economy, employing 600 people out of a population of 18,000. Cook Islander Raymond Newnham spoke on the social and political impact of black pearling at Manihiki, in the Northern Cooks. He said 'Two government institutions, including the Manihiki Island Council, failed to adapt to the new realities of pearl farming and actually hindered its development'.

During the same technical forum, Manihikian Peter Williams told a strange tale of atoll greed and jealousy. The gruff, 20-year veteran of the New Zealand military began with a Manihikian welcoming chant and then said — 'but my father didn't get this chant when he went to Manihiki'. The Manihiki millionaire stated that the development

of his family's highly lucrative pearl farm led to great social conflict at the very traditional remote atoll. At one point, the Williams had to resort to 'firearms' to protect their pearl farm from theft, etc. And a flight from distant Rarotonga to Manihiki carrying technicians to the atoll was blocked and refused permission to land.

French Polynesia's Fritch was very available to the press and gave an overview of Tahiti's black pearl industry. 'Black pearls are our number one export and account for 70 per cent of Tahiti's import/export balance, although the tourism industry generates US$200 million a year compared to US$77 million for pearl. Three thousand Tahitian families are involved in the black pearl'.

Fritch said that in its effort to keep pearling Polynesian, French Polynesia has established a black-pearl school at Polynesia's biggest atoll, Rangiroa. He said that 80 per cent of the buyers of Tahiti's black pearls are Japanese. Australia is the world's top exporter of pearls to Japan.

As a long time pearl producer, Australian expertise is assisting Oceania's developing economies. James Uan, of Kiribati's Ministry of Environment and Natural Resources, says that two of his nation's atolls are experimenting in pearl farming with the assistance of the Australian Centre for International Agricultural Research (ACIAR) and the Forum Fisheries Agency.

Gideon Tirob of the Solomon Islands' Ministry of Agriculture and Fisheries works with Dr Johann Bell, senior scientist of the ICLARM Coastal Aquaculture Centre. Dr John Benzie, of the Townsville-based Australian Institute of Marine Science (AIMS), gave a presentation on the genetics of black pearls that are farmed in French Polynesia and the Cook Islands.

Torres Strait Islander Richard Bowie attended Pearls '94 because his company Northern Star Seafood 'uses compressed air to collect up to 5,000 *Pinctada* pearl shells a day in the Torres Strait to sell to pearl farms, which cultivate them'.

Neil Sims chaired the conference's technical committee, which presented the more scientific-oriented seminars. Dr Benzie of AIMS said that pearl farming is 'pretty benign' vis-à-vis atoll ecology, a sentiment echoed by Sims: 'Pearl farming if done properly is benign, beneficial. It removes pressure from wild stocks. It's an alternative industry — there's no longer pressure for destructive fishing. It increases awareness for the long-term health of the marine environment'.

Pearls '94 termed success, '95 programme planned — *Excerpts from an article published in* The Aquaculture News, *July 1994, p. 23.*

The 1994 International Pearl Conference and Exposition held from 14 to 19 May 1994 in Honolulu may very well have set the stage for many dramatic industry changes to come in the days, months and years ahead, according to conference organisers.

Organisers report that some 645 registrants attended Pearls '94 from all corners of the globe. Seventy six exhibitors displayed their goods and services, including manufacturers, dealers, media and booksellers. An historical display of pearling artifacts and memorabilia by Hawaii's Bishop Museum was included.

The conference began with a speech by Sir Geoffrey Henry, the Prime Minister of the Cook Islands. Other notables followed in the plenary sessions held each morning. Nick Paspaley, a major force in the production and marketing of Australian South Sea cultured pearls, gave an overview of his country's cultured pearl industry.

John Latendresse, President of the International Pearl Association, spoke on North American freshwater mussels. Andy Müller, President of Golay Buchel Japan K.K., shared his expertise on the Akoya and the Japanese cultured pearl industry, followed by Dr Shohei Shirai. Salvador Assael of Assael International prepared an in-depth analysis of the worldwide South Sea Pearl Industry, followed by Martin Coeroli of the G.I.E. Perles de Tahiti speaking on the Tahitian industry and Jacques Branellec of Jewelmer Inc. providing insights on SSP production and marketing in the Philippines.

Johnny Lu, Toshio Ishida, José Romero and Jack Clarkson covered Chinese Akoya and freshwater pearl production and marketing in the Japanese, European and American markets. Fred Ward and David Federman — both noted journalists in the gem industry — gave global overviews and perspectives within and without the pearling trade.

Jewellery and technical forums followed the plenary sessions each day. Debbie Catalan, Jerry Eherenwald, Alex Edwards, Antoinette Matlins, Eve Alfillé and James Porte were among the jewellery experts whose talks and panel discussions were followed by attendees interested in dealing at the retail, marketing and consumer levels.

The technical forums encompassed some 50 or so presentations ranging from resource management to hatchery techniques, from socio-economic issues to oyster culturing in locales as diverse as Mexico, Indonesia and the Cook Islands.

Retailers attended technical forums and came away with a better understanding of the difficulties facing producers, processors, wholesalers and importers.Producers and processors attending jewellery sessions gained a better knowledge of what the retailer faces and what affects the end consumer. 'The only problem was that I couldn't be in two places at once', lamented more than one attendee.

As a result of a poll, two-thirds of the conference respondents voted to return to Hawaii with PEARLS '95. At the final general meeting, Salvador Assael and Nick Paspaley suggested holding next year's conference in Hong Kong in March to coincide with the Hong Kong Gem Show and the Paspaley auction. This would be a more convenient locale for many attendees from Asia and Oceania, would attract more registrants due to the other events being held at the same time and in the same city, and would provide better traffic for exhibitors, among other benefits.

It was finally decided to return to Hawaii in '95, with PEARLS '96 most likely be held in Hong Kong. PEARLS '95 is now scheduled for 13 to 18 May 1995 in Maui, Hawaii.

One of the most important by-products of the event was the consolidation of its sponsoring body, the International Pearl Association (IPA), which grew to some 156 members during the week in Hawaii.

At the end of the conference, the IPA redefined its mission as:

> *To unite and organise, on an international scale, the scientific, technical, sales and marketing leaders within the global pearl industry to:*

- Address issues and opportunities affecting pearl production,
- Establish an international forum within which to exchange ideas and information,
- Provide a showcase for the diversity of pearl products from all pearl-producing nations,
- Develop trade and consumer education and promotional programmes to elevate the image of pearls to rival other gems,
- Increase public awareness, interest and demand for pearls.

Major industry personalities such as Nick Paspaley, Salvador Assael, Robert Wan and Fred Ward were voted onto the Board of Directors of the IPA, and the organisation set a goal of raising at least US$2 million to establish a fund for the worldwide promotion of pearls.

Salvador Assael announced he would start the project rolling by donating US$100,000.

Others joined in, pledging support for a three-month study by an independent adviser to help evolve the means of achieving the promotional funding goal and how best to administer the monies when raised.

Pearls '94 — Technical Session review — *Excerpts from an article by Neil Anthony Sims, published in* Pearl World, *October/November 1994, pp. 2–4.*

It has taken a little time to let the dust settle, but let's now take a brief look at what actually transpired in the Technical Sessions of the first international aggregation of pearl scientists: Pearls '94.

It was exciting for us all to be in the same room together — people whose names we only knew from publications, or perhaps from correspondence or the occasional chance meeting over the years. Most of the world's pearl community — with a few notable exceptions — was present there at Pearls '94. So what was said? What are the big advances looming, and what do they mean for the industry? Did we come away any more enlightened and challenged, or more scared and protective?

As with most meetings of this nature, the quality of the technical presentations ranged widely. There was some superb science, a bit of 'interesting' and 'inferring' and 'in the future', and yes, there was also some pretty wobbly logic or dated data. There were some gleamingly well-polished presentations that were an absolute pleasure to be witness to, there was a bit of the 'dry, but fine', and yes, there were also a few that were pretty dim and drizzly.

The advanced research programmes from French Polynesia and Australia gave an impressive review of black-lip and silver-lip oyster science. Andre Intes', Phillippe Cabral's and Terii Seaman's presentations and Nathalie Cheffort-Lachhar's paper covered the state of knowledge of *Pinctada*

margaritifera biology — and what next needs to be done. Lindsay Joll and Cathy Colgan presented the work to date on *Pinctada maxima* stock assessment and management in Australia. The question of quota limitations and potential for hatchery-produced spat in Australia produced some warm debate — though it never grew heated.

A solid body of science, and some exciting breakthroughs were presented by Mario Monteforte and his team from Baja California, where they now stand on the threshold of reviving the Mexican pearl oyster stocks, and producing Mexican pearls in commercial quantities. There was much admiration for the independent, innovative approach taken by the Mexican team (who have developed nuclei production and pearl seeding techniques solely by themselves), though some questioned whether a more productive approach lay in compromise of principles to expedience.

John Benzie gave an illuminating review of some of the genetic work done to date with pearl oysters and giant clams across the Pacific —and of the need for doing more of it. John Lucas and Johann Bell presented prospects for their respective research programmes, both of which are just now starting up in Townsville, Kiribati, and the Solomon Islands.

John Rowntree demonstrated an eloquence of prose and a commanding grasp of the economics of pearl farming — as a small business and as a development tool. Raymond Newnham was refreshingly honest and perceptive in presenting the perspective of the local pearl farmer in a developing industry in a developing country. Raymond stated very clearly the means by which governments may foster a farming industry that is truly locally-owned and managed.

Francisco Borrero earned wide admiration for his work with the Columbian pearl oyster. This presentation displayed a high quality of science and an admirable clarity (particularly given that Francisco was working in his second language), as well as further demonstrating the diversity of developments happening around the world. There may well be a bunch of nascent industries displaying their first harvests and offering them for sale at Pearls '96 or '97 — Columbian, Mexican, Iranian, Kuwaiti, Marshall Islands, Hawaiian, Solomon Islands, Kiribati, . . .

The Technical Session speakers never addressed whether they foresaw a problem with potential over-production from such a plethora of new farming sites, but then they really didn't need to. The Jewelers' Session seemed to answer that question very nicely by highlighting the potential size of the market out there — if only there were a greater effort made in promotions. There was also much emphasis on the potential for growth of the 'boutique' market — stressing the uniqueness of species and farm location to the consumer, and having them more aware of the diversity of pearl oysters and pearl products.

The take-home message from the technical sessions was that the industry is going to expand, regardless of whether there is ever another pearl conference. The mantra from the jewellers sessions was that the emphasis must always be on maintaining or improving quality of the product. By coming together to talk and share ideas, scientists and farmers can ensure that we don't just grow more pearls, but that — first and foremost — we grow better pearls.

The 'notable exceptions' who weren't present were missed, but it certainly didn't detract from the contributions of those who were there. The most meaningful work transpired not in the formal sessions, but in the personal contacts, in quiet conversations in the conference corridors, or in the corners of bars, or of course — this being Waikiki — on sundrenched lanais with the spectacle of surf and sand and sky all around. It was a glorious week, it was wonderfully productive, and it was unbelievably educational.

Editor's note : For a complete listing of titles from the Pearls '94 Technical Sessions, and selected abstracts, please refer to p. 38 in the Abstracts, Reviews and Current Contents section. Please also note the upcoming Pearls '95 details in the Conferences, Meetings and Workshops section on p. 54.

Tahiti's first annual pearl and jewellery festival

Cultivating black pearls into a regional business — *Excerpts from an article published in* Islands Business Pacific, *September 1994, p. 45.*

French Polynesia pioneered the South Pacific's cultured black pearl trade. The Cook Islands began copying it six years ago and are already making a modest multi-million dollar annual killing. Now the Solomon Islands, Vanuatu, Tuvalu and Fiji are wondering whether they can join the act. In Fiji, in a secluded spot on the north-east coast of Viti Levu, a lone Japanese who would now like to retire has been growing black pearls for a quarter of a century.

But French Polynesia still easily commands the field, producing 95 per cent of world black pearl output. Exports, which exceed two tonnes annually, fetch the French territory more than US$30million a year. They are by far its most important foreign-exchange earner after tourism.

Festival

For four days the trade mounted Tahiti's first annual Pearl and Jewellery festival in Papeete, where the town council signalled its support by proclaiming the territorial capital to be officially designated as 'City of the Pearl'. The festival is intended to promote black pearls to the international market and preserve the territory's dominance as the number one supplier. 'The high growth of pearl production between 1991 and 1993 (73 per cent) needs more than ever a stimulation of the trade to diversify our markets and allow us to meet at best price the specialised needs of each market', according to *Perles de Tahiti*, a company set up in 1991 by the territorial government and two organisations representing over 80 per cent of production – the *Syndicat professionnel des perliculteurs privés* and *Poe Rava Nui*.

Japan normally buys 80 per cent of Tahiti's output, followed by the United States (7.2 per cent), Switzerland (6.8 per cent), Hong Kong (2.24 per cent), Taiwan (0.95 per cent) and France (0.8 per cent). About US$3 million-worth are sold locally, with an estimated 55 per cent bought by tourists.

ACIAR Research Programme

JCU research set to help launch South Pacific pearling industry — *Excerpts from an article by David Russo, published in* JCU Campus News, *Vol. 6 (2), 1994, p. 1.*

Marine scientists at James Cook University (JCU) have been awarded the task of helping to establish a South Pacific cultured pearl industry and at the same time replenish blacklip pearl oyster stocks.

JCU will collaborate on the project with the Queensland Department of Primary Industry, the Kiribati Ministry of Natural Resources Development, the Solomon Islands ICLARM Coastal Aquaculture Centre, and the South Pacific Commission.

The three-year A$600,000 project will re-examine the processes involved in the handling and rearing of blacklip pearl oysters, particularly overcoming high oyster mortality rates and increasing productivity rates.

It will also investigate the possibility of rearing larval oysters in open-enclosure systems in the ocean.

The project is being funded by the Australian Centre for International Agricultural Research and will utilise JCU's Orpheus Island Research Station.

It follows the outstanding success of the JCU co-ordinated Giant Clam Project which developed rearing techniques for restocking reefs along the Great Barrier Reef and throughout the South Pacific.

Co-ordinator of the Pacific Island Pearl Oyster Resource Development Project, Professor John Lucas, said a research team would assess the natural blacklip pearl oyster stocks of Kiribati and Fiji, and juvenile settlement in atoll lagoons of Kiribati.

He said the development of appropriate low-technology hatchery and nursery culture methods would provide oysters for shell or pearl culture and restocking.

The yield of pearls should also be improved through better bead insertion and oyster management practices.

Prof. Lucas said the project would have large economic benefits for small island nations of the Pacific, especially Kiribati, the Solomon Islands and Fiji.

'The remote location of many of the small island nations of the Pacific means they have limited opportunities for export trade.

'Feasible industries must revolve around non-perishable or high-value products, which makes the development of a cultured pearl oyster industry very attractive'.

'In many Pacific countries natural pearl oysters are not capable of supporting an industry based on the collection of wild stock. Rehabilitation of wild pearl oyster stocks to levels which are capable of supporting regular harvesting, and can sustain flexible and economically viable pearl culture operation, has the potential to provide major export earnings.'

While Professor Lucas is the overall Project Co-ordinator, Zoology Lecturer Dr Paul Southgate will act as project leader for JCU. The Department's Research Officer Hiro Ito will also assist in the project.

Cook Islands' Government farm produces disappointing results

Excerpts from an article published in Pacific Magazine.

Officials are not happy with the results of the first (government-owned and operated) cultured black pearl harvest on Manihiki Atoll where pearl farming was established 10 years ago.

Tuingariki Short, Secretary of the Marine Resources Ministry, said that of the 9,000 pearls that were seeded in 1992, 1,200 were lost and only 36 per cent of the remaining oysters produced pearls. After grading and valuation, the pearls were to be sold to a New Zealand wholesaler.

A new management plan has been introduced that is expected to help increase the yield from the next seeding.

Pearl production in the Great Barrier Reef

Sea farm proves pearler idea — *Excerpts from an article by Eugenie Navarre, published in* The Sunday Mail, *21 June 1994, p.102.*

While most women venture into an exclusive store to buy their pearl jewellery, Carly Foggin grows her own.

Pearl farming has become a fascinating new way of life for the Cairns housewife. Her Coral Sea pearl crop is top quality stock. Carly and her seafaring husband John took the gamble of starting the Arlington Pearl farm on the Great Barrier Reef in 1989.

After a successful initial harvest of black *margaritifera* pearls in December last year the couple are optimistic their venture will be worth the initial A$500,000 outlay for experimental seeding, wages and a pontoon on the Reef.

The warm tropical waters of the Great Barrier Reef are proving ideal for the valuable South Sea pearls. The tourism side of Arlington Pearls is now run by Sunlover Cruises, who bring thousands of tourists.

Sunlover gives tourists the opportunity to view pearls growing on long lines and at various stages of development and to buy matured pearls from the first Arlington harvest.

'When we started we had no idea if the water here would be suitable for pearls,'Mrs Foggin said. 'Initially we had to build a pontoon on the reef, which is now manned by one of our staff.

'He lives out there on the reef playing nursemaid to thousands of oysters'.

The Foggins are waiting for their first harvest of white *maxima* pearls at the end of this year.

Mrs Foggins said the pearling industry was dominated by Japanese experts who kept their tricks of the trade shrouded in secrecy. The pearls are seeded and harvested by the Japanese experts.

'They call it a black art,' she said. 'The Japanese technicians won't give away their art to anyone'.

'They come to do the seeding every two years — it takes two years to grow a pearl and the same oyster can be used two to three times.'

The company exports dried oyster meat and is also developing its own pearl hatchery on the reef offshore from Cairns.

Mrs Foggin is in charge of the retail side of the business — the production of pearl jewellery sold to the Sunlover tourists.

'The more you see of pearls the more you like them and every time you handle one you see something different in it. They just grow on you,'said Mrs Foggin, who has the cream of the first Arlington black pearl crop in safe-keeping waiting to be made up into a personal piece.

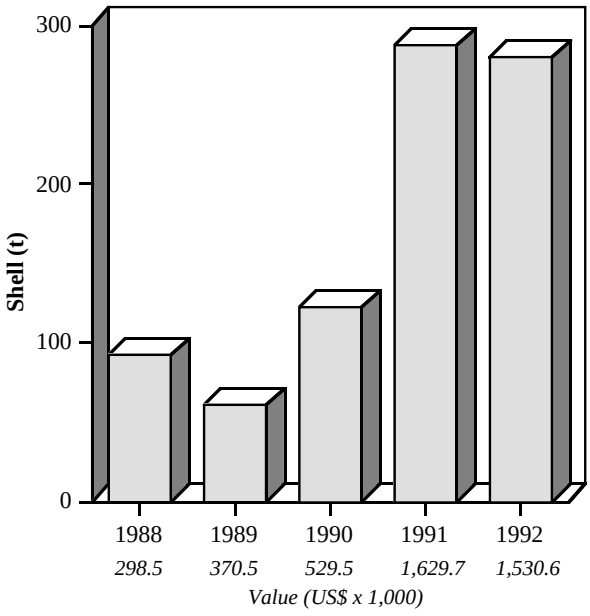
Pearl shell production in Indonesia

Notes on pearl oyster (Mutiara) shell production in South Sulawesi Province, Indonesia — *Article by Dr Rick Braley, Marine Science Education Project (UNHAS), Ujung Pandang, South Sulawesi, Indonesia.*

In a recent issue of the Pearl Oyster Bulletin, I presented information on the production from Maluku Province, Indonesia, for several years up to and including 1991.

I have also obtained from the Provincial Fisheries Department (Dinas Perikanan, Ujung Pandang) data from annual statistics. The table and the figure are based upon these records. The largest increase in production was between 1990 and 1991.

The level remained nearly stable in 1992, but with a slight reduction. The relatively low price / tonne paid in 1988 may have discouraged some fishing for at least part of 1989, thus raising the value in that year. The price / tonne dropped in 1990, along with a doubling in production.



Information based upon Dinas Perikanan, Ujung Pandang records of pearl oyster shell production for South Sulawesi Province

Year	% increase (+) or % drop (-) in total shell weight from previous years	US$/tonne
1988	—	3,250
1989	-33.6	6,080
1990	+100.8	4,330
1991	-134.8	5,670
1992	-2.6	5,470

The large increase in production in 1991 was accompanied by a sizeable increase in value / tonne. The records are not clear enough to know how much, if any, of this shell production came from pearl culture operations.

Pearl oyster and freshwater mussel training courses in the Philippines

Article by Daisy Ladra and Virginia Luyun, Bureau of Fisheries and Aquatic Resources, 860 Arcadia Building, Quezon Ave., Quezon City, Philippines.

In an effort to develop the pearl resources of the Philippines, pearl production training has been initiated by the Bureau of Fisheries and Aquatic Resources this year. Pearl is the eighth largest dollar earner of the Philippines. As of 1991, the industry was worth US$ 36,000,000. The Philippines is able to obtain this amount through export of raw and polished pearl oyster shells, shell buttons and pearls.

The pearl oyster / freshwater mussel training is a basic course designed to develop technical know-how in pearl oyster / freshwater mussel farming and pearl production.

The course runs for a week and covers both theoretical and practical aspects of farm set-up, basic surgical techniques for pearl production, oyster / mussel anatomy and biology, farm operation and maintenance and spat collection. A field trip to a pearl farm is the culminating activity for the course.

The training is also intended to provide the participants with skills which they can immediately apply in their work.

Two courses have been conducted for this year, one for marine pearl and the other for freshwater pearl. The first was held in Zamboanga City under the auspices of Land Bank and the Agricultural Training Institute. The second course, which centred on freshwater pearl production, was held at the Regional Fisherman's Training Center in Tabacco, Albay. Both courses were attended by 18–19 participants coming from the banking sector, private investors and extension workers from the government.

Surgical equipments, shell beads and nets can be manufactured in the country.

From whence cometh '*Pinctada*'? — The mystery of the etymology of the genus

Mr Andy Muller, of Golay Buchel Japan, K.K., requested information on the precise meaning and the etymological root of Pinctada. *Beatrice Burch (Fax: (808) 2646408), of the Bishop Museum in Honolulu kindly did the bloodhound work, and provided the following in reply to Mr Muller:*

I thought that I'd have no trouble in finding out the meaning of Pinctada, *but I was wrong. Finally, I phoned the Chairman of the Classic Language Dept. at the University of Hawaii and he said that the word was not Latin or Greek, and certainly wasn't French, but a made-up word.*

When I told him that it was originally used by Roeding in 1798 for a genus name, he was surprised. I talked also to the modern language teacher who agreed that it had no meaning. How Roeding used it, I've no idea.

Linnaeus in the 10th edition of Systema Naturae *in 1758 used the genus* Mytilus *and the species of* margaritifera *as Neil Sims has said.*

Gmelin in the 13th edition of the Systema Naturae *also used* Mytilus margaritifera. *He did include more references, but neither he nor Roeding did more than just use the word with no explanation. See Gmelin and Roeding (or Röding).*

I would suggest that with your interests that you try to obtain a copy of the Ranson 1961 article. It is delightful, full of information Of course, it is in French.

So all I can say is, the authorities that I consulted, including the professors of the various languages at the university, do not think that Pinctada *is a real word, nor that it could mean bivalve. Our various dictionaries of Latin, Greek, French, German and Spanish only list* Pinna *as meaning bivalve.*

Yes, margaritifera *does refer to pearl and pearl forming. You will note that Roeding said under* Pinctada, *'Die Perlmutter', or 'mother-of-pearl'. Our New Cassell's German Dictionary has a lot on perl–erl this or that, including perl muschel and perlmutter.*

So perhaps what Röding was trying to say was that Pinctada margaritifera *was a mother-of-pearl (Those pearls from it were rare then, as now, and the mother-of-pearl was more striking than even the pearls formed). Had Röding known of the gorgeous Australian* Pinctada maxima*, then that would have been as much of a thrill to him as it is to us today.*

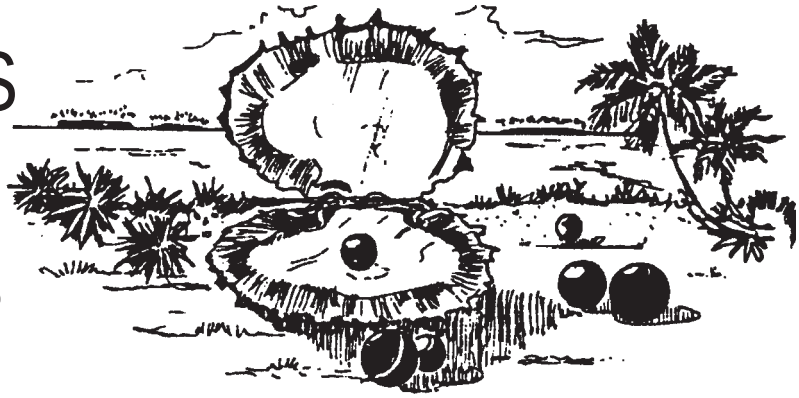
I hope that this rather confusing summary of my last two weeks of looking for Pinctada *is satisfying to you. Certainly, I enjoyed it and learned a great deal.*

By the way, I checked through the Henry Dodge series on 'A Historical Review of the Mollusks of Linnaeus', published as seven parts on gastropods, to see what he said in general about the Gmelin 13th edition of Systema Naturae*, Röding etc., and, while not on bivalves, it was interesting in that it had the sort of comments that I'd hoped for.*

He didn't agree always with Gmelin, thinking it somewhat mixed up, not in just one species, but in several. Too bad this sort of analysis wasn't done for the bivalves. The series is incomplete due to the failure of the author's eyesight. Consequently there are just seven parts to this series put out by the Bulletin of the American Museum of Natural History *in the 1950s. I guess the closest thing that we can have is just the listing in the Ranson article.*

You can see from the Ranson article that he tried to be very thorough with locating literature and specimens of pearl oysters. He, by the way, has P. fucata, P. fucata martensi, P. radiata, *etc. But he places* P. galtstoffi *under* P. margaritifera*, whereas Shirai maintains it as a separate species. Shirai in his new identification manual puts* P. radiata, P. fucata *and* P. fucata martensii *under* imbricata *and doesn't give any reasons for that lumping.*

EXCERPTS AND ARTICLES



A review of pearl farming in Australia

Excerpts of an article by David 'DOS' O'Sullivan, published in World Aquaculture Magazine, *June 1993, Vol. 24 (2). pp. 38–42. David 'DOS' O'Sullivan can be contacted at The Key Centre for Teaching and Research in Aquaculture, University of Tasmania at Launceston, P.O. Box 1214, Launceston, Tasmania, 7250, Australia.*

The pearl culture industry is Australia's most valuable aquaculture industry. It began in 1956 when a pearl culture farm, Pearls Proprietary Ltd. (PPL), was established as a joint Australian-Japanese venture at Kuri Bay, 420 km north of Broome, Western Australia. By 1973 Kuri Bay was reported to be producting around 60 per cent of the world's finest round pearls, as well as half pearls and non-round ('baroque pearls').

Species and farms

Several species are cultured, although the majority of the production is from the silver-lipped or golden-lipped pearl oyster (*Pinctada maxima*). There is some limited production of the Shark Bay pearl oyster (*P.albina albina*) for small pearls. Other species include the black-lipped pearl oyster (*P.margaritifera*) and the winged oyster (*Pteria penguin*).

The majority of pearl production still comes from north-west Western Australia, where there are now 13 companies operating . In the past 2–3 years there has been some renewed activity in the Northern Territory, with six new licences, and in Queensland, with 12 new farm licences.

Farming methods

Collection of oysters (known in the industry as 'shell') takes place by divers, mostly along the Eighty Mile Beach area, in the north-west of Western Australia. Other collecting areas are in Northern Territory and Queensland.

Due to the limited supplies of shell, each company operates under a shell quota which they can collect during the 'fishing' season which runs between March and September. Up to six divers are towed underwater behind each boat and up to 10 dives a day may be undertaken. The use of hookah breathing apparatus gives the divers great mobility in the water and allows a high catch rate with reduced risk factors.

Once collected, the shells are cleaned, sized and placed in specially designed net panels. These are almost universally used in the industry and hold either six or eight shells in individual pockets. They can be made of braided polypropylene twine or from extruded plastic mesh supported by a stainless steel or plastic-coated steel frame.

The net panels containing the shell are clipped onto longline which sit on the bottom of the seabed. As most companies now operate on the pearl shell at the collecting grounds before transporting them to the growout leases, the shell may remain on the longlines for a couple of weeks until the pearl 'seeding' is undertaken.

On completion of the seeding operation, the shells are returned to the net panels and clipped back onto the bottom longlines. The shells may remain in the these holding leases for up to three months.

During this time the shells are turned regularly by divers to ensure that the oyster develops an even envelope of tissue (the 'pearl sac') around the nucleus.

This tissue deposits nacre or mother-of-pearl on the nucleus and this continues throughout the development time of the pearl, usually two years.

After the turning programme has been completed, the net panels are retrieved and transported by boat in tanks full of seawater to the growout farms. During this transport process a high water exchange is maintained to reduce stress on the shells. This transfer is usually undertaken before the beginning of the wet season (December) to take advantage of the improved growing conditions.

The traditional Japanese method of pearl culture using rafts is no longer practised. The major departure is the holding of pearl oysters on or near the seabed, where they are less vulnerable to cyclonic conditions.

The net panels can be held on individual posts or on 'fences' constructed from rows of pickets with a line strung from end to end. These bottom farming techniques require divers to carry out routine work such as cleaning of the shell and maintenance of the culture equipment.

In the last few years more companies have favoured holding the oysters in net panels suspended on longlines. This enables farming to be undertaken in areas where diving is not possible (e.g. due to the presence of crocodiles or strong currents) or where the sea-bottom types do not favour pearl growth.

Both farming techniques have merit. Surface farming is cheaper to conduct but requires relatively well-protected farm sites. Bottom farming is able to exploit more exposed but otherwise more conveniently located farm sites, although at a greater operating expense due to the high cost of using divers.

During the two-year culture period, the shells are regularly cleaned, either underwater by divers or on the surface with high-pressure washing machines on service boats. Experience has shown that the cleaner the shells are kept, the faster the pearls will grow.

The shells are X-rayed approximately six months after operating to check for the presence of a pearl. The shells containing pearls are returned to net panels and the water, while those in which the nucleus has been rejected are held for 're-operating' the following year.

Some shells have been known to produce four round pearls before being considered unsuitable for further round pearl production.

Problems

The heavy mortality due to *Vibrio* infection which used to occur during transfer of the shell from the fishing grounds to the farms has been almost eliminated by improved handling techniques.

The industry is jointly controlled by the Federal and State Governments, and this has slowed changes or updates in regulations. Other problems constraining development include industry fragmentation and low levels of research. Positive steps include the formation of a Pearl Producers Association and a review of the Western Australian industry which provided a range of recommendations for future development.

The industry has also been limited by widely varying spat falls, resulting in a quota system for shell collection. Early work by the Western Australian Fisheries Department into hatchery production of pearl oyster spat has been expanded through the establishment of three private hatcheries (two in Western Australia and one in the Northern Territory). Their success has been limited so far, but progress is being made in increasing production levels.

The effect of increased pearl production that will accrue from the additional hatchery-produced shell is not yet clear. Some market analysts predict that prices will drop below current levels, and this could create difficulties due to the relatively high operating and capital costs involved with pearl farming.

Others suggest that the higher quality and consistency of supply from the Australian pearl producers will either expand the world pearl market or replace some production by competitors from other countries. Two opportunities for increasing the value of production are value-added exports (i.e. finished jewellery rather than raw pearls) and an expanded domestic market.

Production and value

Most of the Australian pearl production comes from Western Australia; in 1990–91, it was estimated to be worth A$126.2 million (see Table on page 14). Despite a softening of pearl prices, this is an increase of A$32 million over the 1989–91 value. While no official figures were available, production in Northern Territory and Queensland appears to be around A$50–60 million.

Estimates of Australian aquaculture production of edible oysters and pearl oysters in 1990–1991

Species	Value (A$)
Sydney rock oysters	29,253,000
Pacific oysters	10,653,000
Native oysters	72,000
Tropical oysters	149,000
Pearl oysters	126,187,000
Sub-total for oysters	**166,314,000**
Australian aquaculture industry total	**237,321,000**

Sources: information provided by State and Territory fisheries/agriculture departments and industries

Most of the Australian pearls are exported to Japan, where they constitute about 30 per cent of the market value.

Half pearls are marketed independently of the round pearls and may fetch between A$5 and A$17 each. Small numbers of half pearls are retained for jewellery manufacture in Australia. When they are a 'worked piece' of jewellery, the half pearls sell for around A$50 each.

Shell which has not been used for half pearl is sold on a weight basis for its mother-of-pearl (M.O.P). In the late 1980s M.O.P. was a highly-sought-after commodity, particularly by Asian and European countries, fetching up to A$10,000 per tonne. Due to an over-supply, prices have dropped to around A$2000–4000 per tonne, with a number of farms stockpiling shell until the prices rise again. A small industry in Australia manufactures jewellery and ornaments from the shell, while some carvings are re-imported from Asia.

The meat of the adductor muscle is considered a delicacy in some parts of Asia, fetching up to A$80 per kilogram in 1988. However little production is currently undertaken.

Prospects

Production in 1991–92 from Western Australia, the Northern Territory and Queensland is expected to continue to increase in value to over A$200 million annually. While the market outlook is a little uncertain due to competition from overseas (especially Indonesia), given the emphasis on quality pearls and consistency of supply, the prospects for the Australian pearl industry are still very good.

Australian pearl diving and pearl culture development

Farming jewels of the sea — *Excerpts from an article by Bernie Aquilina, published in* Australian Natural History, *1993, pp. 46–53. Berni Aquilina has worked in the Australian pearling industry for nine years. She is presently a pearl technician and research officer with Paspaley Pearling Company, Darwin.*

Today the Australian pearling industry is based on cultured pearls grown by the silver-lipped pearl oyster (*Pinctada maxima*), a species that grows naturally in the warm, tropical waters of Thailand, Burma, Indonesia and the Philippines, as well as off the coast of northern Australia. This species is preferred on account of its large size and thick nacre. Shells can be at least the size of a saucer. One old and very large specimen measured 25 by 28 cm — the size of a dinner plate!

In Japan the smaller Akoya pearl oyster (*Pinctada fucata*) forms the basis of a huge industry for pearls ranging in size from about three to ten millimetres. Although the Australian industry produces far fewer pearls, it is able to compete on the world market by producing pearls of a greater size. Australian cultured pearls begin at 10 mm diameter, and pearls as large as 15 mm diameter are not unusual. The largest cultured pearl I have seen measured 20.8 millimetres across — about the size of a five cent piece.

Australia's first cultured pearl farm was established in 1956 at Kuri Bay, north of Broome, Western Australia. But Australian pearling has a history dating back to the last century. The industry was based then upon the sale of mother-of-pearl, obtained from the same species of oyster and prized for the thickness of its nacre. It was primarily used

for the manufacture of buttons and, to a lesser degree, for instruments, dials, inlay work and the like. Pearls, when found, were considered a bonus rather than the mainstay of the industry.

By 1912 Broome was considered the pearling centre of the world, supplying 75 per cent of the world's output of mother-of-pearl. Much of the aura of adventure and romance surrounding the pearling industry is linked to that period, when divers wore full diving dress and 'hard-hat' helmets, rather than the wetsuits used today.

In fact, for the most part, the divers and other crew members of the early pearling fleets led lives of monotonous hardship. They were often at sea for months at a time, working long hours and enduring little variation in their diets. Pearling was a hazardous occupation. Lugger crews were unable to forecast the approach of cyclones or other storms, although divers could sometimes predict them by sudden temperature changes under water and by the ground swell.

A sudden drop in barometric pressure signalled the imminent arrival of a cyclone but often the boats were far from any safe anchorage and were compelled to ride out the storm as best they could. Massive loss of life and equipment could result. In 1935, for example, what was described as a 'very violent Willy Willy' devasted a pearling fleet working at the Lacepede Islands north of Broome, killing an estimated 141 people.

'The bends', a form of decompression sickness, was another frequent affliction of divers that often led to loss of life. The disorder is caused by nitrogen bubbles forming in the bloodstream or body tissues following too rapid an ascent.

The most common symptom is joint pain, which tends to be relieved by holding the affected limb in a bent position – hence the colloquial name. The nervous system may also be affected, causing headaches, loss of consciousness, paralysis and death.

At the turn of the century, the Queensland pearling fleet alone incurred between 10 and 25 deaths each year, three-quarters of them due to paralysis and most of the others resulting from suffocation due largely to inexperience in use of equipment.

Today pearl divers are at far less risk. Advances in meteorological forecasting and communication systems have enormously reduced the risk of cyclone damage. Better understanding of the physiological impacts of diving and development of 'dive-tables' stipulating safe diving and recompression times have dramatically reduced the incidence of the bends. And should an unlucky diver suffer decompression sickness, a recompression chamber and medical aid are just a short seaplane trip away.

A more common diving hazard is the sting of the Irukangdji jellyfish (*Carukia barnesi*), named after a northern Queensland Aboriginal tribe. This seemingly insignificant creature has a body size of a thimble, but also has four almost invisible tentacles up to 65 cm in length and containing extremely toxic nematocysts (stinging cells) that affect the victim by producing acute abdominal pains, cramps, profuse sweating, vomiting, respiratory stress and increased blood pressure.

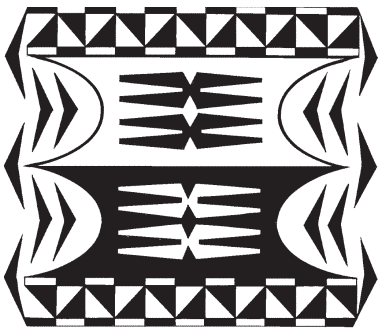
While a sting is not likely to cause loss of life, extreme pain can result. In order to protect themselves from such stings, most divers wear hoods, protective flaps around their regulator mouthpieces and long gloves in addition to their wetsuits.

The pearl diver's task of collecting oysters from the wild is only the first stage in the long process of culturing a pearl. A silver-lipped pearl oyster is usually about two to three years old and 13 cm long when it is picked up by a diver.

It is taken up to the catching boat and cleaned of fouling growth before being placed with other oysters into panels of net pockets stretched over a frame. The panels are returned to the ocean floor until the season's quota of oysters (issued by the Fisheries Department) has been caught.

The total quota for the Western Australian Industry is approximately 500,000 oysters per year, with individual companies having quotas of between 15,000 and 100,000 oysters.

The 'fishing' period usually runs from April to July, but is dependent upon seasonal factors such as weather conditions, underwater visibility and densities of wild oyster stocks.



Not all seeded oysters will grow a pearl. Several reasons for failure are possible: the nucleus may be pushed out of the oyster's body by muscular activity; the cells of the graft tissue might die; or the graft tissue may not be correctly aligned against the nucleus. It is unlikely that even a highly skilled technician would have more than about a 70 per cent success rate. Some months after being seeded the oysters can be X-rayed to identify any that have rejected their nucleus. These can then be re-seeded.

The Australian pearling industry has always had a strong input by the Japanese. In the early mother-of-pearl industry, Japanese were found to be the most successful hard-hat divers.

Later, Australians became dependent on the Japanese for their knowledge of the pearl culturing process. One reason for this is that because, in Japan, early pearl culture experiments were encouraged by the government and led to successful techniques being developed early this century.

In contrast, the Western Australian Government prohibited the artificial culture of pearls from 1922 to 1949, in what was a misguided attempt to protect the mother-of-pearl industry (which was to collapse, anyway, after World War 2, following the development of plastics). Thus the Japanese were in a position to provide technical expertise and financial backing for the Australian pearl industry and they remain a strong force today. Indeed, nearly all technicians currently working in Australia are Japanese-born.

The future outlook for the Australian cultured pearl industry is one of development and change. Hatcheries are being established to breed oysters, reducing the need for divers to collect them from the wild. Indonesia already has several silver-lipped oyster hatcheries, and has the potential to influence the Australian market. In recent years the Australian Government has sought greater skills transfer from the Japanese through the training of Australian pearl technicians.

However, because of the close and long-standing business arrangements that exist between many Australian and Japanese pearling companies (including the exchange of pearls for the use of Japanese seeding technicians, for example), change is sure to come slowly. But whatever happens, one thing is certain: the future of the Australian pearl industry will remain as fascinating as its past.

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Quota increase in Western Australia

Excerpts from an article published in Western Fisheries*, Spring 1993, p.15*

Boost of pearling

Additional quota has been allocated for Zone 1 (Exmouth to Port Hedland) of the WA pearl fishery to boost pearl farming.

Recommended by the Zone 1 selections committee, the new arrangement will commence within three months.

An extra 60,000 pearl oysters are divided between five licencees and will be subject to conditions monitored by the Fisheries Joint Authority. Employment opportunities and diversification of industry in the region are also seen as potential benefits.

Pearl competition from Asia steps up. . .

Excerpts from an article by Don Kirkwood, published in Business Queensland, *23/8/93*

Australia's A$ 200–300 m pearl industry could be threatened by competition from Asia if it does not upgrade its techniques, according to Bruce Stevens, managing director of Reefarm Hatcheries. 'We've got to improve our genetic stock', he says. 'We've just collected our stock from the wild. There's been no selective breeding'.

Reefarm hatcheries produce the high-quality boutique pearl, the highest-priced pearl in the world, fetching from A$400 to A$80,000 each.

He claims that, using techniques developed in Australia, the Indonesian industry is establishing hatcheries, and may well be able to produce higher-grade pearls in future.

He says 'Australian pearl farmers have high labour costs, but hatcheries can produce spat for A$3 each, compared with A$20 each if they're gathered from the wild.'

The natural pearl shell populations in French Polynesia

Excerpts from Atlas de la Polynésie française *(chapter written by André Intes)*

Past over-harvesting of natural pearl-shell stocks has caused widespread depletion of oyster-producing lagoons at the same time as the development of pearl culture requires increasing quantities of oysters. Studies carried out before 1960 showed a progressive decline in stocks and proposed measures to conserve or rehabilitate this resource. None of these recommendations have been implemented, probably because almost all were based on techniques similar to those used in oyster farming (spat collection, oyster beds, husbandry), in which local communities had no faith.

Only when there was no choice but to consider the resource completely exhausted, and when the initial grafting tests demonstrated the product's high commercial value, the techniques proposed, by the Fisheries Service in particular, werequickly adopted.

Since then, exploitation has undergone a complete transformation, with objectives and techniques being radically changed. Only the targeted resource 'i.e. natural stocks' has remained the same. These are still exploited because controlled breeding tests carried out from 1976 to 1979, and those currently under way, have not yet allowed large-scale production of spat.

In 1983, fishing by skindivers still supplied nearly 80 per cent of oysters for grafting, but this harvesting of adult animals will be eliminated soon. Spat collection, for which effective techniques have been developed both by the Fisheries Service and by the Institute for the Promotion of Aquacultural and Maritime Activities (EVAAM), will become the only supply source for professionals, as in Japanese pearl farming.

Having stated these development prospects, the resource's biology as well as its numerical strength remain incompletely understood and must be more closely studied in order to promote pearl culture. This is a very difficult problem, however, for there are as many stocks as there are lagoons and each one has it own characteristics.

For the moment, the scattered geographic locations of the lagoons makes a Territory-wide assessment impossible, but relatively complete information is available on some stocks, such as the one in Takapoto atoll in the Tuamotu Archipelago. This atoll has always been among the principal pearl-shell production centres. Its maximum annual production has been estimated at about 400 mt. In the 1950s, harvests remained large and exceeded 100 mt during some seasons (1955,1957). During 1982–1983, ORSTOM and EVAAM carried out a study and assessment of this stock. The findings are described below.

Stock distribution

Pearl oysters live in shallow depths of up to 60 m, clinging by their byssus to the coral substrates which form their biotope in the atoll lagoon. In this

biotope, abundance varies according to ecological parameters and fishing pressure. These factors determine the distribution of the pearl-shell stocks.

Mean densities, even if they do not allow abundance in the lagoon to be determined absolutely, are a good way of describing stock distribution.

Density measurements

Densities are determined by divers who count oysters along transects. Each strip surveyed by a diver measures 2.5 m in width, i.e. 5 m for a team of two divers. The number of pearl oysters found every 10m is noted. The typical 50 m long line is considered to be the basic density survey unit and corresponds to a sampling area of 250 m^2.

Surveys carried out in 1984 over the entire area of the lagoon have allowed density distribution in Takapoto Lagoon to be described in terms of depth and location. Vertically, depth layers or strata 10 m thick were used. Horizontally, there are three fishing zones, with a reserve area making up a fourth, at the southern end of the lagoon.

This two-dimensional division is of practical interest for stock exploitation; legal fishing is carried out by free divers, leaving the more shallow strata more exposed to harvesting. Fishing seasons are opened on a rotational basis in the various areas. The overall results obtained have been expressed in term of mean densities in Table 1.

The reserve area returns the highest densities, especially in the surface layer. In Area 1, the average density gradient increases with depth. The same trend was observed in Areas 2 and 3, especially if the 0–20 m layer is considered as a single unit. It is probable that this gradient inversion between the reserve area and the fishing areas is linked to both legal and illegal harvesting.

The deepest area of the lagoon, with a depth of more than 40 m, is limited to Area 2 and showed only low densities. These trends by area were also found in the other strata, with the highest densities observed between 20 and 40 m, that is to say, for all practical purposes, beyond the reach of most skin divers.

These observations tend to show that the still relatively productive lagoons, either overall or in specific locations, have densities of around one oyster per 10 m^2.

These average densities allowed Takapoto to be compared with other lagoons where similar studies were carried out between 1982 and 1984, as shown in Table 2.

Table 2: Mean densities of pearl oysters per m^2 in some French Polynesian atolls

Atoll	Mean density	Standard error
Scilly (Society Islands)	0.10	0.09
Takapoto (Tuamotu Group)	0.09	0.07
Gambier Islands	0.02	0.05
Hikueru (Tuamotu Group)	0.01	0.01
Manihi (Tuamotu Group)	0.01	0.01

Table 1: Densities of pearl oysters per m^2 and by area depending on depth

Depth	Mean number of oysters per square metre				
	Reserve	Area #1	Area #2	Area #3	Mean
0-10 m	0.24	0.07	0.04	0.03	0.09
10-20 m	0.12	0.08	0.02	0.02	0.06
20-30 m	0.17	0.11	0.07	0.07	0.10
30-40 m	—	0.13	0.14	0.08	0.12
> 40 m	—	—	0.02	—	0.02
Mean	**0.18**	**0.09**	**0.06**	**0.05**	**0.09**

These lagoons are divided into two groups, whose densities vary considerably. The first group (Scilly – Takapoto) recorded one pearl oyster per 10 m^2, while in the second group (Gambier – Hikueru – Manihi), no more than one or two pearl oyster were observed for every 100m^2.

In Manihi and Hikueru, the margin of error is very small and corresponds to a relatively uniform stock where all the densities observed were low.

The situation is different in the Gambier Islands, however, because high densities do occur, particularly in the area of Aukena (one pearl oyster per 2 m^2), at depths of less than 10 m.

These observations tend to show that lagoons which are still relatively productive sustain densities of around one pearl oyster per 10 m^2, either overall or in specific locations.

Density is very important for reproduction, because successful spawning depends heavily on the number of gametes released and on simultaneous spawning by the parental stock. These two aspects, called mass effect (the quantity of sexual cells) and group effect (spawning by one animal induces that of its nearest neighbours) are fundamental elements of stock management.

Stock assessment

In addition to the density measurements described above, it is important to know the extent of the pearl oyster biotope in order to estimate the stock's size.

Extent of the biotope

The limited penetration depth of satellite telemetry techniques does not allow all hard lagoon substrates to be surveyed. In contrast, echosounding eliminates bathymetric constraints and permits a sampling effort proportionate to the size of the lagoons surveyed, which can vary from 80 to 300 km^2. The presence of coral structures shows up the recording as irregularities in the relief and a thicker trace.

In Takapoto, 12 transverse radials were used to estimate the area of the lagoon floor. The area of the biotope favourable to oyster growth represented about 65 per cent of the developed area of the lagoon floor, of 83 km^2.

This relatively large area should not be surprising, as it is known that more than 400 coral patches and pinnacles rise above the sediment to emerge at high tide and that the number of lesser-sized structures, especially those invisible from the surface, is even greater. The surface area of coral slopes and walls is thus considerable.

Using information on the extent of the biotope and average densities by strata, the stratified sampling technique allows the size of the lagoon population to be calculated (figures are given in Table 3).

Scilly Lagoon in the Society Islands is twice the size of the Takapoto lagoon, and has higher mean densities, but as the biotope is proportionally much less developed, its total population is only 5.5 million specimens compared with 7.5 million in Takapoto.

Table 3: Pearl shell population of Takapoto lagoon

Depth	Pearl shell population				
	Reserve area	Area #1	Area #2	Area #3	Total Lagoon
0 - 10 m	220,000	65,000	65,000	50,000	400,000
10 - 20 m	320,000	435,000	205,000	110,000	1,070,000
20 - 30 m	325,000	1,210,000	800,000	750,000	3,085,000
30 - 40 m		500,000	1,600,000	700,000	2,800,000
> 40 m			122,000		122,000
Total	**865,000**		**2,210,000**		**2,792,000**

Biomass

A regular monthly sampling carried out in Takapoto lagoon over a one-year period allowed the average weight of specimens by size to be calculated (Table 4).

The population's demographic structure was deduced from a series of measurements taken by divers, as depicted in Figure 1.

From a combination of these various approaches, stock biomass can be calculated in three different ways: total wet weight (weight of the shell and soft parts), wet body weight (weight of the wet soft parts) and dry body weight (weight of soft parts after drying).

- Total wet weight:1,773 mt
- Biomass: 188.5 mt
- Dry weight: 39.5 mt

Characteristics of the population

The growth and mortality parameters were determined from a tagging experiment which commenced in 1983, during Cyclone Veena, and continued until 1987. More than 500 oysters were tagged and periodically checked at seven lagoon stations.

Stainless steel tags were driven into the substrate in the immediate vicinity of the selected animal. This process avoids stressful handling and the animal's growth is not disturbed.

Subsequent measurements are carefully taken by divers, also in order to avoid stress. The data gathered during nine inspections, at intervals ranging

Table 4: Mean length–weight relationships of pearl oysters in Takapoto lagoon

Length	Mean weight (g)		
	Total weight	Biomass	Dry weight
40 mm	5.1	1.4	0.1
50 mm	10.4	2.5	0.3
60 mm	18.6	3.2	0.5
70 mm	30.4	5.7	0.8
80 mm	46.6	7.9	1.2
90 mm	67.8	10.5	1.7
100 mm	94.9	13.6	2.3
110 mm	128.6	17.2	3.1
120 mm	169.7	21.3	4.0
130 mm	219.1	26.0	5.0
140 mm	277.5	31.2	6.3
150 mm	345.8	37.0	7.7
160 mm	424.8	43.3	9.8
170 mm	515.4	50.3	11.3
180 mm	618.5	57.9	13.4
190 mm	734.9	66.2	15.7
200 mm	865.5	75.1	18.3
210 mm	1,011.3	84.7	21.2
220 mm	1,173.0	94.9	24.4

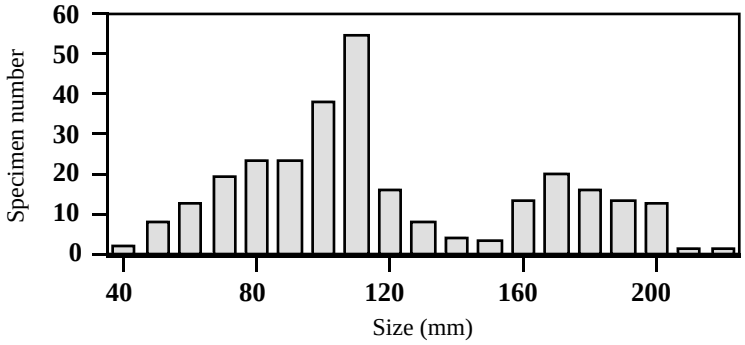


Figure 1: Structure of the pearl–shell population in terms of specimen size

from three months to one year, made it possible to plot a graph of size increases over time and to calculate mortality rates.

Growth

Growth was studied using the von Bertalanffy model:

$$Lt = Lw\ (1 - e^{-k}\ (t - t_o))$$

in which: Lt = Length after time t
Lw = Theoretical length reached at the end of an infinite period
K = A constant value expressing the rate of growth of this species
t_o = Curve origin

Fitting this model to the data observed made it possible to suggest the following mean growth equation: $Lt = 206.14\ (1 - e^{-0.264}\ (t + 0.503))$

The growth data obtained from the tagging experiment are summarised in the age / size key of Table 5.

If it is considered that the maximum length is the last size significantly recorded in the population, minimum lifespan would be approximately 9.5 years.

Maximum lifespan as calculated from the von Bertalanffy equation parameters, using the Pauly formula, would be approximately 11 years.

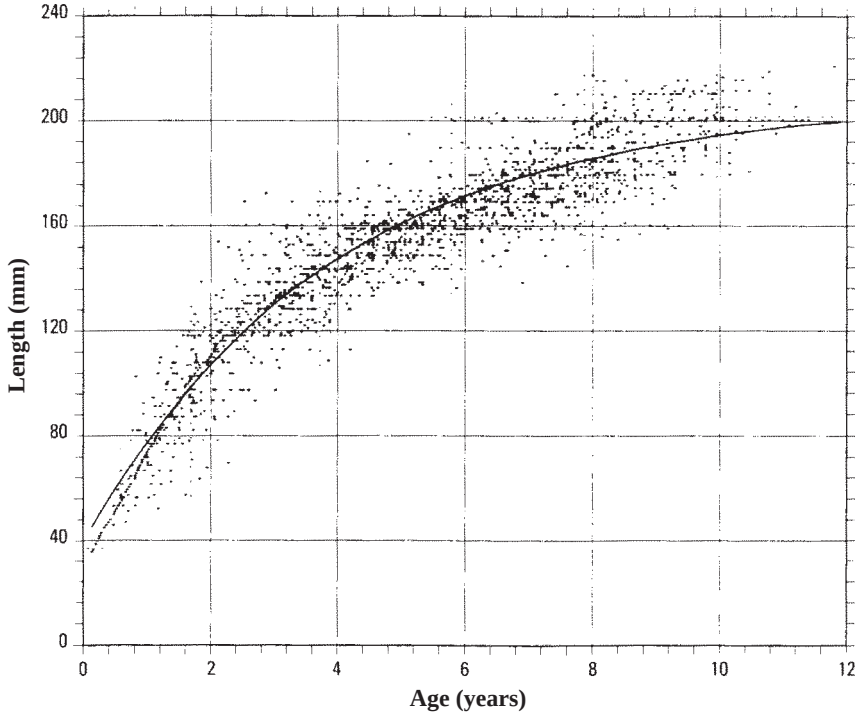


Figure 2: Theoretical pearl-oyster growth rate using the von Bertalanffy model

Table 5: Comparison of the sizes of oysters observed at Takapoto with theoretical sizes

Age of pearl oysters (years)	Mean length (mm)	
	As observed and std. deviation	As calculated
0.5	40	49.0
1	63 ± 8	67.5
2	102 ± 13	100.0
3	129 ± 12	124.0
4	145 ± 11	143.5
5	156 ± 12	158.0
6	166 ± 10	169.0
7	175 ±10	177.5
8	185 ± 11	184.0
9	193 ± 12	189.0
10	200 ± 9	192.5

Production

The growth and biomass data obtained from this stock can be used to calculate annual production. Natural recruitment and mortality were not, however, taken into consideration in the following calculation and production is estimated as at a constant stock size.

Production from the Takapoto stock is thought to be approximately 620 mt of biomass, from which can be inferred a production / biomass ratio of 0.35, higher than that which the species' life span and mortality would seem to suggest.

Mortality

A very high mortality rate occurred in various lagoons in 1985 and Takapoto was particularly affected. According to the local press, farms raising spats and grafted animals suffered losses of 50 to 80 per cent of stock and natural stocks were also hit, to such an extent that in some stations all the tagged oysters died.

Such events had already been observed with this same species in 1969 and then in 1973 in the Red Sea, at Hikueru Lagoon in the Tumaotu archipelago, French Polynesia, in 1971. The Australian pearl oyster, *Pinctada maxima,* also suffered periods of intense mortality from 1967 to 1977. Marine organism deaths can often be attributed to vigorous phytoplancton blooms, as was the case in the Taiaro Lagoon in 1906, Mataiva Lagoon in 1953 and Punaauia Lagoon in 1963, but no similar phenomenon has been observed in the Red Sea, and there is no proof that an event of this kind occurred at Takapoto.

Studies of dead oysters carried out by IFREMER and EVAAM have revealed identical symptoms to those observed in the Red Sea, but the causes of the disease have not been identified either in the Red Sea or in Australia. The Australians have, however, recently implicated a bacteria of the genus *Vibrio* which is responsible for high mortality rates in oyster-carrying tanks, but its impact in the natural environment has yet to be proved.

It should be added that all the specimens from the five French Polynesian lagoons showed varying degrees of cellular deterioration. This would imply that the stress undergone extended throughout the Tuamotus and indeed perhaps throughout the Territory, but that it led to death only in some lagoons.

In July 1985, the local media announced abnormally high mortality rates in the Takapoto pearl farms, most of which are situated near the village. Observations by ORSTOM divers in October 1985 showed that natural stocks were also affected in the southern part of the lagoon.

The oysters were showing signs of physiological damage, not, however, necessarily leading to death. Fresh observations then revealed that the disease

had spread to cover all the southern half of the lagoon in January 1986 and the rest in June 1986.

This was corroborated by observing mortality rates in tagged animals as part of growth studies. High mortality first emerged close to the village in December 1984, and then spread northwards. Every lagoon station had been affected by the first half of 1986.

Inspections showed that minimum natural mortality rates could be broken down into three groups:

- the shell was found with the tag. The oyster died a natural death and the record is annotated with an 'M'. Such cases represent minimum natural mortality.

- the shell had disappeared but the tag was still present. Two theories can be imagined in such cases: the oyster died a natural death, but the shell disappeared because it moved or crumbled away, for example, or the oyster was taken by a predator (fish, squid) or a fisherman (legally during the diving season or poached). Whatever the reason for its disappearance, the animal is lost to the natural stock and the entry is 'D'; such cases represent minimum total mortality.

- where both shell and tag had disappeared, a variety of theories could be entertained: both were taken together, the tag had been destroyed by corrosion or separated from the substrate, or the scientist could not relocate it. So wide is the range of possible theories that this case cannot be included in mortality rate calculations.

If it is considered that the stock when tagging began corresponded to the previous assessment, an attempt can be made to quantify mortality during the experiment by applying calculated coefficients, but without taking into consideration population renewal by natural recruitment.

If minimum natural mortality is taken into consideration, stock numbers would have developed as shown in Table 6.

Almost 3.5 million oysters are thought to have died from natural causes, including 2.5 million during the worst ravages of the disease, in the first half of 1986.

If cases of disappearance are added to the minimum natural mortality figures, it is possible to appraise minimum mortality (see Table 7).

Table 6: Minimum natural mortality on Takapoto Atoll

	April 1983 to January 1986	January to June 1986	June 1986 to June 1987
No*	7,500,000	6,760,947	4,084,596
Minimum nat. mortality	739,053	2,513,904	162,447
Mortality rate	0.039	1.107	0.039
Percentage	9.85%	37.18%	3.97%

No* = number of pearl oysters at the beginning of the period under consideration

Table 7: Minimum total mortality on Takapoto atoll

	Avril 1983 to January 1986	January to June 1986	June 1986 to June 1987
No	7,500,000	3,376,713	2,100,768
Nt*	4,393,953	2,733,626	592,295
Minimum tot. mortality	4,123,287	1,275,945	1,505,473
Mortality rate	0.201	1.130	0.700
Percentage	54.90%	37.78%	71.60%

Nt* = number of pearl oysters at the end of the period under consideration

Population size differences between the end of one period and the beginning of the following may be explained by the fact that specimens for which neither shell nor tag were found were included in the appraisals.

At the end of this mortality study, it emerged that minimum natural mortality is very low if the dramatic circumstances which occurred in late 1985 and early 1986, during which almost 40 per cent of the population probably perished, are excluded.

On the other hand, mortality due to predation (natural or fishing) was very high except during the peak period of natural mortality and more particularly after that period. The nature of the data collected does not make it possible to quantify either type of predation, but since fishing activity was clearly responsible, this is a very touchy stock management issue.

It clearly raises the problem of defining fishing quotas and controlling poaching, especially when such harvesting is damaging a stock which has already been considerably weakened by natural causes.

Tuamotu pearling in legend and literature

Pearls live in legend, literature — *Excerpts from an article by Fran Dieudonne, published in* Pacific Magazine, *May/June 1994, pp. 52–53.*

> '*Much of the mystery and myth of these burning atolls were concerned with the quest of pearls – hundreds of thousands (throughout history) had perished to fetch them from the depths of the sea.*'
>
> Frederick O'Brien, *Atolls of the Sun*, 1922

Moody, mysterious and mesmerising; that is how some of the early South Sea writers described the 'Paumotu atolls', more commonly known as the Tuamotu Archipelago of French Polynesia.

Frederick O'Brien, Louis Becke and S.W. Powell were three writers who found their way to this overpowering place that laid such a lasting claim on them and their readers.

In O'Brien's day, the atolls were decrepit, a place of rickety, salt-stained lean-tos and corroded sheds. O'Brien writes about an era that no longer exists and of the rough, hazardous and often overly romanticised life of the pearl-fisher:

'On many maps, these atolls are yet inscribed as the Pearl Islands. About their glorious lagoons was a mist of obscurity and wonder for centuries.

There were accounts of divers who sank deeper in the sea than science said was possible, and the priceless pearl plundered or bought for a drinking song'.

He described the prostration of Paumotuan pearl divers who went to depths of 148 feet and who then 'continued to pursue their fascinating and near-fatal employment until, by afternoon, a heap of heavy, darkish bivalves lay in the canoe'.

> *There are moments in a diver's life;*
> *One, when a beggar, he prepares to plunge;*
> *Then, when a prince, he rises with his pearl.*

The unknown poet of the above envisioned the diver's emotions, but it is Powell in his *South Sea Diary*, 1912, who best paints a word-picture of the stampede that followed when a diver announced his possession of a pearl by holding his hand aloft as his canoe or boat came into the shallows:

'Buyers stampede toward him. Their rush is like the rush of animals; they flounder; they barge carelessly into one another in their eagerness not to be late. Their voices assassinate the stillness. They bid; disputing, barking, contesting like beasts.'

An ancient chinese poet described pearls as the 'hidden soul of the oyster.'But, the life of the pearl diver was less than poetic. The procedure was primitive. A diver, after taking a few deep breaths, would descend several fathoms. O'Brien, in describing the dive, wrote:

'He had about his waist a *pareu* of calico, blue with large white flowers, and a sharp sailor's knife at the belt. Around his neck was a sack of coconut fiber.

'He forced himself down with astonishing speed and in 20 seconds, he was at his goal. He moved

carefully about and finally reached the shells, breaking them loose from their birthplace and thrust them into his sack.'

O'Brien, who tells fascinating tales about pearlers in *Atolls of the Sun*, uses his protagonist, Mandel, a Parisian pearl dealer, to tell the story of the coming change in the world of the pearler.

The setting was Mapuhi's Store. The year was 1922. Mapuhi was a Paumotuan chief on Takaroa Atoll. On the counter lay 25 pearls, the 'fruit of Mapuhi's tribe's harvest in Takaroa Lagoon.' Mandel comments:

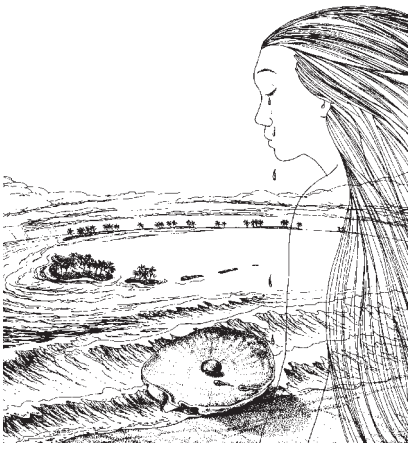
'The cultured pearl is every year hurting our trade more and more and someday may make pearls so cheap that you will get a third of what you do now'.

'Let me tell you! Last year, I visited three culture fields and they are doing wonderful things. Kokichi Mikimoto has gone much further than anybody. I spent a week with him at his pearl farm in the Bay of Ago in the Inland Sea of Japan.'

Just a few years before *Atolls of the Sun* was published, Mikimoto had introduced his cultured pearls in London (1919), at prices considerably lower than natural pearls. Pearl divers all over the world were in panic. They tried to discredit cultured pearls, but they lost the battle simply because a cultured pearl *is* genuine.

Mandel, O'Brien's protagonist, said (around 1922) that most of Mikimoto's pearls were about as big as 'French peas' and noted that his oysters were merely the 'winged-shelled kind and small' and mistakenly dismissed them.

But, he did say, prophetically : 'Here are these Paumotu shells - up to 18 inches across - think of what they might do if they were put to work by science!'.



Indeed, by the 1960s the French government maritime research organisation began experimenting with pearl farms and artificial pools. Soon, farms were opened on Rangiroa and Manihi. By 1980, 10 Tuamotuan atolls had cooperative pearl farms.

The pearls that were harvested were of better quality than those found by diving and the number was so great that 12,000 pearls were sold in 1981 and became the major French Polynesian export.

So, the saga of pearls continues. In their 1981 book, *Accross the South Pacific*, Iain Finlay and Trish Sheppard include a chapter set in the Cook Islands called 'Manihiki: A quarter of a million dollars in black pearls'.

They chronicle the adventures of the Cumming family, who in the late 1970s sold everything in New Zealand and journeyed to the Cooks to start 'an amazingly ambitious scheme' — pearl farming on the island of Manihiki.

Now, with new technology and genetic engineering, another drastic change looms for pearlers. The day may come soon when pearls are produced in laboratories and pearl farms may be a thing of the past.

Will the romance and allure of pearls be lost with a land-based pearl oyster culture? Not if there are others who think like actress Elizabeth Taylor, who owns one of the world's most famous pearls, *La Peregrina*, which was found in the Gulf of Panama in the 16th century.

Taylor sums up her feeling about pearls: 'I love to hold them, feel them, press them. For women, pearls are feminine and warm and very romantic.'

Cartier designed the necklace that holds *La Peregrina*. It was previously owned by various royal families in Europe before being purchased at an auction in 1969 by actor Richard Burton, then married to Taylor, for US$ 37,000. He presented it to her for Valentine's Day.

Today, in French Polynesia the talk of the Tuamotus is, who will be crowned Pearl Queen of the Pearl Archipelago? Last year it was Teravahaumui Tekurio, who was Miss Tuamotu–Gambier 1993. She was originally from Takaroa, the remote atoll O'Brien used for so many of his tales about pearl fishers.

Rarotonga's Queen of Pearls

Excerpts from an article by Christine Hatcher, published in Pacific Islands Monthly, *July 1994, p.25.*

To ask Cook Islander Joan Rolls about black pearls is like inviting a doting mother to describe her favourite child. As owner of Rarotonga's most exclusive jewellery and art retail business, she readily shares her knowledge about a favourite subject.

Joan is a discerning businesswoman and knows her subject well. The 15 years' experience she has in the pearl retailing business have sharpened her 'fine tuning' mechanisms. It is fitting that this resourceful woman is involved with what the new Minister of Marine Resources, Tepure Tapaitau, has predicted will equal tourism as the Cook Islands' major income-earner.

Her most recent continuing education programme included attending the 1st International Pearl Conference and Exposition in Hawaii in May with partner David Cragg. Aptly, Cook Islands' Prime Minister Sir Geoffrey Henry was the key-note speaker.

In an interview on his return home he stated his government's intention to expand pearl production to Penrhyn and Suwarrow, the Cook Islands' marine reserve. Presently earning approximately US$6 million for the country, pearls are a valuable natural resource. Joan's business could be a major contributor to that figure.

The pearl industry is 'in my blood, a family heritage', says Joan. Father, Ron Powell, was instrumental in the technique of farming shell in the 1950s when the lagoon was almost depleted by collecting the wild shells. 'As a pioneer for the industry he was often busy', she says.

Consequently, Joan grew up expecting to help out in the family business. Opened in the early 1940s, Island Craft was one of the first shops on the island geared towards tourism. In 1979 Joan opened her own first shop.

Success followed and over 12 years Beachcomber became the 'in' place to buy quality pearls and other interesting craft. Then the growing demand and awareness of black pearl jewellery forced expansion. A serious hunt for larger premises to accommodate the stock began.

For many years, the weed-choked shell of the London Missionary Society Sunday School built in 1845 had sat neglected at the edge of town.

It took a year to secure the lease for this landmark. 'I had always wanted somewhere big enough to have an arts and craft gallery, a workshop to design jewellery. A home for my pearls. This building has a historical connection with the pearl industry. Its construction coincided with a thriving export industry in pearl-shell buttons to Peru and Europe. It just seems right', says Joan.

In her office at the 'Sunday School' Joan does most of the designing from which New Zealand and Australian jewellers create unique one-off pieces. 'I see enormous export potential in the Pacific region for our designs. I know our own distinctive and individual pieces, hand-crafted with simple classical lines, will become synonymous with the Cook Islands,' says Joan.

Now she has expanded again — put a connection back into town. Her new 'baby' is a simple small, thatched, ethnic-style hut in the centre of the business area. In this attractive setting a working jeweller, trained by Joan, crafts pieces while you wait – or just watch. David says they sell 'pearls at reasonable prices — value for money — nothing over NZ$100'.

This new venture may be the connection that completes the symbolic circle in the form of a hut similar to the one that housed her father's business. For Joan, it ensures the survival of a love that will surely last a lifetime.

Saltwater pearl fisheries and pearl culture in India: an update

Excerpts from an article by P.S.B.R James and K.A. Narasimham, published in Aquaculture Magazine, *July/August 1994, pp.41–49.*

The natural pearls from the Gulf of Mannar in India and the Persian Gulf are famous throughout the world as 'Orient pearls' and have been held in high esteem in world trade from time immemorial.

Unfortunately, the pearl fisheries of India (utilising natural pearls from wild oysters) came to a grinding halt in the 1960s, with no hope of revival in the near future. Working at the Central Marine Fisheries Research Institute (CMFRI), India, Alagarswami (1974) achieved a breakthrough in 1973 in the production of spherical cultured pearls in the pearl oyster *Pinctada fucata* (Gould).

Since then, with considerable thrust given to the R & D programme on pearl culture by CMFRI, significant advances have been made in the hatchery production of pearl oyster seed; mother oyster farming; production of cultured pearls; training in all aspects of pearl culture, both at national and international level; and transfer of technology.

In the past two decades more than 70 scientific papers have been published, mainly based on the work done at CMFRI, and except for four, they all appeared in Indian journals. Important general accounts on pearl culture in India are by Alagarswami (1987, 1991), Anonymous (1991), James et al. (1991) and James and Narasimham (1993).

Pearl oyster resources and fisheries

Resources and distribution: In Indian waters six species of pearl oysters, namely *Pinctada fucata* (Gould), *P. margaritifera* (Linnaeus), *P. chemnitzii* (Philippi), *P. sugillata* (Reeve), *P. anomioides* (Reeve) and *P. atropurpurea* (Dunker) have been recorded. Among these, the first two are of commercial value in pearl production, and the remaining four species are broadly called 'flat' oysters.

P. fucata is the most dominant, and occurs in large numbers in the pearl banks, made of hard ground and called 'paars' in the Gulf of Mannar. There are about 65 paars located at a distance of 12–20 km away from the coast at 15–25 m depth. The extent of these paars varies from a few hundred square metres to a few square kilometres. In the Gulf of Kutch, *P. fucata* is found in small numbers in the intertidal coral reefs known as 'Khaddas'. There are about 42 reefs covering 24,000 ha.

The black-lip pearl oyster, *P.margaritifera*, is confined to the Andaman and Nicobar group of islands. Recently a few specimens were collected from the Gulf of Mannar.

The fishery

The documented history of pearl fisheries in the Gulf of Mannar indicates that so far 38 pearl fisheries have taken place between 1663 and 1961. The pearl fisheries were irregular and inter-spaced with long gaps of unproductive periods due to the decline of the oyster population.

The Tamil Nadu government exercised a monopoly and organised the fishery after ascertaining the abundance of pearl oysters in the paars. Plank-built canoes were towed by a motorised boat to the predetermined pearl bank and the divers worked without any diving aids. Each dive lasted for a maximum of 90 seconds. The 1955–61 series, the last conducted to date, is considered as the best held so far and the average annual yield was 12,322,116 oysters; the average annual revenue was Rs316,065.

The Gulf of Kutch pearl fishery was controlled by the Gujarat Government. The fishermen waded through the international beds and hand-picked the oysters. During 1913 to 1967, 25 pearl fisheries were held and fewer oysters were collected then in Gulf of Mannar fishery. From 1950 to 1967, the average number of oysters fished per year was about 17,000; the highest value of pearls realised from the fishery was Rs 619693 during 1943–44.

P. margaritifera occurs in low densities and does not form a fishery.

Current status of resources

Scuba diving was introduced in India in 1958 for the survey of pearl banks under the auspices of FAO. The surveys conducted by CMFRI during 1975 to 1986 in the Gulf of Mannar showed a revival of pearl oyster population in some paars, but the yield was inconsistent except for 3 or 4 paars. During this period, for a total diving effort of 595

hours in various paars, 239,000 oysters were fished. Pearl oysters other than *P. fucata* (flat oysters) formed 10.36 per cent of the population. Predation of the oysters by the gastropods *Cymatium cingulatum* and *Murex vitgineus* led to heavy mortality. In successive years the population was composed almost entirely of less-than-one-year old pearl oysters. These oysters are too young to be of use for the production of natural pearls. Experience shows that oysters above three years of age give satisfactory pearl yields.

There have been no improvements in the Gulf of Kutch pearl oyster population since 1968.

Sea ranching of hatchery produced spat

With the objective of enhancing the natural stocks of *P. fucata* CMFRI has embarked upon a sea ranching programme for hatchery-produced spat in the Gulf of Mannar. During 1985–1990, a total of 1,025,300 spat of *P. fucata,* placed in box-type cages covered with synthetic net webbing, have been ranched on 17 occasions. Due to practical difficulties in locating the cages, the ranched stock could not be monitored.

Spat collection from nature

Many attempts to collect pearl oyster spat by laying collectors such as empty pearl oyster shells, ropes, synthetic filamentous spindles, split bamboo and coconut shells made at Veppalodai and Tuticorin harbour farms of CMFRI during 1975–81 were futile, with either no spat or very few spat. At Vizhinjam, nylon ropes, hapa, or fish cages proved to be useful, but profuse settlement of fouling organisms affected pearl oyster settlement.

Hatchery production of spat

Success was achieved in the breeding and production of spat of *P. fucata* at the Shellfish Hatchery Laboratory of CMFRI at Tuticorin in 1982 (Alagarswami et al. 1983 b). The techniques are basically the same developed in the U.S.A. for several bivalves (Loosanoff and Davis 1963). Rip pearl oysters are held in groups of 25 in the conditioning room around 25°C and fed with mixed micro-algae grown in outdoors tanks.

Spawning is induced by slowly raising the water temperature to about 33°C. Spawning has also been induced by chemical methods (Alagarswami et al 1983 a) such as transferring the oysters to seawater containing hydrogen peroxide (62.5% success), tris buffer (78% success) and injecting hydrogen peroxide at the base of the foot (48% success).

The larvae are reared in 1 t FRP tanks and the seawater (sand-filtered) is changed on alternate days. *Isochrysis galbana,* cultured in 100-litre perspex tanks at 25°C under axenic conditions, is given as food. Spat settlement occurs in about 20 days, with 20–30 per cent survival from initial larval stock. The spat are fed with mixed microalgae and reach 3 mm size in about 2 months from spawning. The hatchery has the capacity to produce one million spat per spawning run under favorable conditions.

Success was also achieved in the breeding and spat production of *P. margaritifera* (Alagarswami et al. 1989).

Pearl oyster farming

This involves two aspects, namely mother oyster culture and post-operative cultures. The former comprises growing the spat collected from the pearl banks / hatchery until the oysters reach nucleus implantation size. The farming techniques are broadly the same for these two phases of culture except that additional care is taken with the implanted oysters.

Wooden rafts measuring 6 x 5 m, moored in depths of 5 m and more racks of 6 x 6 m size are erected in 1 m to 2.5 m for suspending the pearl oyster cages. Box-type cages of 40 x 40 x 10 cm or prism-shaped cages with 35 cm sides made of 6 mm steel rod and covered with 2 mm mesh velon screen are used for rearing spat. These cages are inserted into a bag made of 10 mm nylon fish-net for protection against crabs and predatory fishes.

As the oysters grow, the velon screen net is dispensed with and the box-type cages are covered with nylon fish-net of appropriate mesh. During the grow-out the predatory gastropods such as *Cymatium cingulatum* and *Murex virgineus* and crabs *Charybdis* sp., *Atergatis* sp., *Leptodius* sp. and *Tahlamitta* sp. enter the cages in young stages and cause serious damage. Biofouling by barnacles, bryozoans, simple ascidians and bivalve molluscs is common.

Boring sponges and polychaetes drill their way in and form blisters in the pearl oyster shell. The cages and the oysters are periodically cleaned to remove the predators, foulers and borers.

Other remedial measures include immersion of oysters in fresh water for 3 – 10 hrs depending upon size, exposure to air for 2 – 3 hrs and immersion in 1 per cent formalin for a few seconds. Hatchery-produced *P. fucata* grown in the Tuticorin Harbour farm attained 47.0, 64.5 and 75.00 mm at the end of 1 – 3 years respectively.

The survival of both implanted and mother oysters in the grow-out of 10 –12 months is about 80 per cent.

Nucleus implantation and post-operative culture

P. fucata measuring 45 mm and above and in inactive or resting reproductive phase are used in pearl production. Sprinkling of a small quantity of menthol powder into the seawater containing the oysters makes them slowly open their valves in 60–90 minutes. Immediately a wooden plug is instered in between the valves and thus the oysters are conditioned. The ventral part of the mantle of a donor oyster is cut into 2 to 3 mm broad pieces for grafting. Mild solutions of eosin, mercurochrome or azumin in seawater are used in graft tissue preparation.

The surgical instruments are indigenously fabricated and consist of oyster knives incision-cum-grafting needles, nucleus insertion needles, spatulas, needle hook, graft knives, forceps, speculum and oyster clamp. The conditioned oyster is mounted on an oyster stand, a speculum is inserted between the two valves, a passage is cut through the gonad up to the spot selected for nucleus implantation, and the mantle piece is placed at the selected site. The shell-bead nucleus is placed in contact with the outer epithelium of the mantle piece.

In multiple implantation the process is repeated for each nucleus through the same incision by cutting a passage through the gonad in suitable directions up to the selected site. After implantation, the two ends of the incision at the base of the foot are brought in contact and smoothed out. In *P. fucata*, 2–8 mm diameter nuclei imported from Japan are used. Indigenously made nuclei from the chank, *Xancus pyrum*, appear promising.

After implantation, on transfer to slowly moving seawater the oyster recovers in about 30 minutes. For 2–3 days the oysters are kept under observation in FRP tanks having a mild flow of seawater. Then they are placed in box-type cages of 40 x 40 x 10 cm and transferred to the farm.

The skill of the technician is an important factor in the surgery. A technician implants about 100 oysters per day. The common reasons for the rejection of nucleus are too wide incision and passage cut through the gonad, damage to vital organs, rough handling and exposure to strong stimuli such as currents, waves, tides, etc. Good-quality pearls are produced when oysters are cultured in 5 –10 m depth. Strong sunlight on oysters results in poor quality pearls. The duration of the post-operative culture for the production of pearls depends upon the size of the nucleus implanted, water temperature, food supply, etc.

In Indian waters, due to favourable water temperature the pearl grows fast and reaches marketable size in 3 – 4 months with a 2 – 3 mm nucleus, and 15 – 18 months with nuclei of 6 – 7 mm diameter. The following table on the growth of nacre illustrates the advantage of pearl culture in India when compared to the temperate waters of Japan (see Table below).

Growth of Nacre: India vs. Japan

Country	Nucleus diameter (mm)	Thickness of nacre of cultured pearl (mm)	Duration of culture
Japan (Cahn 1947)	3.05	0.318	2 years
	4.1	0.363	2.5 years
	6.1	0.439	3 years
	7.9	0.5	3.5 years
India (Alagarswami 1975)	3	0.32	191 days
	4	0.31	161 days
	5.81	0.26	159 days

The pearls are harvested by cutting open the oysters with a sharp knife, thereby killing the oysters. During the post-operation culture some oysters die due to natural causes and surgery while some reject the nucleus.

Production of cultured pearls

Considerable variations in the production rate are discernible. In the Veppalodai (Tamil Nadu south-east coast) farm of CMFRI, gross pearl production of 62.8 per cent in single implantation and 68.3 per cent in multiple implantation with reference to the number of nuclei used has been reported (Alagarswami 1974).

In a recent study (Victor A.C.C., personal communication) conducted by CMFRI at Valinokkam; (Tamil Nadu, south-east coast), by scaling up the

operations, out of a total of 9,414 oysters implanted (single implantation with 3–5 mm nuclei), mortality during one year of post-operative culture was 2,108 oysters (22.39%). On harvest, the remaining 7,306 oysters yielded 1,849 pearls (25.31%). A total of 5,457 oysters (79.69%) did not contain pearls due to rejection of nuclei or non-deposition of nacre. This variation in the production of the pearls in these two studies is indicative of the range of production under variable conditions.

Grading and processing of pearls

Grading

The quality of the cultured pearls depends upon the thickness of the nacre, iridescence, lustre, colour, size, shape and flaws. They are graded into the following three main categories (Shirai 1970):

A-grade: Flawless, one flaw, small flaws, small stain, pink, silver or light cream;

B-grade: Fairly large flaws, stains, cream colour, irregular shape;

C-grade: Trash pearls, wild-shaped, badly coated, heavily pock-marked, clayey lumps, half good and half bad.

In the earlier studies by CMFRI at Veppalodai, A-grade formed 37.6 per cent, B-grade 37.6 per cent and C-grade 24.8 per cent (Alagarswami 1987). In the recent study at Valinokkam (Victor, personal communication) A-grade formed 36.15 per cent, B-grade 54.03 per cent and C-grade 9.82 per cent.

Processing

In surface processing the pearls are mixed with salt in equal volume and placed in a tub with little water. The residual mucus on the surface of the pearl is removed by rubbing with salt to obtain good lustre. To improve the quality the drilled pearls are bleached with hydrogen peroxide.

Technology transfer

Concurrent with the development of pearl culture technology, CMFRI has given priority to training the manpower for operating the pearl culture ventures. Beginning from 1976 officials sponsored by foreign countries and the fisheries departments of Tamil Nadu, Kerala, Karnataka, Gujarat, West Bengal, Andaman and Nicobar Islands and Lakshadweep and also pearl farmers, numbering 72, have been trained in eight training programmes organised by CMFRI.

The training course is 4–6 weeks long, specially designed for technicians, and covers all aspects of pearl culture.

CMFRI adopted an open policy in dissemination of technology and, subject to the Indian Council of Agricultural Research guidelines, foreigners had the benefit of these programmes. In 1979 a technician from the South-East Asian Fisheries Development Center, Philippines, participated in a training course.

The Regional Sea Farming Development and Demonstration Project of the Network of Aquaculture Centers of Asia (NACA) in Bangkok has recognised CMFRI as a Lead Center to train the aquaculturists of South-east Asian countries in pearl culture. Under this programme an International Training Course was organised by CMFRI at Tuticorin from 1 February 1991 to 28 February 1991 and 26 candidates from 10 countries have been trained.

Tamil Nadu Pearls Ltd., a joint sector company, was the first to commercialise the technology developed by CMFRI. It produced and marketed over 13 kg of cultured pearls. With the same technology, the Gujarat State Fisheries Department at Okha and Sikka and the Lakshadweep Fisheries Department at Bangaram have produced cultured pearls in small quantities.

Current status

Based on the technology developed by CMFRI, the Tamil Nadu Fisheries Development Corporation (TNFDC) has been operating a pearl culture project at Krusadai since 1990 and has produced more than 3 kg of pearls and marketed them. Since the revival of the natural stock of pearl oysters in the Gulf of Mannar pearl banks is uncertain to meet the requirements of the commercial venture, TNFDC set up a hatchery in 1992 with technical assistance from CMFRI. The TNFDC pearl farms are located at Krusadai and Tuticorin.

Currently the R & D programmes of CMFRI on pearl culture are carried on at the Institute's farms located at Tuticorin and Valinokkam. Local fishermen are actively participating in the farm work at Valinokkam and recently they have been trained in nucleus implantation also. As a result they have developed the necessary skills to take up pearl culture on their own.

India has the advantage of possessing a complete package of tested technology (except for the import of nuclei), solely developed by indigenous efforts. Another advantage is the presence of a strong R &

D base and also well-trained manpower to operate pearl culture ventures.

However, entrepreneurs and farmers are yet to take up pearl culture in the country for reasons such as the need to locate suitable culture sites along the mainland coast, lack of awareness, hesitancy due to risk-prone nature, absence of laws for the usage of bodies of water, governmental monopoly over resources constraints by way of input supply, etc. Suitable sites for pearl culture are indicated in the Gulf of Mannars, Bangaram in Lakshadweep and the Andaman and Nicobar group of islands.

Future outlook

In recent times, with the Indian cultured pearls available in the market, there is increasing awareness among the people about the technology and product. It will not be long before the message 'pearls give the highest profit return of all marine products cultivated in coastal waters' (Wada 1973) reaches the entrepreneurs and farmers, venturing into pearl culture.

At CMFRI, priority is given to short-range projects on location testing of pearl culture at several places along the Indian coast. R & D efforts, already directed to take the technology to the grass-root level as is being done at Valinokkam, will be strengthened. While the programme on the upgrading of the technology in *P. fucata* will continue, pearl production in *P. margarifitera* will also receive attention. Also plans are underway to initiate a project on *P. fucata* mantle epithelium culture, leading to *in vitro* production of pearls of desired colour.

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Sudanese pearl shell culture

Cultivation and Economics of pearl oysters in the Sudan: requirements for strengthening local technological and management capacities — *Excerpts from an article by Dr Sayed Mohamed Ali, published in the Report of the Expert Group Meeting on Acquisition of Marine Surveying Technologies, United Nations, Addis Ababa, 19–23 October 1987, pp. 95–116.*

Introduction

Sudan has an area of 2.5 million km^2 and a population of more than 20 million. Its coast extends along the Red Sea for 450 miles. Excluding major ports, the coast is sparsely inhabited by semi-nomadic people who are generally very poor, earning a living by raising camels and sheep and by fishing.

Most of the coastal plain lacks exploitable resources; therefore the chances of improving the living conditions of its inhabitants are very limited.

Marine fisheries comprise a small part of the total fisheries in the Sudan. The annual catch of fin-fish from the sea is estimated at 1,500 tons, compared to 20,000 tons obtained from inland freshwater resources.

Though small, marine fisheries have always been very important to the inhabitants of the coast. In addition to fin-fish, two species of molluscs are also important: the black-lip mother-of-pearl oysters and the Red Sea trochus.

These are collected from various parts of the coastal waters by divers. Mother-of-pearl oysters have been cultivated in the Sudan since 1900. Both molluscs are valued only for their shells, which have iridescent nacre. Their meat is of no commercial value. Most of the cultivated shells are exported, mainly to Italy and Germany.

Occurrence of mother-of-pearl oysters

The scientific name for the black-lip pearl oyster is *Pinctada margaritifera* var. *erythraensis* (Jameson). This variety is found only in the Red Sea.

Though it is found almost everywhere on both sides of the sea, there are two especially productive areas: Dongonab Bay and Shubuk Suakin.

Dongonab Bay is located 110 miles north of Port Sudan. It is the major natural breeding ground of mother-of-pearl oysters, due to the following factors:

(a) Its large size, gentle currents and restricted entrance, affording only limited exchange of water with the open sea. Hence, larval oysters produced during the breeding season are not washed out to open sea but are mostly retained within the Bay;

(b) Its shallowness, together with many areas of flat, rocky, silt-free bottoms, which present good opportunities for larval setting, spat fixation and survival.

The Bay covers 100 square miles. It is completely enclosed by land, hence wind-driven currents are mild. Tidal changes usually do not exceed one foot. The mouth of the Bay is partially blocked by reefs, islands, shoals and sills.

The maximum depth of the Bay is 50 m, but most of its area is more than 20 m. The banks of shores and islands slope gently towards the deeper inner water. There are large areas of shoal water with a limited growth of coral on the western side, but on the eastern side, the bottom is remarkably flat, rocky and silt-free.

In the Bay, the healthiest mother-of-pearl oysters are found at a depth of less than 5 fathoms, with very few found beyond a depth of 15 fathoms. Shells from deeper than 7 fathoms are usually infected with such parasites as mud worms (*Polydora*), boring sponges (*Cliona* ssp.) and boring bivalve (*Lithophaga*).

Trochus shells (*Trochus dentatus*) are found on reefs throughout the Red Sea, mostly at depths of between 2 and 5 fathoms, but not at depths greater than 9 fathoms.

History of cultivation

By 1900 a small but significant fishery of wild mother-of-pearl oysters and trochus shells collected by native divers was flourishing along the entire Red Sea coast. In Sudan, to boost the industry further, the Government thought of investigating the possibility of large-scale cultivation of the oysters.

In 1904 the late Dr Cyril Crossland made a study of pearl fisheries of the Sudanese Red Sea. He was subsequently employed as a marine biologist with the Government of the Sudan and directed a marine biological station and pearl shell farm at Dongonab from 1905 to 1922.

He was able to devise methods for the profitable large-scale cultivation of mother-of-pearl oysters from spat to commercial size. However, in 1923, following the first World War, the Sudanese Government stopped all cultivation activities because prices had fallen to uneconomic levels. By the time the farm was closed in 1923, it was producing an annual crop of more than 300 t.

Conclusion

Commercial mother-of-pearl oyster cultivation in Sudanese Red Sea coastal water is technically feasible and profitable. Resumption of large-scale cultivation is of great socio-economic importance.

Before this can be done, however, a pilot project jointly run by the Fisheries Research Section, the Fisheries Administration and native fishermen must be established. Socio-economic studies on native fishermen must also be undertaken.

The strengthening of local technological and management capabilities of the Red Sea Fisheries Section and the Fisheries Administration is a perequisite for future large-scale cultivation of mother of pearl oysters.

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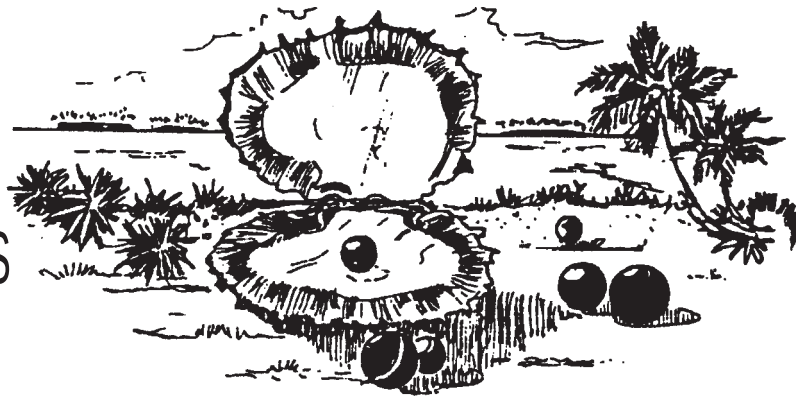
PEOPLE, PRODUCTS and PROCESSES



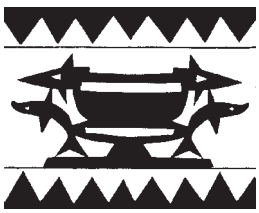
Pearl World

Pearl World, 'The International Pearling Journal' is a bi-monthly publication, soon to be entering its third year. Headquartered in Phoenix, Arizona, Publisher / Editor, Richard 'Bo' Torrey, became introduced to the cultured pearl industry by authoring a 48-page, 4-colour brochure for a major European gem and jewellery wholesaler, manufacturer, and distributor, Golay Buchel of Switerland, through its cultured pearl headquarters in Kobe, Japan.

Upon relocating back to the United States after 13 years in Japan, Torrey expanded his contacts and nowadays reports on the full scope of the cultured pearl industry, from farmers and producers to importers, wholesalers, retailers and the consuming public.

'We are the only publication in the world (to our knowledge) that reports only on pearling matters, and only in English', he states. 'Most cultured pearl advertising is carried in a handful of major jewellery magazines coming out of Asia, the U.S. and Europe; and there is a weekly newspaper, the *Shinju Shimbun*, which primarily covers the Japanese industry and its Akoya cultured pearl production and marketing, in Japanese, naturally,' he relates.

'But *Pearl World* curries no favour from any particular region or product. We tell it like it is, and that often doesn't sit well with certain segments of an industry that has been steeped in decades of secrecy and peopled by frequently arrogant princes of the realm.'



Pearl World has reported, over the past year, in and on the following issues:

February/March 1994: the reversal of fortune for Indonesian pearling due to the meteorological changes caused by the El Nino current; the Japanese hama-age auction results; the sad state of Chinese seawater Akoya production; current events in Japan, Australia and the U.S.; the upcoming Pearls '94 conference and the formation of the International Pearl Association (IPA).

April/May 1994: the gathering momentum of Pearls '94; the growing conflict between Japanese and Chinese Akoya; the boom in South Sea cultured pearls; artificial propagation in Australia (by Dr. Robert A. Rose); *Pearls of Wisdom*, a new column by Fred Ward.

June/July 1994: a complete conference report after the conclusion of Pearls '94; Fred Ward's column from the Hawaiian conference; strengthening the formation of the IPA; the potential of a growing native, land-title debate in Australia; a new farming venture in Indonesia; Part II of CIBJO's *Pearl Book*.

August/September 1994: the sudden resignations from the Board of the IPA and the potential for the organisation's breakup; a review of the technical sessions held at the Hawaiian conference; a report on the Burma auction, and its uncertain future; a plan to help preserve U.S. freshwater mussels in the face of the growing zebra mussel infestation; preview of the Japanese international Pearl Summit '94.

October/November 1994: successful cultured pearl sales techniques at the retail level; a detailed examination of the El Nino phenomenon and its world-

wide effects; the harvest worries of Japanese pearl farmers and processors; the soaring SSP production (and spirits) of Australia; Part 1 of the History of the Pearl King, Kokichi Mikimoto; the establishment of the Tahitian Black Pearl Associations of Japan and the Americas.

December 1994/January 1995: a complete, 12-page issue with detailed coverage of the Japanese International Pearl Summit '94; the formation of the South Sea Pearl Consortium and its likely effects; introduction of Fred Ward's new book, *Pearls*; Salavador Assael receives Modern Jeweler's Lifetime Achievement Award.

February/March 1995: (our current issue, at press as this is being written): the future of 'Pearl City', Kobe, Japan, after the disastrous January 17th earthquake; the scope of the disaster; the establishment of an International Cultured Pearl Industry Kobe Relief Fund for the population of Kobe and its environs, and how donors can help the needy, the homeless, the sick; a special diary covering the first 12 days of the catastrophe by a surviving pearl dealer; the growing zebra mussel problem in the U.S. , and its effect on nucleus supply and demand; how the new pearl consortiums have spurred increased promotional efforts, and will continue to do so; the Japanese reaction; China's efforts to 'clean up its act' in terms of Akoya and FWP production.

Pearl World is published bi-monthly by Haggis House Publications, Inc., with offices at 1822 West Glendale Avenue, Suite 401, Phoenix, Arizona, U.S.A. Telephone: (1-602) 246 1586. Fax: (1-602) 246 1586. One-year subscription: US$ 100 for domestic USA, Canada and Mexico; US$120 elsewhere. Back issues: US$7.50 each.

For further information on *Pearl World*, contact:

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Australian company serves pearl farmers

George Ventouras writes:

We have been involved in the pearling industry for over ten years and have developed many revolutionary products for use in Australian farming. We now provide a total integrated system for the pearl farmer which is 'tailor-made' to suit the particular species of shell, the individual farm site and any other pertinent factors. By specially designing the farming systems to suit the individual, more efficiency and greater cost-effectiveness will result.

Australian Netmakers – *The development of various types of revolutionary pearl nets that will enable better growing of pearls and reduction of farming costs. Further development in the manufacture of equipment for hatcheries and the grow-out of oyster shells. Updating and re-engineering of long line systems to save money and improve performance. Various other projects regarding the more efficient growing of pearls.*

Paragon Pearling – *Perfecting the process of the manufacture of nuclei, resulting in the best possible surface finish, free from marks and defects. Current experimentation with various materials to be used as substitutes for Mississipi and other freshwater mussel shells.*

For more details, contact:

George J. Ventouras
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Tel (61-9) 331 1855; Fax (61-9) 337 6582
Paragon Pearling
Tel (61-9) 337 7370; Fax (61-9) 337 6582

Alucraft delivers an impressive pearl cleaning catamaran

Excerpts from an article by Bill Beecham published in Professional Fisherman

Alucraft may not be the biggest aluminium boat builder in Western Australia, but the Spearwood-based company's impressive track record includes a wide range of work and pleasure craft, including a 12 m catamaran that is its latest delivery.

'It's a shell cleaning boat for the pearling industry, built for Morgan & Co.,' said Tony Serrangeli who operates Alucraft in partnership with his brother Marco. 'Its main purpose will be for washing lines of pearl shells, but Dick Morgan will do other jobs with it as well, using the boat as a general work platform'.

The prosaically named 'P2' should prove absolutely ideal for the multiple roles it will be called on to perform at a pearl farm in the Montebello Islands off the coast of Western Australia.

The design by Alucraft has an overall length of 12.10 m and measures 11.10 m on the waterline. Beam is 4.40 m and draught 375mm.

The catamaran concept guarantees optimum stability for pearl farm operations, particularly when the heavily-laden frames of shells are being winched aboard for cleaning.

The twin hull configuration also gives a much larger work deck-area than would be found on a monohull of similar length and this should prove an important advantage to the vessel's crew as they perform their varying duties.

The shell cleaning machine is positioned amidships on the starboard side with the lines of shell frames fed to it via hydraulic winch heads. Located below the work-deck to port and slightly ahead of the shell-cleaning machine is the 50hp Perkins diesel that powers the vessel's hydraulics and the high-pressure water hose used to clean the pearl shells.

Steering is Seastar hydraulic and 'P2' carries 1,800 litres of fuel when the 900 litre tank in each hull is filled to its maximum capacity. Twin Fiat Aifo Iveco SRM 13 marine diesels were selected as the main propulsion source. Each develops 130hp and is coupled to a Hamilton 211 waterjet through a Twin Disc gearbox of 1.1:1 reduction for a maximum speed of 15 knots. High speed was not a major consideration when 'P2' was designed, so cruising speed of 12 knots is more than sufficient.

Details of any design in the Alucraft range of monohulls and catamarans can be obtained by contacting Tony Serrangeli at Alucraft, 177 Barrington Road, Spearwood, Western Australia 6163; tel: (61-09) 434 2964 or (61-09) 335 2784, after office hours; fax: (61-09) 434 2964.

Mother-of-pearl can repair human skeletons

Excerpts from an article by Evelyne Lopez, Sophie Berland and Anne Le Faou, published in La Recherche, *February 1994, Vol.25, pp.208–210.*

> *A tropical oyster is opening up new prospects for surgery. Its very tough mother-of-pearl, which has regenerative potential, can be used to treat bone defects due to disease or accident.*

About 200,000 bone grafts and 265,000 joint repairs are carried out annually in the United States, while a million and a half patients are treated for diseases connected with a loss of bone mass (osteoporosis). One goal of the fast-expanding medical discipline of implantology is to treat bone complaints and disorders and restore the skeleton to functional order.

One research aim is to find a reliable surgical method for the reconstruction and regeneration of bone tissue by providing the skeleton with a substitute material in the event of loss of bone substance and by inducing or stimulating the deficient stages of bone formation to achieve a complete repair.

Our recent research at the general and comparative physiology laboratory, associated with the CNRS (French national scientific research council), at the Paris National Museum of Natural History, has revealed that the mother-of-pearl shell of the silver-lip pearl oyster, *Pinctada maxima*, is an efficient material for bone replacement and regeneration. Implanted, its mother-of-pearl can be 'bio-integrated'.

Since it is totally accepted by human organism the biomaterial and the recipient bone are bonded through the stimulation of osteogenesis, or bone formation. The restoration is compatible with the physiological functions of the bone tissue and the implant behaves exactly like a graft.

Why use mother-of-pearl when bone itself would naturally seem to be the best biomaterial for bone implantology? Not only does it have appropriate physical and chemical characteristics, but it also contains substances stimulating ossification, the Bone Morphogenetic Proteins or BMPs. In fact, bone grafting has inherent limits: when the bone to be grafted is taken from the recipient himself or

herself, the amount of bone available is clearly not great and this is a limiting factor; where the recipient is not also the donor, the risk of rejection or infection by the grafted material is very real.

Research work, in particular that carried out at the National Institute of Health in Maryland, USA, has led recently to the identification, purification and cloning of some of the active factors contained in bone.

The aim is to obtain molecules that, on their own, can stimulate bone growth. Such substances would make it possible to recruit a wide range of cells which would take part in the bone regeneration process from within the uncalcified tissues surrounding the bone defect.

Until such time as a way is found to effectively use such molecules, the disadvantages of bone grafting can be avoided by employing artificial biomaterials (metals, alloys, polymers or ceramics).

However, to restore the integrity of bone tissue, such materials must ally biocompatibility, mechanical strength and appropriate density, so that the forces which naturally act upon the component parts of our skeleton can be resisted to the full.

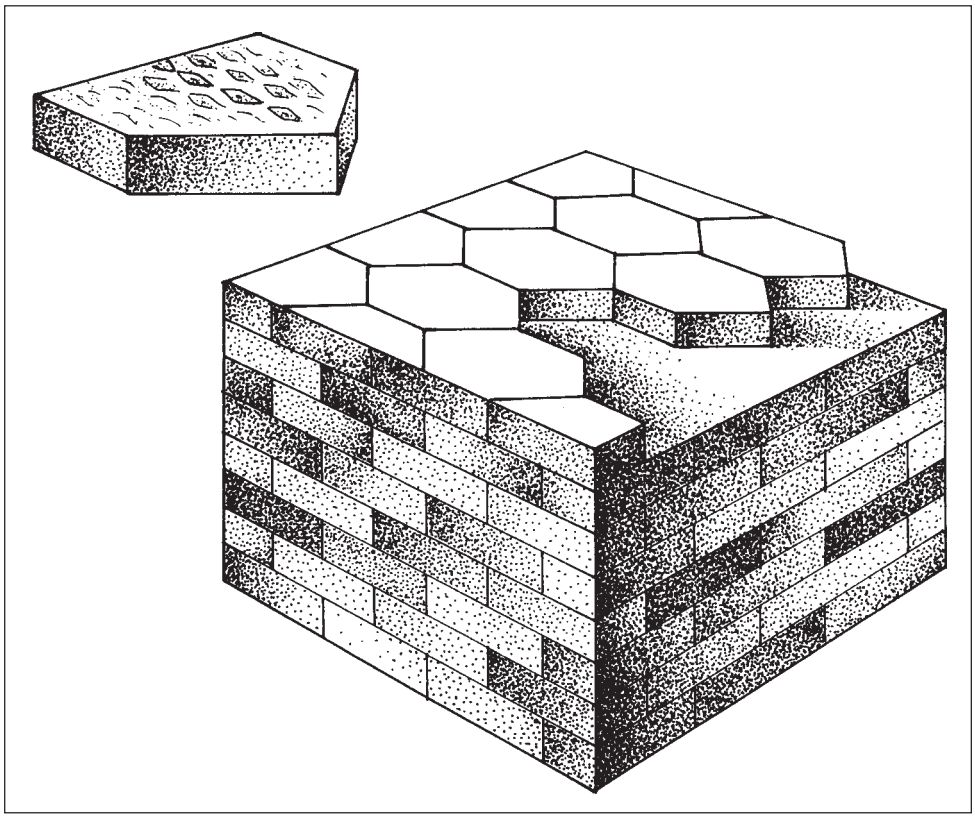
Although tolerated by the system (biocompatible), these artificial biomaterials have their own inherent properties which prevent the establishment of a complete physiological continuum with the tissue into which they are introduced.

Mother-of-pearl, as a biomaterial of biological origin, does not have this disadvantage. On the contrary, in the same way as bone, it is formed of a majority mineral fraction deposited on an organic matrix.

In mother-of- pearl, the mineral which is deposited is calcium carbonate ($CaCO_3$), crystallised in the form of pure aragonite; in bone, the mineral is calcium phosphate, crystallised in the form of hydroxylapatite ($Ca_{10}(PO_4)_6OH_2$).

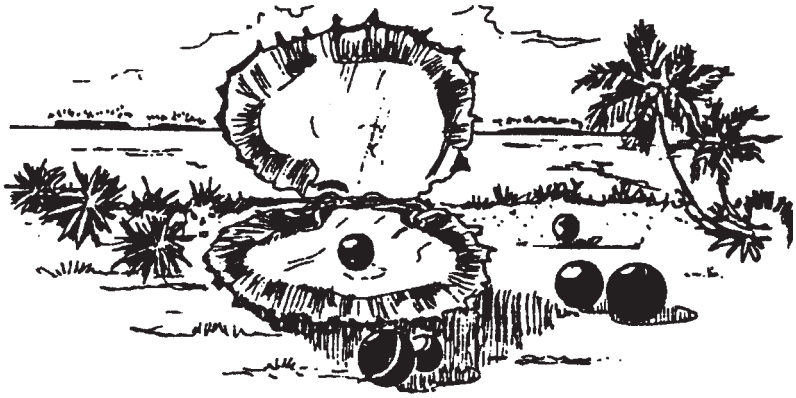
This particular association between the organic matrix and the mineral substance gives these mixed tissues (bone and mother-of-pearl) their outstanding physical, chemical and mechanical characteristics.

Despite many industrial experiments, there is so far no way of satisfactorily reproducing the relationship between an organic substance and a mineral fraction which exists in bone. Thus, mother-of-pearl, in which a type of association between these two fractions, similar to that of bone, is found, emerges as an ideal bone substitute biomaterial.



Tridimensional structure of the mother-of-pearl

ABSTRACTS, REVIEWS and CURRENT CONTENTS



Pearls '94 paper titles, and selected abstracts

Abstracts of papers presented at 'Pearls '94' — *Abstracts published in* Journal of Shellfish Research, *Vol. 13, No.1, 325–354, 1994. The abstracts of papers were compiled and edited by C. Richard Fassler, Conference Chairman.*

The scarcity of a gem and the degree of quality control by its producers or processors play major roles in determining its value. Pearls are no exception to this rule. For this past century, the Japanese, like to De Beers with diamonds, have enjoyed a monopoly on cultured pearls – even on those produced outside the country, because they were marketed through Kobe or Tokyo.

This dominance has benefited the global industry, as both price and product quality have been preserved at high levels. However, in recent years, the situation has changed drastically, resulting in a crisis.

This change has come about because of several significant factors, including the meteoric rise of Chinese freshwater (and now saltwater) pearls; the decline of Japanese production, due to environmental considerations; and the spread of pearl farming to other areas of the world, mainly Southeast Asia and the South Pacific. Like De Beers, Japan now finds itself losing control.

Without the traditionally strong Japanese involvement, the crucial question facing the industry is: can product quality and high prices be maintained? Another important concern is the endangered status of more than half of the American mussel species which provide nucleus material. A call to address these issues went out to pearl farmers, jewellers, scientists, equipment suppliers and government officials.

The response was most enthusiastic. The State of Hawaii and the Hawaii Jewelers' Association hosted, and the International Pearl Association sponsored, the largest and most diverse assemblage of the world's pearl community ever held.

The meeting, from 14 to 19 May 1994 at the Sheraton Waikiki Hotel in Honolulu, attracted speakers and technical presentations from Japan, China, French Polynesia, Barhairn, Kuwait, India, Colombia, Canada, the U.S.A., French Polynesia, Australia, the Solomon Islands, Mexico, the Cook Islands, Myanmar, Vietnam, New Caledonia, Bangladesh, the Philippines, France, India, Taiwan, and Iran. Another 20 nations sent delegates. There was a wide range of topics, which included: the future of the American freshwater mussel; starting a pearl farm; pearl culture in India; the pearl resources of Bahrain; conch pearls; and abalone pearls.

Conference participants discussed both obstacles and opportunities. Marketing strategies were presented, and the exposition featured a vast number of pearls of all colours and sizes for sale. The Jewelers' Forum assisted the jewellers to sell more pearls through sessions that included pearl grading, stringing, peeling, design and quality control, and overviews from all major pearl producing countries.

Importantly, the meeting provided an in-depth understanding of all aspects of the pearl business, and offered the participant the chance to influence the course of the industry over the next decade.

Pearls '94 was for persons who love pearls, and who wanted to be part of the history – and future – of this ancient and most treasured jewel.

Paper titles

Australia

J. Benzie: Genetics of black-lipped pearl oyster.

K. Colgan: Evaluating pearl shell habitat in Torres Strait and the Arafura Sea.

C.D. George: Concept of the South Sea pearl and its future from lessons of the past.

C.C. George: Japanese pearl policy law for overseas pearl cultivation: implementation and effects on the Indo-Pacific.

C.D. George: Tribulations of pearl cultivation in Australia.

L. Joll: Research for wild stock management of *Pinctada maxima* in Western Australia.

J. Lucas: ACIAR / JCU Blacklip pearl oyster project (Kiribati).

D.O'Sullivan & D. Cropp: An overview of pearl production techniques in Australia.

Bahrain

M.N. Sarker: Status and potential of pearl fishery of Bangladesh.

China

Q. Wang & H. Wu: Pearl culture in China.

Colombia

F. Borrero: Potential of pearl oyster culture on the Colombian Caribbean – preliminary results.

Cook Islands

M. Haws: Ecological characterisation of the Tongareva Lagoon.

R. Newham: The development of black pearl farming in Manihiki.

H. Thomforde: Pearl farming: A profile of basic techniques.

H. Thomforde: Pearl culture on Tongareva, Cook Islands: Impact of community-based management.

P. William: A pearl Farming family.

France

A.Intes: Growth and mortality of *Pinctada margaritifera* in French Polynesia.

French Polynesia

P. Cabral: Lagoon and resource management: example of the pearl oyster in French Polynesia.

P. Cabral & T. Seaman: Rangiroa's pearl oyster *Pinctada margaritifera* hatchery: results of the work between 1987 and 1992.

T. Seaman & P. Cabral: On land maturation of the pearl oyster *Pincatada margaritifera* – preliminary results.

N. Cheffort-Lachhar: Contribution to the knowledge of the dynamics of population of the black pearl oyster in French Polynesia.

India

D. Dev: Development of the pearl culture industry in India.

D. Dev: Commercial production of Indian pearl oyster (*Pinctada fucata*) spats in hatchery.

D. Dev: On the Indian pearl oyster resources and conservation.

A. Sonkar: Freshwater pearl culture in India.

A. Victor, A. Chellan, S. Dharmaraj & T. Velayudhan: Recent developments in pearl research in India.

Indonesia

T. Wimanto: Status of pearl culture in Indonesia.

Iran

M.S. Doroudi: Infestation of pearl oysters by boring and fouling organisms in the northern coast of the Persian Gulf.

Kuwait

S. Almatar, X. Xu & S. Alhazeem: The current fishery population density and culture feasibility of pearl oyster *Pinctada radiata* in Kuwait waters.

Mexico

M. Carino: Natural pearl farming in the early XXth century in Bahia de la Paz, South Baja California, Mexico.

S. Farell, E. Arizmendi & D. McLaurin: Perspectives and opportunities of pearl oyster culture development of the coast of Sonora, Gulf of California, Mexico.

M. Monteforte: Perspectives for the installation of a pearl cutlure enterprise in Bahia de la Paz, South Bahia de la Paz: South Baja California Mexico.

M. Monteforte, H. Bervera & S. Morales: Growth and survival of pearl oyster *Pinctada mazatlanica* and in extensive conditions at Bahia de la Paz, South Baja California, Mexico.

M. Monteforte, H. Bervera, S. Morales, V. Perez., P. Saucedo & H. Wright: Results of the production of cultured pearls in *Pinctada mazatlanica* and *Pteria sterna* from Bahia de la Paz, South Baja California, Mexico.

M. Monteforte & C. Aldana: Spat collection growth and survival of pearl oyster *Pteria sterna* under extensive culture conditions in Bahia de la Paz, South Baja California, Mexico.

M. Monteforte & H. Bervera: Spat collection trials for pearl oysters *Pinctada mazatlanica* and *Pteria sterna* in Bahia de la Paz, South Baja California, Mexico.

M. Monteforte & H. Wright: Ecology of pearl oysters: Spat collection and survival of pearl oyster *Pteria sterna* under extensive culture conditions in Bahia de la Paz, South Baja California, Mexico.

P. Saucedo & M. Montforte: Breeding cycle of pearl oysters *Pinctada mazatlanica* and *Pteria sterna* in Bahia de la Paz, South Baja California, Mexico.

C. Rangel-Davalos, M. Monteforte, H. Bervera, V. Perez & H. Wright: Repopulation of natural beds of pearl oysters *Pinctada mazatlanica* and *Pteria sterna* in Bahia de la Paz, South Baja California, Mexico.

Myanmar

T. Tun: A brief account of Myanmar's pearl culture industry.

T. Tun: A view on pearl seeding.

New Caledonia

G.L. Preston: Black pearl culture development in the Pacific Islands.

Philippines

D. Ladra: Trends and development of the pearl oyster industry in the Philippines.

R. G. Lawyer: Recent developments in artificial propagation of the gold or silver-lipped pearl oyster *Pinctada maxima* (Jameson).

V. Luyun: Potentials of pearl culture in the Philippines.

Solomon Islands

J. Bell: Variation in abundance of blacklip pearl oyster spat in the Solomon Islands

United States

L. Creswell & M. Davis: Queen conch pearls – a uniquely Caribbean gem.

C.R. Fassler: Hawaii's impact on the international pearl industry.

M. Rapaport: Socioeconomic and political aspects of the Tuamotuan black pearl industry.

J.T. Rowntree: Pearls and economic development.

N.A. Sims & D.J. Sarver: Hatchery culture of the black-lip pearl oyster in Hawaii – stock reestablishment and expansion of commercial pearl culture throughout the region.

J.K. Wang: Laboratory growth rate of *Pinctada margaritifera* – a preliminary report.

Vietnam

P.N. Kim, N. To & V. N. Tuan: Freshwater pearl culture at West Lake (Hotay), Vietnam.

H.D. Thang: Pearl farming in Vietnam.

Abalone pearls

P. Fankboner, Canada (Session Head): Abalone pearls: past, present and future.

G. Brown, Australia: Gemmology of abalone and other gastropod pearls.

S. Koethe, United States: Natural abalone pearls

American freshwater mussels

R. Neves, United States (Session Head): Prognosis for the future: crisis management of an imperiled mussel fauna.

S. Ahlstedt, United States: Invasion and impacts of the zebra mussel in the United States.

N. Cohen, United States: Commercial harvest of freshwater mussels in the United States.

R. Neves & J. Williams, United States: Status of the freshwater mussel fauna in the United States.

Variation in abundance of blacklip pearl oyster spat in the Solomon Islands, *by Johann Bell, ICLARM Coastal Aquaculture Center, P.O. Box 438, Honiara, Solomon Islands.*

The Australian Center for International Agriculture Research (ACIAR) has provided ICLARM's Coastal Aquaculture Centre funding for two years to assess the feasibility of farming pearl oysters in Solomon Islands.

The project stems from the observation that reasonable quantities of blacklip pearl oysters have been harvested from many areas within the Solomon Islands on a regular basis.

In view of the success of the blacklip pearl industry in Tahiti and the Cook Islands, ACIAR, ICLARM, and the Solomon Islands Fisheries Division are collaborating to determine whether it is possible to establish blacklip pearl oyster farms in other types of coral reef habitats in the Pacific, e.g. the more open lagoon complexes of the Solomons.

The most important question in this regard is, 'Are there sufficient wild spat of the blacklip pearl oyster in the Solomon Islands to set up a viable industry?' To answer this question, staff from the Coastal Aquaculture Centre have designed a sampling programme to measure spatial and temporal variation in abundance of blacklip spat over a wide area of the Solomon Islands.

Spat of blacklip pearl oyster will be collected from three sites in each of five main areas (i.e., a total of 15 sites). At each site, a longline 100 m in length will be set up. Spat collecting bags will be suspended from the longline every three months and left to soak for six months to allow enough time for the spat to grow to a size where they can be identified easily. Two types of spat collecting material will be used in the spat collecting bags: shade cloth and black plastic sheet.

The five main areas to be sampled are Ngela, South Malaita, Seghe, Munda and Gizo. All these areas provide access to a range of sheltered reef habitats. Selection of the three sites in each area was based on aerial photographs and historical levels of blacklip harvests.

Blacklip spat collected at each site will be grown-out in nearby coastal villages using conventional methods. The hope is that the programme will identify areas where villages can reliably catch and grow enough spat to establish their own farms, or to sell live oysters to an overseas pearl farming company.

Genetics of black-lipped pearl oyster *(Pinctada margaritifera)*, *by John A. H. Benzie, Australian Institute of Marine Science, PMB No.3, Townsville MC, 4810, Queensland, Australia.*

Genetic data now available from black-lipped pearl oyster stocks from Japan, French Polynesia, Kiribati, the Cook Islands, the Great Barrier Reef (GRB) and Mauritius are reviewed. *P. margaritifera* stocks have high levels of gene flow between populations widely separated geographically. Early work emphasised the lack of geographic differentiation.

However recent surveys of populations from the West and Central Pacific have shown significant genetic differences, not only between the Great Barrier Reef and central Pacific populations, but between local populations within island groups. The implications of these findings for restocking and stock transfer are discussed.

Potential of pearl oyster culture on the Colombian Caribbean, *by Francisco J. Borrero. INVEMAR, Instituto de Investigaciones Marinas de Punta de Betin, A.A. 1016, Santa Marta, Colombia.*

As part of a preliminary, but comprehensive programme to assess the feasibility of culturing several species of bivalve mollusks from the Colombian Caribbean, we have initiated studies on the potential for cultivation of the mother-of- pearl oyster (*Pinctada imbricata*), and the winged pearl oyster (*Pteria colymbus)*.

We are carrying out five major studies related to elucidating aspects of the biology and ecology of local pearl oyster populations, which are critical to any culture plans:

1. We are surveying the extent and status of natural stocks of pearl oysters, including cartography of bottom types, abundance and oyster size distribution, and density;

2. We are studying the spatial (across bays, and bathymetric) and temporal variation of intensity in spat settlement on artificial collectors made of two different materials, and placed at several depths;

3. We are monitoring temporal changes in abundance of planktonic bivalve larvae, including those of pearl oysters, both at the surface and on deeper waters, with the goal of elucidating possible relationships between changes in environmental conditions and abundance of planktonic larvae, as well as examining the relation between changes in abundance of larvae in the water and of spat on collectors;

4. To elucidate the sexual system of these species, we are studying the relationships between size / age and sex, as well as fecundity of the two pearl oysters, and are monitoring the occurrence of the main spawning seasons;

5. in an effort to identify important seed collection areas, we are studying the local hydrographic patterns, and their relation to major seasonal changes of climate.

In addition, we have built a small hatchery for artificial seed production, which will prove useful due to possible variability in spat settlement. These studies will result in a recommendation to the Government of Colombia regarding the biological feasibility of pearl oyster cultivation.

Contribution to the knowledge of the dynamics of populations of the black pearl oyster in French Polynesia, *by Nathalie Cheffort-Lachhar, ORSTOM Papeete/Brest, P.O. Box 2089, Papeete, Tahiti, French Polynesia.*

Four atolls with different levels of pearl farming exploitation and geomorphology were investigated. Several dives were made in 1990 to estimate the density and size frequency distribution. A tagging procedure enabled us to estimate the growth and mortality coefficients.

Evaluating pearl shell habitat in Torres Strait and the Arafura Sea, *by Kathy Colgan, Bureau of Resource Sciences, John Curtin House, P.O. Box E11, Queen Victoria Terrace, ACT 2600, Australia.*

Stocks of pearl shells have declined markedly in the Torres Strait and the Arafura Sea. Extensive surveys of historically important pearling beds were carried out in 1989. Environmental factors associated with presence / absence and abundance of pearl shell were monitored and relationships modelled.

Hawaii's impact on the international pearl industry, *by Richard Fassler, Aquaculture Development Program, State of Hawaii Department of Land and Natural Resources, 335 Merchant Street, Honolulu, HI 96813.*

The pearl oyster, *P. radiata,* occurs in close-in waters in Hawaii. Pearl Harbor, for example, was reputed to have an abundant supply of 'pipi', which the early Hawaiians used for food.

The deeper-water *P.margaritifera* was also in abundance, especially in the northern Hawaiian island region. These oysters yielded few pearls, but the Hawaiians utilised the mother-of-pearl for implements, such as fishhooks.

Commercial pearling in the Island was initiated in 1927 and 1928 when an American fisherman harvested 100 tonnes of *P. margaritifera* from Pearl and Hermes Atoll, 1100 miles north-west of Honolulu.

Concern over the possible depletion of the resource led to a joint State/Federal commission in 1930, which surveyed the oyster throughout the islands. The members concluded that conservation measures should be initiated, and these have remained to this day.

Modern pearl farming in the state has been impeded by environmental constraints, which have made utilisation of the open ocean extremely difficult. Therefore, efforts have been directed to on-land operations. These have occurred at the Natural Energy Laboratory Authority of Hawaii (NELHA) site at Keahole Point, on the big island.

In 1990, Hawaii Cultured Pearl, Inc. attempted to raise the Japanese pearl oyster, *P. fucata*, by culturing algae in tanks and feeding these algae to oysters in raceways. A lack of success led to a halt in this experiment. Efforts have been made to resume operations.

The next attempt to raise pearls in Hawaii focused on utilising freshwater lakes and reservoirs to raise American mussels. In 1992, Cross-Pacific Pearls of California was investigating this possibility, and applied for permits to import various species of mussels, but financial problems terminated the firm's plans.

In 1992, Black Pearls, Inc. developed hatchery methods for the Hawaiian blacklip pearl oyster, *P.margaritifera galtsoffi*, and is now examining the feasibility of commercial pearl culture in land-based or ocean-based systems in Hawaii. In addition to establishing commercial culture techniques, the company is testing methods for a stocking programme to help re-establish the Hawaiian pearl oyster.

Black Pearls, Inc. is also using its hatchery technology to supply spat to other South Pacific islands. Black-lip pearl oysters from the Marshall Islands have been spawned, and the larvae successfully raised to settlement in the deep-OTEC water available at NELHA. Use of this pathogen-free water ensures that quarantine concerns are met. Spat recently returned to the Marshall Islands have shown good growth and survivorship.

The Black Pearls, Inc. effort has significance for islands and atolls in the South Pacific, like Namdrik, which are lacking a major source of mature oysters. Moreover, other areas that are rapidly depleting their oyster resource may need to rely on firms like Black Pearls, for future supplies.

In 1993, the Biosystems Engineering Department of the University of Hawaii began experiments with raising algae to feed to *P. margaritifera* for on-land oyster culture.

The successful production of three key species of diatoms directly from an ocean intake of seawater, without having to maintain expensive laboratory cultures, has pointed to cost-effective land-based culture. The university is attempting to repeat this success with *P. maxima*.

The University's experiments may lead to pearl culture on atolls, or islands, like the Hawaiian Islands, or even in Mainland locations, where access to the open ocean is either difficult or impossible.

Perhaps Hawaii's most valuable contribution to the world pearl industry is *Pearls '94*, the largest and first truly international gathering of pearl farmers, researchers, government officials, jewelers and equipment suppliers.

As originally conceived in 1991, the meeting would bring aquaculturists together to discuss ways to accelerate pearl farming in the South Pacific. In subsequent years, strong interest from other areas of the world considerably expanded the scope of the gathering. More than 30 nations will be represented in Hawaii.

Pearls '94 is excepted to have a profound impact on international pearling by offering important opportunities, which include:

1. Stimulating sales, through identifying and solving industry problems;

2. Creating marketing strategies;

3. Disseminating information on the latest farming techniques

4. Encouraging investments in farms;

5. Heightening awareness of quality control;

6. Informing pearl producers and buyers of the most recent development in pearl production throughout the globe; and

7. Formulating plans for future international pearl conferences.

Concept of the South Seas pearl and its future lessons of the past, *by C. Denis George, P.O. Box 5811, Cairns, Qld. 4870, Australia.*

The pearls from the South Seas are a later addition to the ones known since antiquity from the legendary pearl fisheries of Arabia, India, the Americas and elsewhere.

With the exploration of the Indo-Pacific region, the much larger pearls discovered attracted more admiration – especially the black ones from Polynesia. As the fisheries were declining, advances in the alluring mystery of pearl-formation were promising new horizons in reproducing them at will.

After the ingenious Chinese pearly-images and the Linneous pearl in 1893, W. Saville-Kent published a half-pearl he had developed earlier, created an impetus with his first South Sea pearl farm in 1906 and developed a round pearl *in situ*.

In 1894, K. Mikimoto made his first half-pearl and by-passed the controversy on the origination and Saville-Kent's influence. The fact is that by 1920 the Japanese had mastered the cultivation of a pearl when Australia, with better resource potential which it had started to develop, outlawed it as illegal.

Dr Sukeyo Fujita, in visualising a better pearl, after years of trials, had achieved it by 1928 in the Celebes. By 1932, the Japanese had initiated six pearl farms at Palau and an industry started. The concept of the South Sea pearl was created:

'A pearl equal to the natural one but at 1/4 of its value and, with a nucleus of 1/3 only to the overall diameter'.

The standard was maintained in the post-war era with the renowned Burmese pearls, until the late 60s, when Japanese in Australian joint ventures flooded the market with inferior pearls, selling them as cheaply as A$10.00 each. An all-around catastrophe took place, and a woman's 'beloved-pearl' was devalued, to her dismay.

There were other similar crises: repetitive production calamities from continuing shell mortalities; a quality decline; uncontrollable production increases with deficient approach; whatever being produced was sold for as much as possible; new aspiring producers looking for profit; the over-priced thin-skin large pearl; lack of overall coordination and expertise guidance.

There was, then an overall decline of the concept of the South Seas Pearl, with looming calamities and an uncertain future.

Ecological characterisation of the Tongareva lagoon, *by Maria Haws, Ben Ponia, Daniel Cheney, & Hugh Thomforde, RDA International, Inc. c/- Tongareva Marine Research Centre, Ministry of Marine Resources, Omotea, Tongareva. Cook Islands.*

The ecological monitoring programme on Tongareva has three objectives:

a. To collect baseline data on the physio-chemical and biological parameters needed to form a database containing information on the hydrological and biological processes of the Tongareva lagoon;

b. To collect data relevant to oyster culture to benefit development of management plans; and

c. To monitor possible environmental impacts of farming or other human activities.

Baseline water-quality data were collected over the year prior to the start of intensive pearl farming. Periodic sampling included measurements at 40 stations around the lagoon, at both shallow and deep depths, of temperature, salinity, pH, dissolved oxygen, orthophosphate, silicates, ammonia, total dissolved nitrogen, chlorophyll, total organic carbon, and total dissolved phosphorus.

The values obtained are typical of a tropical coral atoll with oceanic water exchange. Values for most parameters were highly variable throughout the lagoon and no spatial trends were detected. No indications of deleterious human impact were found. None of the values were suggestive of nutrient loading or eutrophication.

This database will serve as a reference to assess environmental changes associated with farming and human activities in the future. Several patch reefs were surveyed for an assessment of coral type and fish abundance / diversity.

A stock assessment was conducted to estimate the standing stock of the *Pinctada margaritifera* popula-

tion. It also established permanent sites to monitor the mortality and recruitment rates of the pearl oyster fishery. Total standing stock for the lagoon was estimated at 2 to 3 million oysters.

Alternatives to collection of wild stock for farming purposes. such as spat collection and hatchery production, will be emphasised, since these will reduce fishing pressure on the wild stock in the future.

Experiments were conducted to evaluate the feasibility of using spat collectors to obtain oysters for farming. Results to date are inconclusive and spat collection trials continue.

Oysters were collected for histopathological examination in 1992 and 1993. The *P. margaritifera* population appears to be generally healthy with no prevalent pathogenic or parasitic infection.

Growth and mortality of *Pinctada margaritifera* in French Polynesia, *by Andre Intes, Institut Français de Recherche Scientifique pour le Développement en Coopération (ORSTOM). Centre de Brest, B.P. 70, 29280, Plouzane, France.*

In the early 1980s, pearl culture was still exclusively dependent on the prosperity of natural populations to provide stock for pearl farms. At least 70 per cent of pearl oysters were caught by skin diving and the remainder came from the rearing of collected spat.

But most of the required biological parameters (reproduction, growth, mortality, stock assessment) needed to promote new management of these natural stocks were lacking.

To assess growth and mortality, which are two of the most important parameters of the population dynamics, a tagging experiment was initiated. This species is particularly suitable for tagging as, in theory, individuals can be measured when ever desired. Individuals (505) were tagged from April 1983 to April 1984; only 37 were present and still alive in June 1987.

The data collected over four years could have provided very valuable information on growth and mortality if some unpredictable climatic and biological events had not occurred.

During late 1982 and early 1983, six hurricanes struck the Tuamotu Archipelago, destroying most of the shallower bottoms and pearl farms.

Two years later, from mid-1985 to 1986, high mortality affected both the farmed and natural populations, but there was no obvious explanation, such as disease or hydrological disturbance.

As the mortality developed mostly in the more pearl-productive lagoons, the hypothesis of an overload of the carrying capacity was considered. In the year following the hurricanes, stock reproduction was exceptional and natural recruitment, combined with rearing of the collected spat, could have enhanced the biological trophic demand to a level unsustainable by the ecosystem.

The monthly mean length increment for individuals greatly decreased during the year with maximal mortality, but had recovered to various levels by the end of the experiment.

Examining growth by age classes, it seems that the maximum length increments do not occur during the same period for adults over three years old and for juveniles. Most of the trophic energy captured by adults is used in the maturation of gonads from January to March, when juvenile growth rate is highest.

ACIAR/JCU blacklip pearl oyster project, *by John S. Lucas, Zoology Department, James Cook University, Townsville, Queensland 4811, Australia.*

This three-year project, 1993–1996, is funded by the Australian Centre for International Agricultural Research. It involves James Cook University, the Queensland Department of Primary Industry and the Ministry of Natural Resources, Kiribati. There will also be some collaboration with ICLARM's Coastal Aquaculture Centre, Honiara.

The project is focused on the Republic of Kiribati, a Pacific nation consisting of a series of coral atolls.

Pinctada margaritifera, though shell and / or cultured pearls, is one of a limited range of potential export commodities for this country.

However, the pearl oyster stocks appear to be low, either intrinsically or from overfishing. Thus, the overall objective of this project is to build up the *P.margaritifera* stocks in selected atoll lagoons in Kiribati as a means to an appropriate pearl industry.

Initially, pearl oyster stocks will be systematically surveyed to establish in which atoll lagoons they occur and their abundances. Spat collectors on longlines will be deployed at selected sites in lagoons to determine levels of natural settlement and the potential of settlement on these artificial substrates as a source of pearl oyster stocks.

The alternative source to spat collection is hatchery production of spat, and simplified hatchery methods, suitable to a coral atoll environment, are being investigated. These are based on the system of flow-through culture, with artificial diets that were developed for successful hatchery culture of giant clams. The objectives are to get away from air-conditioned culture rooms and sophisiticated algal culturing facilities.

One further aspect of the project is related to the pearl bead insertion process. It addresses the trauma and infections of the operation, and considers how these can be reduced.

The first aspect of this research programme, related to pearl oyster stocks and settlement in Kiribati atoll lagoons, is particularly applicable to that country; but if there are significant advances in the other two aspects, low-technology hatchery culture and aspects of bead insertion technology, these will have general application.

The development of black pearl farming in Manihiki, *by Raymond Newham, Terone Pearls LTD, Tahumu, Cook Islands.*

This paper looks at the development of black pearl farming in Manihiki, a coral atoll in the North Group of the Cook Islands.

The focus is on the three areas of the industry: access to technicians, material supplies, and marketing. The functions of the development agencies responsible for pearl farming in Manihiki are discussed. Some considerations are offered to other countries contemplating pearl development programmes.

Black pearl culture development in the Pacific Islands, *by Garry L. Preston, South Pacific Commission, New Caledonia.*

The paper describes the potential for, and constraints to, the development of black pearl culture industries in those Pacific island countries where such industries do not yet exist. The paper also describes the international institutional development efforts in Pacific Island nations, and suggests ways in which they might be strengthened specifically to support pearl culture industry development.

Socioeconomic and political aspects of the Tuamotuan black pearl industry, *by Moshe Rapaport, University of Hawaii, Department of Geography, Porteus Hall, Honolulu, HI 96822.*

Black-pearl farming in the Tuamotus has experienced dramatic growth in recent years. However, among the atoll communities, there have been deep divisions on the criteria to be applied for allocating lagoon concessions. Management efforts by the Tahitian administration have been frustrated because of their insufficient attentiveness to local concerns.

Hatchery culture of the black-lip pearl oyster in Hawaii — stock re-establishment and expansion of commercial pearl culture throughout the region, *by Neil Anthony Sims & Dale J. Sarver, Vice-president (Research), and President, Black Pearls, Inc., P.O. Box 525, Holualoa, HI 96725.*

The establishment of a commercial hatchery for black-lip pearl oysters (*Pinctada margaritifera*) at the OTEC facility in Kona, Hawaii, has significance for the preservation of threatened populations, as well as opening up commercial pearl culture potential for Hawaii and other Pacific Islands.

The Hawaiian variety of black-lip (*P. margaritifera galstoffi*) was overfished in the past, and is now rare to the point of being protected by the State. Relict stocks in Pearl and Hermes Reef, Kaneohe Bay, and along the Kona Coast show no signs of recovery. Hatchery culture would allow a stock re-establishment programme.

Ocean-based pearl farming options are being explored at several sites through the Hawaiian Islands. Land-based pearl culture is also being developed at the OTEC plant in Kona.

The feasibility of using pathogen-free deep-OTEC water for broodstock maintenance, larval culture and early spat rearing has been proved in trials with Marshall Islands pearl oysters.

These techniques remove the risks of inadvertent transfer of exotic organisms (pathogenic or benign) and genetic mixing between stocks. Pacific Islands with small quantities of broodstock can now use this system to provide spat for stock re-establishment or development of commercial pearl culture.

With this technology, the natural scarcity of pearl oysters in a lagoon is no longer a principal constraint to the development of pearl farming. The Kona facility can operate as a regional hatchery for the central Pacific, obviating the need for expensive construction and operation of pearl oyster hatcheries on each island group.

Pearl culture on Tongareva, Cook Islands: impact of community-based management, *by Hugh Thomforde, Rorangi Tonitara, & Amelita Tabique, RDA International, Inc., Tongareva Marine Research Centre, Ministry of Marine Resources, Omoka, Tongareva, Cook Islands.*

The authors live on Tongareva (also known as Penrhyn) in the Cook Islands. They review the development of the cultured pearl industry and the effects of traditional fishing and recent economic factors on that development.

Prior to 1992, the majority of the residents of Tongareva were either uninterested in or opposed to pearl farming. A large share of the adult population feared loss of local control over lagoon tenure rights and increased control in all lagoon affairs by the central government.

As many as five per cent of adults in the village of Omoka feared pearl seeding would induce a biological catastrophe on the scale of nuclear explosion, with the consequent necessity to evacuate their homeland.

This was apparently due to the incorrect association of the word 'nucleus' – used to refer to the beads used in spherical pearl seeding – with the word 'nuclear' in regards to the contamination experienced at Bikini and Enewetak atolls in the Marshall Islands.

In March 1993, the Penrhyn Island Council shifted from a policy of opposition to supporting pearl seeding, although public opinion remained highly divided on the issue. By November 1993, pearl–seeding licences were initiated and prospective pearl farmers were required to apply for a permit from the Island Council.

The economic potential of pearl farming was the overriding factor which influenced people to support commercial farming. The recent collapse in the copra industry, due to reduced world market prices, and the steadily declining price for pearl shell have obviously been influential.

From November 1993 to January 1994, support for pearl farming and commercial seeding ran at about 95 per cent of the adult population in the village of Omoka. There is still lower support for pearl culture at the village of Tetautua because of a greater reliance on regular harvests of pearl shell for basic subsistence. It is anticipated the opposition for establishment of reserve areas, or for a total ban on wild harvesting, could come from Tetautua.

A pearl farming family, *by Peter William, William Family Pearl Farm, Manihiki, Cook Islands.*

The William family owns and operates the first and the largest local farm in the Cook Islands. This paper reviews the history of the farm's development, and outlines the present status of the William family farm in Manihiki.

The history of differences in development approaches and industry management between the local and the central government are discussed.

The paper describes the role these difficulties played in hindering the development of the William farm, and the whole industry.

The importance of good seeding technicians is highlighted. Recent marketing strategies for Manihiki pearls are presented.

The socio-economic, cultural and political changes wrought by pearl farming are profound. These changes are described, and possible solutions are outlined.

Book reviews

The two following books were reviewed by Beatrice Burch.

Pearls and Pearl Oysters of the World, *by Dr Shohei Shirai, Marine Planning, 528 Yonehara, Ishigaki, Okinawa 907-04, Japan, 108 pages (US$ 65 + US$ 14 for postage).*

This colourful Japanese–English identification guide contains information on both pearl oysters (24 species of the family Pteriidae) and 238 North American freshwater pearl mussels of the families Unionidae and Margaritiferidae.

It includes 13 other pearl-bearing molluscs from around the world in beautiful photographs, and distributional maps of pearl oysters and locatlities of pearl farms.

The photos of oysters and mussels are interspersed with photos of pearls (cultured and natural), oyster anatomy, pearl from abalone, conch pearls and even pearls from the non-nacreous but beautiful venerid, *Mercenaria mercenaria*, and the odd and massive pearls from *Tridacna*.

Illustrations are very clear, with both interior and exterior of shells documented by size and museum source.

Pearl jewellery of pre-Columbian American origin is shown, as are lovely baroque and non-nucleated (**keshi**) pearls, and the brilliantly gleaming pearls from the black–lipped Polynesian pearl oyster and the magnificent white or gold pearls from the silver–or gold–lipped oyster from Australia and S-E Asia.

The exquisite Japanese pearls are there, of course, as are the all-American cultivated Tennessee pearls from North American freshwater mussels, with their deeply lustrous beauty.

I was startled to see that *Pinctada radiata, P. fucata, P.fucata martensii* (the Japanese Akoya), and *P.radiata* from Venezuela, Columbia, Mediterranean, Hawaii, etc. are all given as synonyms of *Pinctada imbricata*.

There is no reference to literature, so I look forward to a future paper from the author in peer-refereed journals to clarify this point. Systematics is a difficult problem, but with such an excellently pictured guide, even if names are questioned, the photographs will identify most of the specimens. Having each cited by museum source with museum names and with Dr Shirai's names is wonderful guidance.

Systematists will want to compare these illustrations of pearl oysters with the well-documented paper on pearl oysters by Ranson, G. (1961). *'Les espèces d'huîtres perlières du genre Pinctada (biologie de quelques-unes d'entre elles'*. Mem. Inst. Roy. Sci. Nat. Belgique. 2ème série: 67–95. I compared the pearl mussel names against the North American pearl mussel paper by Williams, J.D., M.L. Warfen, Jr., Kevin S. Cummings, John L. Harris & R.J. Neves (1992)— Conservation Status of Freshwater Mussels of the United States and Canada. Fisheries, Vol. 18 (9): 6–22, Am. Fisheries Society.

I was satisfied that the names of pearl mussels agreed very well with those mentioned in this paper. This book should be utilised by many general readers and specialists interested in the pearl world.

The Scottish pearl in its world context, *by Dr Fred Woodward, Diehard Publishers, Spittal Street, Edinburgh EH3 9DY, Scotland. 1994. 165 pages (£ 6.50).*

This is an intriguing account not only of the Scottish pearl, but of the almost international freshwater mussel, *Margaritifera margaritifera* (Linnaeus, 1758) and the global pearl industry past and present.

The 165-page book includes enjoyable early records from Babylon to the present and even pearl fishing in Scotland in a poem published in 1638! But that isn't all. The book also covers pearls, Mikimoto pearl methods and how imitation pearls are made (at last we can learn how fish scales are used to make imitation pearls).

Habitats of pearl mussels and methods for pearl fishery, including those for Scotland in detail, and a delightful trip to Russia and its rivers are shown. The last few chapters dwell on how conservation may or may not be able to save and enhance pearl mussel populations.

For some geographic areas, it is obvious that all is not lost, although it does seem bleak for the United States. Dr Woodward feels that at least in Europe, and certainly in Russia, rivers are being cleaned up. In Germany, the United States, England and Scotland, successful work is being accomplished experimentally, even using artificial means to retain the parasitic larval stage of mussel species dependent on certain fishes as temporary nurses and for dispersal. Or, if those fish are absent, experiments have been devised for artificial dispersal of mussel populations.

Interestingly, there is no mention of the problems present in North American rivers due to the invasion of the Asiatic clam *Corbicula fluminea*, which has spread across American rivers and canals over the last 50 years, nor anything of the recent invasion of the Mississippi River system by the European Zebra Mussel, *Dreissena polymorpha*, found in navigable rivers and in the Great Lakes since 1988.

Obviously, the author, a member of the European Invertebrates Survey, the Bern Invertebrates Specialist Group, the Mollusc Specialist Group of the Species Survival Commission of the World Conservation Union (IUCN), member and former president of the Conchological Society of Great Britain and Ireland, and Fellow of the Linnean Society, is well-suited to have written a thoroughly delightful book.

He is also interested in sharing his experience in how an individual can help in saving an animal important for the stability of river communities. As the writer of the foreword, Mr. Tony Andrews, Director of the British Council, states, '*Margaritifera margaritifera* is more than yet another threatened species or a biological indicator. Ultimately it is a measure of our commitment to sustaining our environment.'

Beatrice Burch also kindly offers the following notes on sources for pearl promotional booklets and pearly mussel posters and videos.

Bo Torrey left a bunch of the Golay Buchel pearl promotional booklets, by Andy Miller and Bo Torrey, for us to sell to benefit the Hawaiian Malacological Society. They can be obtained for US$5.00, plus postage, from Mr. George Cook, care of the Hawaiian Malacological Society, P.O. Box 22130, Honolulu, Hawaii 96823-2130.

Also, at the Pearls '94 conference, Dr. Richard Neves gave his talk and then showed a video on America's pearl mussels. The video, its script and the pearl mussel poster are available from Virginia Technological Inst., Virginia at immensely moderate costs. These productions have been mostly subsidised by the U.S. Government, so the prices are very low and are primarily for postage and handling.

Mussel script: Free; Mussel poster: US$1.75; Mussel video: US$6.00.

To order, send US$ cheque payable to:

Treasurer Virginia Tech
Virginia Tech Extension Distribution Center
112 Landsdowne Street
Blackburg, VA 24061-0512
USA

Beatrice Burch can be contacted at: 236 Kuuhoa Pl., Box 309, Kailu, Oahu, Hawaii 96734, Phone: (1-808) 261 7465, Fax: (1-808) 263 6408.

Australian Fisheries Research and Development Corporation: Final reports available, and research projects funded

'Growing techniques and disease prevention in West Australian pearl oysters' sets out how to reduce the death rate of wild oysters used in the pearl culture industry. The report recommends handling and transport methods, stocking densities and disease containment techniques (Print copies only, A$ 20.00 including postage).

'Electron microscopy of tissues producing organic matrixes in pearl shells' raises the possibility that the nervous system may be the only physiological control mechanism in the regulation of shell secretion. B.J. Vance of James Cook University also identifies the mechanism pearl oysters use to seal off their pallial space and thus produce a specific inner nacreous layer. (FRDC 92/39, A$30)

Projects approved:

Aquaculture

No. 94/079, Dr. C. Shelley, NT Primary Industries and Fisheries, Phone: (61-89) 894363, Project title: **Pearl oyster aquaculture: health survey of North-**

ern Territory, WA and Qld pearl oyster beds and farms; completion; June 1997

Harvesting

No. 94 / 098, Dr. R. Wong, Pearl Producers Association, Phone: (61-9) 3862198, Project title: **Pearl divers diving safety** - 2; completion: June 1997

Marketing

No. 93 / 194, Mr P. Hawkins, Pearl Producers Association of WA, Phone: (61-9) 3862198, Project title: **Cultured pearl classification equipment; development**; completion: June 1994.

Stock evaluation

No. 92 / 147, Dr. L. Joll, WA Department of Fisheries, Phone: (61-9) 2468425, Project title: **Stock evaluation and recruitment measurement in the WA pearl oyster fishery**; completion: June 1995

For more details, contact the Australian Fisheries Research and Development Corporation, P.O. Box 9025, Deakin, ACT 2600. Tel: (61-6) 285 4485.

Iranian pearl research in progress

The following project summaries are extracted from the Annual Report 1992/93, published by the Iranian Fisheries Research and Training Organisation.

Project title: Identification of edible molluscs and pearl oysters in the interdidal zone of the Persian Gulf

Executor: Persian Gulf Mollusc Fish. Res. Ctr

Objectives: To determine diversity and abundance of molluscs (oysters) in the intertidal zone

To identify molluscs inhabiting separated areas and explain distribution pattern and boundaries envisaged

Summary of activities:

Selecting sites between Bandar Abbass and Hendijan;

Sampling intertidal molluscs present in prefixed sites;

Fixing samples and transporting them to laboratory of the center;

Identifying samples with available keys;

Evaluating relative distribution and density of each mollusc at separate sites.

Project title: Surveying biological impact of oil pollution on pearl oysters in the Persian Gulf

Executor: Persian Gulf Mollusc Fish. Res. Ctr.

Objectives: To obtain biological indices for early pollution awareness

Summary of activities:

Collecting approximately 150 molluscs and keeping them in aquarium;

Dividing specimens into four experimental groups;

Placing molluscs in four environments with different densities of oil pollution;

Drawing blood from the molluscs in each experimental group and carrying out blood analysis;

Analysing blood-related parameters for achieving the indices of pollution.

Various abstracts

Anaesthetizing *Pinctada radiata* with MS 222, *by Fariborz Ehteshami, DVM., Persian Gulf Molluscs Fisheries Research Center, Bandar Lengeh, IFRTO. (Source:* Iranian Fisheries Bulletin, *Jahad Sazandegi Ministry, Iranian Fisheries Research and Training Organisation, No. 3, Summer 1993).*

The effect of MS 222 for inducing anaesthesia in 60 *P. radiata* was studied under different concentrations and various stimulating factors.

Based on the results of mortality rate, induction time, duration of anaesthesia, recovery time, responses of the organism to the anaesthetic and handling, it was concluded that the concentration of 1ppt of MS 222 was the best for inducing anaesthesia in *P. radiata*.

Infection of pearl oyster *Pinctada margaritifera* with *Cliona* sp. and subsequent destruction of oyster shell, *by Mehid Saveh Doroudi, DVM, Persian Gulf Molluscs Fisheries Research Center, Bandar Lengeh, IFRTO. (Source:* Iranian Fisheries Bulletin, *Jahad Sazandegi Ministry, Iranian Fisheries Research and Training Organisation, No. 3, Summer 1993).*

One of the major problems of pearl oyster cage culture in the Persian Gulf is boring and fouling organisms attacking oyster under culture.

The infected oysters lose their commercial longevity, which results in a decrease in pearl production capability.

P. margaritifera is one of the rarest species of pearl oysters in the Persian Gulf.

As such much research is now being undertaken to study the parasites and their relationship with the host organism in an effort to protect stocks.

Cliona sp. has been found to be the most common parasite, causing much destruction to the oysters.

In this article the extent of oysters infested with this parasite and subsequent destruction of oyster shells is described.

The relationship between frequency of cleaning and growth of *Pinctada radiata* during winter season in Bandar Lengeh coastal waters, *by Mehdi Saveh Doroudi, DVM, Persian Gulf Mollusc Fisheries Research Center, Bandar Lengeh, IFRTO. (Source:* Iranian Fisheries Bulletin, *Jahad Sazandegi Ministry, Iranian Fisheries Research and Training Organisation, No. 3, Autumn 1993).*

The relationship between frequency of cleaning and growth of *Pinctada radiata* was investigated from January to April 1993 in Bandar Lengeh coastal waters. The oysters were divided into three groups (n=30) and they were cleaned after every 23 ± 2, 45 ± 2 and 92 days, respectively. The rate of mortality due to invasion of fouling organisms was nil.

Analysis of variance indicated no significant difference in growth rate between the three experimental groups. Thus it is suggested that settlement of fouling organisms does not produce any significant difference in either mortality or growth rate of pearl oyster *P. radiata* during the winter season in the Bandar Lengeh coastal area.

Early larval development of pearl oyster, *Pinctada margaritifera* (Linnaeus), *by Fariborz Ehteshamei, Department of Aquaculture, Mollusc Fisheries Research Center, P.O. Box 1416 Bandare Lengeh, Iran, Fax: 98 7622 4913.*

Thirteen mature male and female pearl oyster *Pinctada margaritifera* selected from the Kish Island oyster farm were induced to spawn by ultraviolet irradiated seawater followed by warm shock.

97–98 per cent of eggs underwent successful fertilization and the larvae were reared up to umbo stage in one experiment. The largest umbo larva was 120 µm.

Results indicated that thermal stimulation (both cold and warm shock) was less effective in induction of spawning of both sperm and eggs than the natural spawning.

Fertilized eggs were cultured in 2l and 20 l vessels containing filtered ultraviolet-treated seawater.

Ninety per cent of the fertilized eggs successfully reached the straight hinge-stage in 20–26.5 hours. The umbo stage was reached in 13 days.

Larvae were fed with the algal mixtures of *Isochrysis galbana* and *Chaetoceros calcitrans*. Antibiotics and supplementary foods were not used throughout the experiments.

Solubilization of the insoluble organic matrix in the nacreous layer of *Pinctada fucata* (Preliminary Report), *by Tetsuro Samata, Department of Aquatic Biology, Research Institute of Biosciences, Azabu. Abstract of an article by Tetsuro Samata, published in* Venus, *Vol. 52, No. 4 (1993): 313–315.*

The water-insoluble organic matrix in the nacreous layer of *Pinctada fucata* was solubilised by formic acid. As a membrane was synthesised from the solubilised component by evaporating formic acid, this reaction may mainly be due to the break of the hydrogen bond between the peptide chains.

As a result, the analysis of the solubilised component will provide valuable information about the structure and function of the water-soluble organic matrix and hence lead to a more precise understanding of the role of the organic matrix for shell formation.

Growth and physiological condition of the Japanese pearl oyster, *Pinctada fucata martensii* (Dunker, 1850) in Ohmura Bay, Japan, *by Katsuyuki Numaguchi, Ohmura Branch, National Research Institute of Aquaculture, Ohmura, Nagasaki, 856, Japan. Abstract of an article by Katsuyuki Numaguchi, published in the* Journal of Shellfish Research, *Vol. 13, No. 1, 93–99, 1994.*

Growth and physiological condition of the Japanese pearl oyster, *Pinctada fucata martensii*, were investigated from May to December of 1984 and 1985 in Ohmura Bay, Japan. Mean growth rates (whole weight) of one- and two-year-old pearl oysters were 138–157 mg / day and 68–69 mg / day, respectively.

These growth rates were comparatively low as compared with a good–growth pearl farm. The slow growth of pearl oysters in the Ohmura Bay pearl farm has been caused by low food concentrations, as indicated by phytopigment concentrations, which reflect food quantity.

Red tide occurrences (*Heterosigma* sp. or *Prorocentrum* sp.) in 1985 may have slowed the recovery of meat condition and glycogen stores in pearl oysters after spawning. It is also possible that the temperature stress (above 28–30°C) in the summer may have contributed to the decline of physiological condition and the cause of mortality of pearl oysters weakened by spawning.

Microscopic anatomy of the mantle of the pearl oyster *Pinctada mazatlanica*(Hanley, 1856) , *by Alejandra Garcia-Gasca, Rosa Isabel Ochoa-Baez & Miguel Betancourt, Department of Marine Biology, CICIMAR/ PN Apdo, Postal 592, La Paz, B.C.S., Mexico, C.P. 23000. Abstract of an article by Alejandra Garcia-Gasca, Rosa Isabel Ochoa-Baez, and Miguel Betancourt, published in the* Journal of Shellfish Research, *Vol. 13, No. 1, 85–91, 1994.*

The microscopic anatomy of the mantle of *Pinctada mazatlanica* is described using histological and cytochemical techniques. The typical structure of the mantle of a bivalve was observed, with three folds in the marginal zone. Four different secretory cells were characterised:

a. Large secretory cells, lightly basophilic, found in all the epithelia of the mantle which contain carbohydrates, acid proteins, sulfated acid mucopolysaccharides;

b. Small secretary cells, highly basophilic, found only in the middle fold which secretes acid mucopolysaccharides;

c. Acidophilic secretory cells, found in the periostracal groove and in the shell epithelium, which take part in protein synthesis; and

d. Large acidophilic cells found only in the central zone associated with glycogen synthesis.

Lipids were found in the epithelia and pallial nerve. Carbonic anhydrase activity was found in the shell epithelium. Alkaline phosphate activity was found in all epithelia, except the inner epithelium of the outer fold.

The presence of specialised secretory cells, carbonic anhydrase and alkaline phosphatase in the outer mantle epithelium can be related to calcium deposition.

These observations suggest that this epithelium is the most suitable as graft tissue in pearl culture.

Growth of the pearl oysters *Pinctada mazatlanica* and *Pteria sterna* in different culture strctures at La Paz Bay, Baja California Sur, Mexico, *by Isabel Gaytan-Mondragon, Carlos Caceres-Martinez & Marcos Tobias-Sanchez. Department de Ing. Pesquerias, Universidad Autonoma de B.C.S., A.P. 19 La Paz, B.C.S., Mexico, 23000. Abstract of an article by Isabel Gaytan-Mondragon, Carlos Caceres-Martinez and Marcos Tobias-Sanchez, published in the Journal of the* World Aquaculture Society, *Vol. 24, No. 4, December 1993.*

A growth study of *Pinctada mazatlanica* and *Pteria sterna* was conducted to explain the basic steps required for the development of a pearl culture programme in Mexico. Seed for both species was collected using onion bags filled with black polytheylene sheets (40 x 80 cm) and 5 g of vexar filament.

The spatfall was July–August 1987 for *P. mazatlanica* and December 1987–February 1988 for *P. sterna.* The seed (12.8 ± 1.2 and 13.0 ± 0.6 mm respectively) was placed in pearl-nets for intermediate culture (to attain 30 mm height). Populations were subsequently divided into three groups, two groups at 10 m depth in lantern and pocket nets and third placed over a submerged shelf at 10 m depth in plastic net cages.

Growth in height, survival and temperature were monitored. After 22 mo *P. mazatlanica* showed no significant differences in growth between culture structures. Nevertheless, the survival obtained in cages (99%) was larger than that obtained in hanging structures (65%).

After 18 mo of culture, significant differences ($F = 5.199$, $P = 0.05$) in growth were observed for *P.sterna* . Largest animals were found in pockets (106.6 ± 0.8 mm) followed by those in lanterns (104.0 ± 0.7 mm) and finally those in cages (103.5 ± 0.6 mm).

Survival was 99 per cent in pockets, 84 per cent in lanterns and 98 per cent in cages. With the operation of the different culture structures used in this study, the bottom-cage system seems optimal to begin a culture programme to obtain pearl-oysters for nucleus implantation.

Titles

The following titles were provided by Stephanie Pallay, Information Officer, ICLARM Coastal Aquaculture Centre, Honiara, Solomon Islands.

Alamatar, S. M.; Carpenter, K.E.; Jackson, R; Alhazeem, S.H.; Alsaffar, A.H.; Ghaffar, A.R.A; Carpenter, C. Observations on the pearl oyster fishery of Kuwait. *J. Shellfish Res.* June 1993, 12, 1, 35–40.

Dowing, J.A.; Rochon, Y.; Perusse, M.; Harvey, H. Spatial aggregation, body size, and reproductive success in the freshwater mussel *Elliptio complanata*, J.N. Amer. Benthol Soc. June 1993, 12, 2, 148–156.

Norton, J.H.; Shepperd, M.A.; Prior, H.C. Papovavirus-like infection of the golden-lipped pearl oyster, *Pinctada maxima*, from the Torres Strait, Australia, *J. Inverterb. Pathol.*, September 1993, 62, 2, 198–200.

Norton, J.H.; Sheperd, M.A.; Perkins, F.P. ; Prior, H.C., Perkinsus-like infection in farmed golden-lipped pearl oyster *Pinctada maxima* from the Torres Strait, Australia. *J. Inverterbr. Pathol.*, July 1993, 62, 1, 105–106.

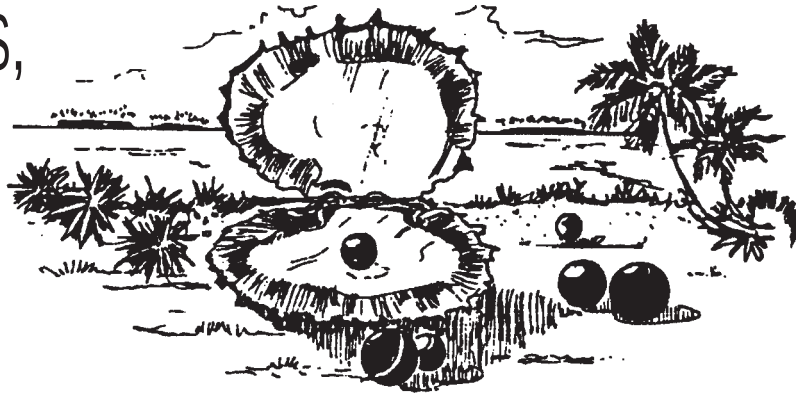
Pekkarinen, M. Reproduction and condition of unionid mussels in the Vantaa River, South Finland, *Arch. Hydrobiol*, May 1993, 127, 3, 357–375.

Sims, N.A., Population dynamics and stock management of the black-lip pearl oyster, *Pinctada margaritifera* (L), in the Cook Islands, South Pacific. *Aust. J. Mar. Freshwater Res.*, 1992, 43, 6, 1423–1435.

Tankersely, R.A.; Dimock, R.V. The effect of larval brooding on the respiratory physiology of the freshwater unionid mussel *Pyganodon cataracta. Amer. Midland Naturalist*, July 1993, 130, 1, 146–163.

Thielley, M.; Weppe, M.; Herbaut, C. Ultrastructural study of gametogenesis in the French Polynesian black pearl oyster *Pinctada margaritifera* (Mollusca, Bivalvia) I-Spermatogenesis. *J. Shellfish Res.* June 1993, 12, 1, 41–47.

CONFERENCES, MEETINGS and WORKSHOPS



Pearls '95

Pearls '95 — Taking our congress to the next level — *Information provided by the International Pearl Association; tel: (415) 5952625.*

If you rely on pearl revenue for a healthy bottom line, you do not want to sit this one out. The second International Pearl Conference and Exposition will bring all facets of the industry together: growers, retail buyers, manufacturers, wholesalers, designers, scientists, investors, media and government officials.

Attendees and exhibitors alike will gain new prospects and meet new players emerging from all over our global community in a rapidly-changing market place, requiring new technology, new marketing strategies and answers to a substantial list of challenges. This requires a constant exchange of reliable and timely information among those who will be counted as leaders in the industry. The technical and jewellery forums will proceed from where they left off at Pearls '94.

Pearls '95 will showcase an impressive representation of the world's pearl business. Our roster of presenters will include prominent industry leaders who will offer their experience and leadership as we collectively elevate pearls to a higher magnitude of profitability and visibility in the global market place.

Two locations were considered for Pearls '95 – Hong Kong and the return to Hawaii.

Both offered great potential; logistically Hong Kong did not work out for 1995. The optimal site chosen was on the island of Maui. The Survey conducted at Pearls '94 revealed that Hawaii got eight times the response that Hong Kong received.

The site chosen for Pearls '95 is the Grand Wailea Resort, Maui. The resort is located on the southwest shore of the island of Maui on 40 magnificent acres fronting beautiful Wailea Beach and is a brief 20-minute drive from Kahuli Airport.

The Grand Wailea world-class resort is the perfect choice to host this prestigious event, hosted by IPA and the Hawaii jewelers Association. This luxurious resort's amenities are among Hawaii's best and we have negotiated rooms at an attractive and affordable 50 per cent discount. The eight restaurants will offer you a culinary journey to Japan, Italy and Polynesia.

The luxurious Spa Grande has over 50,000 square feet of floor space. After a full day of meetings, attendees can enjoy the Scuba Diving Pool, Game Room, Weight Training Room, Aerobics Room, Racquetball Court, a quick round of golf on a world-class course and Camp Grande – a special haven created just for children.

Make plans now to join the more than 1,000 industry leaders from throughout the world to exchange information, technology, buy, sell and trade pearls at our expanded show.

Save the date: 14 to 18 May 1995, Maui – the Magic Isle. Exhibit space still available. Phone 800 222-8882 or 415 595 2625 for information on registration.

A pearl auction direct to the trade in Maui

Source: International Pearl Association , Pearl Visions*, Vol.1, No.2, February 1995.*

The Board of Directors of the International Pearl Association in a special meeting during the Tucson Gem and Mineral Show in 2 february 1995, determined the future course of the organisation.

New board membership and sources of funding to underwrite the cost of operation were the main points of discussion. Several pearl-producing nations have approached us since the successful Pearls '94 Conference and Expo. with requests to incorporate a pearl auction in conjunction with the Pearls '95 event.

The decision to proceed with the Buy Direct Auction has been given full and enthusiastic support.

For the first time ever, producers, dealers, retailers, and collectors will have the opportunity to present and purchase selected offerings in a sealed-bid auction.

Viewing and evaluation of the lots submitted will take place during the first three days of the Exposition and bidding will take place on the last day. The auction will be open to all the wholesale members of the trade present.

Auction offerings will run the gamut of single-piece natural pearl packets to larger harvest lots, representing all sizes, type, shapes and colours. By popular demand, diamonds are also being considered.

Conservation and Management of Freshwater Mussels II: Initiatives for the future

Source: Upper Mississippi River Conservation Committee.

You are invited to participate in the second symposium on the Conservation and Management of Freshwater Mussels II, sponsored by the Upper Mississippi River Conservation Committee, to be convened October 16–18, 1995 at the Embassy Suites Hotel, in St. Louis, Missouri.

The first symposium in 1992 was a great success, attracting over 215 participants. We hope this second symposium will generate information pertinent to the challenges facing mussel resources. Paper and poster sessions will be devoted to the exchange of timely information on endangered and at-risk species, relocation and refugia, reproduction and propagation, sampling methods, the mussel industry, and developing partnerships in preservation. Plenary and closing sessions will focus on proactive mussel stewardship, where we've been, what works and why, where we need to go, and how to get there.

The Conference planning committee is extending a first call for platform and poster presentations dealing with the freshwater mussel resource. Specific details on abstract format, preparation, and deadline will be available within the next 2 to 3 months. Mark your calendars now and plan on spending October 16–18 in St. Louis. For more information, contact either Alan Buchanan (Tel.(1-314) 8829880) or Kevin Cummings (Tel. (1-217) 3331623).

Proceedings from the 1992 Conference are still available for US$15.00 from the UMRCC Coordinator (Tel.(1-309) 793 5800).

LATE NEWS....French Polynesian 1994 pearl exports double in value

A recent report on Hawaii Public Radio quoted French Polynesian officials as stating the export value of black pearl production in 1994 as US$ 135 million. This represents a total of 91.5 per cent of total export earnings for French Polynesia.

No official confirmation of the figure had been obtained as of press time. If correct, this represents a further doubling of export earnings from pearls from the 1993 record of US$ 77 million.

Welcome to new members

The Pearl Oyster Special Interest Group is growing. We have received additional completed questionnaires (as at 15 March 1995) from the individuals listed below. The previous lists of members are available in the past seven issues of the SPC Pearl Oyster Bulletin. *If you are on the list and your name and address is wrong, please send us a correction. If you are not on the list and would like to be, fill in the form enclosed with the bulletin or write to us for a new one.*

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