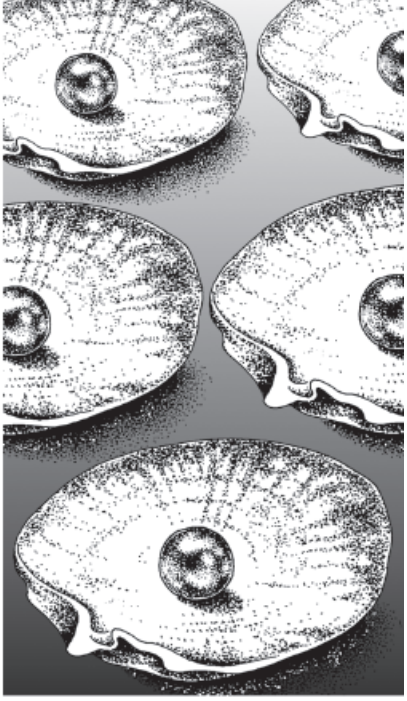

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PEARL OYSTER information bulletin

Inside this issue

Editor
Paul Southgate
School of Marine and Tropical Biology
James Cook University
Townsville, Qld. 4811
Australia
Fax: +61 7 4781 4585
Email: paul.southgate@jcu.edu.au

Production
Information Section,
Marine Resources Division
SPC, BP D5, 98848 Noumea Cedex
New Caledonia.
Fax: +687 263818
Email: cfpinfo@spc.int
www.spc.int/coastfish

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Editorial

Welcome to the 18th issue of the *Pearl Oyster Information Bulletin*, albeit somewhat later than anticipated. Much of the delay results from my involvement in a new book — dedicated to pearl oysters — which was recently published by Elsevier. The iconic "Gervis and Sims" has been the major reference source for pearl oyster biology and culture since it was published in 1992, but there has been a considerable volume of research on pearl oysters over recent years, particularly the past decade. This new book deals comprehensively with all aspects of pearl oyster biology and culture, pearl formation and current market trends, and provides an overview of recent research in this field. More details of the book's contents and contributors are given on page 19 of this issue.

The Industry Notes and Reports section of this issue contains an interesting overview of recent influences and developments in the global pearl culture industry, as well as excerpts from the 4th International Gemological Symposium, and a report on recent pearl auctions. Closer to home, this section also contains an update on pearl production and sales in Fiji, and developments in the Cook Islands. The Research Notes and Report section contains an interesting article from Mexico reporting on gametogenic activity in mantle tissue of pearl oysters, as well as a report on pearling research in Tonga. Again, I would like to invite contributions to the above sections of the Bulletin, particularly reports or articles relating to pearl industries and research in the Pacific Islands region. We encourage submission of longer articles, updates from research groups, and country statements, where appropriate. The required format for larger articles submitted to the Bulletin can be found on SPC's website at: http://www.spc.int/coastfish/News/POIB/POIB.htm.

More than 100 publications on pearl oysters were added to scientific databases over the past couple of years, representing significant research output. It is interesting to note the high (and increasing) proportion of publications from China, and the large volume of papers relating to aspects of biomineralization and molecular aspects of pearl oyster biology. This issue contains an abbreviated list of abstracts from these publications.

As usual, this and all previous issues of the bulletin are available in PDF format on SPC's website at: http://www.spc.int/coastfish/news/POIB/POIB.htm. Please note that the SPC fisheries digital library is

now available on SPC's website (http://www.spc.int/mrd/fishlib.php). The digital library gives access to electronic versions (in PDF format) of more than 6600 fisheries and aquaculture-related documents (in English and French) produced by, for, or in collaboration with SPC. This digital library is full text searchable. Finally, I would like to thank the dedicated staff of SPC's Fisheries Information and Publication sections, who maintain the high quality of this publication.

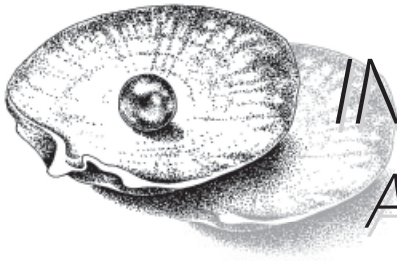
Happy reading!

Paul Southgate

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

PIMRIS

Pacific Islands Marine Resources Information System



INDUSTRY NOTES AND REPORTS

Cultured pearls in the 21st Century: A free market and new looks

Russell Shor[1]

The cultured pearl industry has experienced a dramatic transformation during the past 15 years, from a single commodity dominated by one country to a multi-colored array of goods and an ever-expanding group of producers (Fig. 1).

The Fall 2007 issue of *Gems & Gemology* (p. 200–226) offered an in-depth look at these changes and how they have transformed pearls into a must-have fashion item.

Japanese dealers relinquish control

For many decades after pioneering the cultured pearl in the early twentieth century, Japanese companies maintained tight control over its technology, production and distribution (Fig. 2). In the 1960s, however, large, white South Sea cultured pearls from Australia and black cultured pearls from French Polynesia began entering the market alongside the traditional white Japanese akoya.

Figure 1. Recent years have seen dramatic changes in the types of cultured pearls and their sources, with (top to bottom) Tahitian, Chinese, South Sea, and Japanese akoya (bottom two rows) goods represented here. Tahitian earrings courtesy of Mastoloni; South Sea strand courtesy of The Collector Fine Jewelry (Photo: Harold & Erica Van Pelt).

Figure 2. Japanese technicians controlled the art of grafting beads into mollusks for many years and in many different localities (Photo: Russell Shor).

1. GIA Senior Industry Analyst

The French Polynesians initially struggled to gain acceptance for their products, as many believed they were treated-color. A breakthrough came in the early 1970s when GIA researcher Robert Crowningshield determined their black color was indeed natural. Meanwhile, the South Sea cultured pearl was becoming a branded fashion item, though the Australians still marketed their output solely through Japanese wholesalers.

The real changes began in the 1990s, when the nearly century-long grip of the Japanese loosened due to a combination of factors: aggressive marketing efforts for South Sea and black French Polynesian pearls; the rise of lower-cost, fine-quality Chinese freshwater cultured pearls (Fig. 3); and the outbreak of a disease that devastated much of Japan's pearling industry.

The Australians and the French Polynesians (now selling under the "Tahitian" banner) began marketing their products as distinct from Japanese akoyas: the South Sea goods as luxury items that were not subjected to treatments, the Tahitians as exotic fashion pieces. Producers of both types of cultured pearls embarked on multi-million-dollar consumer campaigns to promote their goods and the images they wanted them to convey.

By the mid-1990s, Chinese farmers, who for years had produced small, irregularly shaped and very inexpensive goods (dubbed "rice krispie pearls"), were successfully growing round, akoya-like cultured pearls.

The quantity of Chinese goods entering the market threatened to inundate Japanese distributors. The Japanese entered talks with the Chinese government in an effort to control production and exports of such goods, but they failed on both fronts.

Then, in 1996, reports began filtering in that Japanese pearl farms were suffering the massive mortality of their oyster crops. By year's end, an estimated two-thirds of the akoya oysters under cultivation in Japanese waters had died from infectious disease — a blow from which that country's cultured pearl industry has not yet fully recovered. As a result, Japanese producers no longer had the financial resources to control supplies and distribution, thus creating a true free market within the industry.

Market instability meets fashion revolution

The first test of the new free market came at the end of the decade, when the large amounts of Chinese goods depressed prices for some categories and the production of Tahitian black cultured pearls skyrocketed with little control over quality. Prices for lower-quality black cultured pearls in particular plummeted, a situation that took several years to reverse as the French Polynesian government imposed stricter controls on exports. The Japanese attempted to move akoyas more up-market by concentrating on larger sizes, while the South Sea producers increased their luxury marketing and advertising campaigns.

At the same time, cultured pearls in pastel shades of green, violet, pink and blue began showing up in designer pieces in the late 1990s, while a producer in the Philippines launched a marketing campaign for gold-colored goods. Within the past few years, "chocolate pearls" have become a fashion item. Once rejected by pearl producers and distributors who thought only in terms of black and white, such fancy-colored cultured pearls started a fashion revolution that still continues.

As some of the world's top designers began working with cultured pearls and the major producers

Figure 3. Mussels used by Chinese culturers can produce dozens of pearls at one time (Photo: Doug Fiske).

increased their spending on branding and advertising (Fig. 4), large retailers took a much greater interest. Indeed, Tiffany & Co. created an entire chain of retail stores (Iridesse) based on pearl jewelry, because they could now offered a diverse array of products across a very broad price range.

In the future, the success of these many ventures will undoubtedly attract new enterprises in other nations, particularly around the Pacific Rim — but also in Mexico and the Middle East — while existing producers will continue to experiment with new products. Recently, one designer partnered with a Vietnamese farm to culture black pearls around gemstone bead nuclei.

Identifying treatments will remain a challenge, and retailers and consumers alike must beware of the many techniques that can be used to enhance the appearance of cultured pearls, especially irradiation and dyeing, and the methods that can be used to identify them.

Figure 4. Cultured pearls have become a favorite of jewelry designers worldwide. This suite (8–11 mm) by Mari Saki of Nagahori Corp., Tokyo, was a 2006 winner of the Perles de Tahiti design competition. Courtesy of GIE Perles de Tahiti.

Abstracts from the 4th International Gemological Symposium Fall 2006

The challenges and opportunities of growing and marketing South Sea cultured pearls

Nicholas Paspaley, AC

Over the last 50 years, the cultured pearl industry has undergone a significant transformation. It has changed from a period when Japanese and (later) South Sea cultured pearls were effectively the only cultured pearls in the marketplace to the situation today, where there are a large variety of cultured pearls available from many different localities and of many different types.

In the pre-culturing era, all oceanic (saltwater) pearls were classified as Oriental pearls and South Sea pearls fell into this generic category. With the advent of pearl culturing, however, pearls became more accurately known for the type of oyster that produced them and the region in which those oysters grew — hence the term *South Sea pearls*.

Naturally occurring pearls from the *Pinctada maxima* oyster native to the South Seas have been traded for thousands of years. But in past centuries, many natural South Sea pearls were undoubtedly traded simply as Gulf pearls. Because of its spectacular nacre, the South Sea pearl oyster historically has produced some of the most significant natural pearls in the world. Therefore, it follows that this oyster has the ability to produce magnificent cultured pearls as well.

However, the competition for market share between gem producers as well as between different pearl types is fierce. At the same time, there are significant gaps in the expertise required to grow pearl oysters and conduct pearl farming compared to many other fields of knowledge. There are very few experts today who have a broad knowledge on a comprehensive range of pearl and pearl farming issues.

The challenge for the South Sea cultured pearl industry today is twofold: to produce pearls of a superior quality, on the basis of which they can be differentiated in the wider pearl market, and to improve the level of knowledge and understanding of pearls in the market place.

Chinese freshwater cultured pearl evolution

Joel Schechter

Seven years ago, we presented "Chinese Freshwater Cultured Pearl Revolution" at the last GIA symposium. In a very controversial session, we predicted the enormous impact China would have on the pearl markets.

Nearly a decade later, the entire industry has changed. Huge quantities of affordable cultured pearls now are harvested annually — by conservative estimates, more than 1,200 tons of freshwater cultured pearls were harvested in 2005 — putting pressure on other pearl-producing countries. The pearl industry is now in a Darwinian "survival of the fittest" mode. Rounder and brighter cultured pearls from China (Fig. 2) have totally altered Japan's previous dominance as the major pearl power. Large sizes are beginning to affect the South Sea markets. Even golden and Tahitian pearls are not immune to China's fury, as improved color enhancements allow freshwater cultured pearls to mimic colors from all over the globe.

What does the future look like for the next decade? With 11–14 mm bead-nucleated freshwater pearls beginning to show up in the marketplace, China appears to be taking even sharper aim at South Sea producers. And while the quantities harvested in China continue to rise, can anything be done to support pricing? Are more affordable cultured pearls a good thing for the market as a whole?

Interestingly, China's exports are rising dramatically, but total revenues have not kept up. Falling prices have badly hurt many of the growers, creating a "sell it before it drops further" mentality. All this continues to put financial pressure on the country's market. While China produces 95% of the world's cultured pearls, pearl associations estimate it keeps only about 8% of the revenue they ultimately generate — an amazing statistic.

To keep prices up, China needs to tackle the issues surrounding the low image of its cultured pearls. Better processing, improved marketing and elimination of low-end products are vital to support higher values for the market.

The Tahitian cultured pearl

Robert Wan

The Tahitian cultured pearl industry is the second largest industry in French Polynesia and the primary source of foreign currency from direct exports. It has a major socio-cultural and economic impact on the nation. With more than 7,000 Polynesians earning their livelihood within the pearl industry, it is an integral part of the fabric of Polynesian life.

The meteoric popularity of the Tahitian cultured pearl in the 1980s triggered a veritable boom in the industry. For many years, this market demand made pearl farming a lucrative endeavour, but the industry reached its saturation point in the year 2000. Flagrant overproduction and slack quality control, combined with a slowdown of the world economy, dealt the Tahitian pearl industry a serious setback. Suddenly, pearl farming was no longer a viable activity.

According to the official figures from the French Polynesian Pearl Culture Bureau, this glut caused many pearl farms to close and others to consolidate. In only seven years, the number of pearl farming operations decreased from 2,700 registered in 1998 to only 800 remaining in activity at the end of 2005 — half of them shell producers, the other half pearl producers.

Drastic measures had to be taken to ensure a stable production and a quality standard for the Tahitian cultured pearl. Consequently, the French Polynesian Government established the Pearl Culture Bureau in 2001. This organization aimed to enforce strict quality controls and production regulations on the supply side of the spectrum. These included the following measures:

- Limit the number of pearl farming concessions
- Limit the number of production and export licenses
- Shut down pearl culturing activity in certain lagoons
- Establish a firm classification system aimed at ensuring that only high-quality product enters the world market
- Strictly control a minimum required nacre thickness in all exported cultured pearls
- Destroy all rejects to prevent their commercial use.

All these regulations combined with an effective marketing program, conducted by the non-profit GIE Perles de Tahiti, resulted in a marked increase in the total value of Tahitian cultured pearl exports of 14% in 2004 and 16% in 2005, accompanied by trading price increases of 30% from 2003 to 2004 and 20% from 2004 to 2005. Confidence has been restored to the market and production in 2006 has remained stable to date.

Maintaining the viability of Tahitian pearl culturing activity is the principal objective of Perles de Tahiti. The specific objectives include:

- Export cultured pearls and cultured pearl jewellery totalling $200 million in 2012
- Limit the number of active producers on the island to 1,000
- Perpetuate the pearl-bearing oyster resources
- Improve the quality of production.

The future of the Tahitian pearl industry is critical to French Polynesia and its direction will dictate the future social, cultural and economic well being of the islands. Protection of the environment is a pivotal aspect of this. The life of a Polynesian and his family depend on his livelihood. The islands and their lagoons are our heritage and our future, worth every bit of our protection. Pearl culture is indeed a miracle of nature and of man. We must give back to nature what she has so graciously given us.

Branding cultured pearls: From a retail perspective

Meyer Hoffman

Over the years, the retail landscape has undergone many changes. Consumers have become savvier and more demanding, retailers have created an "environment" or buying experience to attract these sophisticated consumers, and manufacturers and suppliers have developed appealing "brands" to set themselves apart from the competition. The most prominent examples can be found in the apparel industry where leading fashion designers have truly captured the hearts and wallets of the high-end consumer with strong brand identities and distinct product assortments. More recently, apparel retailers have created their own brand significance by setting themselves apart from the high-end fashion world with innovative store concepts and individually developed product lines.

Critical factors

- Companies must clearly define and market their brand essence, strive for differentiation and target their audience with precision.
- Defining one's brand essence can take many forms, but it must remain clear and consistent over time. There are many examples of established houses that have successfully reinvented themselves (Burberry) and well as newly created brands that are aggressively targeting Generations X and Y (Abercrombie and Fitch).
- Creating differentiation is crucial in today's retail environment. There are too many look-alike products or generic copies that offer no value added and consequently are not appealing to an affluent audience. In today's highly competitive marketplace where product life cycles are getting shorter, it is imperative that successful brands strive to create a point of difference.
- Finally, attracting a well-defined audience will ensure that companies achieve increasing sales and sustain a profitable business model. Generational marketing (including psychographic profiling) is one aspect of defining and attracting the most appropriate audience for your product.

Justin Hunter and Pearls Fiji

Source: Pearl World, The International Pearling Journal, volume 16, number 4 (December 2007)

Justin Hunter had a big dream. Why not, he thought, grow pearls that looked nothing like the traditional black pearl. Why not produce pearls in beautifully distinctive hues that are also larger than what are traditionally grown. So he came back home to Fiji from the United States to establish J. Hunter Pearls Fiji in 1999 where he implemented his bold new pearl farming techniques. Now, he is reaping the rewards of his innovative thinking... and his pearls are highly sought after for their uniqueness and their untraditional colors.

Justin's dream did not end with growing the world's best pearls. His goal was to blend pearl farming with Fiji's natural environment and its indigenous people to create a working partnership. Justin is intensely committed to keeping the marine environment of Savusavu Bay in its pristine condition and to improving the lives of the people of the community.

J. Hunter Pearls Fiji provides much needed jobs for local people, which give them the resources to improve their villages and their lifestyles. Justin's

commitment also includes providing school scholarships to deserving students and to be personally involved with the Savusavu community at large.

Before Kokichi Mikimoto discovered the technique of culturing pearls in the early 1900s, natural pearls were so rare and expensive that they were reserved for only the noble and very rich. But the technology of pearl culturing changed all that. These days, of course, most all pearls are cultured. That is to say, the hand of man enters into nature's realm to begin the process of making a pearl, then nature takes her course while the farmer continues aiding the process with specific oyster management. Today, Justin Hunter and his team of farmers and technicians are perfecting the pearl culturing process. Every step of the operation is carefully managed, with years spent refining the methods toward the ultimate goal of growing the perfect pearl. Everyone at J. Hunter Pearls Fiji is devoted to the creation of beautiful pearls, utilizing the uniquely colored oyster shells that grow naturally in Savusavu Bay, creating pearls that are exceptionally different from all others.

History of J. Hunter

J. Hunter Pearls Fiji was established in 1999 when Justin Hunter returned home to Fiji after he earned his marine biology degree and gained his aquaculture experience with Taylor Shellfish Inc., of the US.

Justin spent his childhood in the small township of Savusavu, and it was his goal to find a way to use his aquaculture expertise and live in his favorite place in the world: Fiji. Creating J. Hunter Pearls, along with his partners who are also his cousins from Taylor Shellfish Inc., has been a dream come true.

The company

J. Hunter Pearls Fiji is situated in Savusavu Town on the island of Vanua Levu in the north of Fiji, an area that's still largely untouched. This unspoiled location provides a truly unique location for aquaculture. The pearls are cultured in a natural environment that's largely free of impurities and pollution. The office and jewelry boutique is situated on Main Street in Savusavu Town, close to the wharf, while the pearl farm is just a short distance away on the bay. The founder, Justin Hunter, is an active community citizen who strives to protect and maintain Savusavu Bay's healthy marine environment. J. Hunter Pearls Fiji works closely with the traditional owners of the local fishing rights and provides much-needed jobs for the community, such as contracting work to women's groups to help the villagers improve their standard of living. The company also sponsors village improvements and provides a school scholarship annually for deserving students. Justin is using his expertise in aquaculture toward innovative and carefully-managed pearl farming. His goal is to make J. Hunter Pearls known as the world's supplier of Fiji Pearls, beautiful pearls in colors not found anywhere else. In 2005, J. Hunter Pearls won the Unique Exporter of the Year award presented by the Fiji Trades and Investment Bureau, in the coveted Exporter of the Year category.

The pearls

J. Hunter Pearls are a tribute to their unique environment, and the singular expertise of those who graft and nurture them. As Justin himself told us: "I thought you might just like to look at what we are producing. We have some of the best multi-colored pearls being produced anywhere. The size of our pearls is also very good, averaging around 10.5 mm for the first seed. We are producing around 120 kilograms this year."

"As you can see, we are not trying to mass produce the same pearl over and over again in huge quantities (à la Tahiti). We are really trying to produce something different for which we will hopefully be able to eke out a small niche market. And we proudly guarantee these pearls to be totally natural — neither dyed, colored nor enhanced in any way. They are grown in the warm pristine waters of Savusavu Bay, on the island of Vanua Levu of northern Fiji, where the environment remains precisely as nature intended it."

These nutrient-rich waters feed the oysters so well that J. Hunter pearls have a nacre thickness averaging 1.6 mm, well above the established nacre thickness of other pearl growing countries. "Most of our crop (around 65%) now fits into the lighter shade of pearls. We believe that the oyster we cultivate (produced from our own hatchery) is a sub-species of the oyster that survives in the atoll," says Justin. "Our oysters have distinctively colored shells and pearls," continues Justin. "And, as you can see, the shells we have are striking and in return they produce pretty striking pearls that I am quite sure you have not seen the likes of, ever before".

Operations

According to Ben Ponia, Aquaculture Adviser of the Secretariat of the Pacific Community: "The J. Hunter Pearls label is quickly becoming an exclusive high quality product line for Fijian pearls. The farm success is the result of attention to a number of critical factors such as good business acumen, attention to marketing and consultation with local communities. "Under the managerial direction of Justin Hunter, the farm has approximately 500,000 oysters under cultivation and the pearl harvest grosses several million Fijian dollars per annum. "Upon arrival I viewed several crops that had just been harvested.

The pearls display the usual spectacular array of color which Fiji pearls are becoming renowned for". Amongst this crop some dark "chocolate" colored pearls were pointed out. "The quality of pearls is probably in part due to the expertise of Japanese technicians employed by the farm. These technicians also provide seeding services for other pearl farmers in the surrounding area. The J. Hunter operation is also expanding to another location.

"The pearl farm operates its own hatchery and routine spawning operations were underway during my visit. The Fiji oysters appear to have a high fecundity and large sized eggs, which could be related to the nutrient rich water quality environment of Savusavu Bay.

"The pearl oyster egg sizes and spawn quantities seem larger than what are normally obtained in the Pacific region, quite likely a result of the nutrient-rich waters, causing the oysters to have an unusually healthy gonadal condition.

"Whilst the hatchery is not large by commercial standards, it still has scope for expansion and could accommodate other species. "The farm also employs a University of the South Pacific graduate as its biologist to carry out ecological baseline studies, particularly water quality monitoring and carrying out basic pearl grow out experiments.

"The pearl farm provides direct benefits through avenues such as employment (of all genders and a range of ages) but also indirectly through the business that the high investment pearl farming enterprise generates. "The farm also pays a dividend from its profits to the local village. For example, it has provided funds for a community hall, which also serves as emergency shelter in case of hurricanes.

"In addition, the farm sponsors an education scholarship for young students from the village. Those interested to know more about the farm operations can visit their website: http://www.pearlsfiji.com.

"Whilst at the farm we discussed the possibility of carrying out some mabe-pearl seeding trials. The Hunter Pearl Farm has thousands of reject oysters that could be used for the experiments. It would be particularly interesting if the geographical scope for this experiment could be standardized and extended throughout the Pacific and other countries."

The product

Justin is also proud of the finished product in which his pearls ultimately appear:

"When setting our pearls, we showcase the singular beauty and uniqueness of each pearl. "Our ring and pendant collections are inspired by the individual characteristics of our high quality pearls.

"All diamonds in our pieces are supplied in the VS1 to SI clarity categories and are H-I in color. "Our pearl necklaces and earrings are all hand-matched, with each piece being uniquely beautiful."

Fiji pastels

"When we first took our pearls to Japan in 2003, we could not, for the life of us, get anyone to purchase our Pastel/Fiji light pearls. "Now we get a premium price for our pastel pearls. Early on, though, most buyers that looked at our pearls initially said they were interesting but did not want to take the risk of supplying something completely new to the market... but we believed in both our product and with the concept of developing a new and exciting product, says Justin.

The auction

J. Hunter's Fiji Pearls Auction was held in Japan on June 15th, 2007. At this event were offered approximately 30,000 pearls in 89 lots with an average size of 11.5 mm. The biggest round pearl was 18 mm. Participants numbered 18 from countries such as Germany, Italy, Hong Kong, Japan, and several other locales. Seven were from Europe. Those in attendance delivered the following comments:

"The world pearl market has been longing for something new like Fiji pearls."

"We were amazed at the various colors of Fiji pearls, colors which we have never seen before."

"The strong luster impressed me a great deal."

"These were rare and larger pearls, compared with Tahitian pearls."

"I appreciate J. Hunter's farmer's concept."

Justin's comments

"Our unique marine environment and careful selection of oysters possessing rich color variation have produced these pearls that are in a class of their very own."

"Our vision is to continue the work we have started. We look to be champions of a new direction of pearl farming. We will look to challenge the current corporate style of systematic mass production of pearls and focus instead on producing high quality pearls.

"We will continue to work to provide truly unique pearls that represent Fiji."

"I have been very fortunate to have great people behind this venture that believed in what we were doing, and made this work.

"Our recent auction has given us the success we have been working so hard for".

Editor's note

A follow-up article in the most recent issue of *Pearl World* (October–December 2008) describes the second auction of pearls from J. Hunter Pearls Fiji in Yokohama earlier this year. It reports that 90% of lots were sold. There was particularly keen bidding for a 18.9 mm round pearl and for baroques in "earthy" colors which are in demand. The article also reported on expansion of J. Hunter Pearls activities to a second 250 ha farm site at Kioa in the northern group of Fiji. This farm site will greatly increase production in coming years.

Pearl auctions

Source: *Poe Vira Vira*, April 2008 (courtesy of *Jewellery News Asia*, April 2008)

The international pearl auctions held in February and March 2008 in Hong Kong concluded with good results, although buyers generally adopted a more cautious attitude amid worries over the slow moving US economy.

PASPALEY: Commenting on prices, chairman of Kobe–based Hosei Co Ltd, Yoshihiro Shimuzi, noted that prices were stable for cleaner better quality merchandise that were in demand, but were softer for spotted or lower quality items. Leung Sik Wah, director of Hong Kong-based Cogent Trading Co Ltd, and co-organizer at the Paspaley auction commented that buyers adopted a "wait and see" attitude in the face of economic uncertainties. "Nobody knows what will happen in three to six months' time. Given the sub-prime issue and falling stock markets, buyers have become more cautious — buying just what they need and being less willing to stock up". The 38th Paspaley Pearl Auction, a three-day event, sold 148,769 pieces (420 kg) of white and golden South Sea pearls or 64% of the total on offer. Average price per pearl was USD 88.23. Buyers attendance was high (105) and Europeans topped the buyers list, thanks to the strong Euro. Large sizes and baroques captured the attention of buyers at the Paspaley Hong Kong auction. Several lots consisted of only one pearl, mostly 16 mm, and fetched high prices. The one with the highest per-gram price was a 16 mm (6.18 g) white pearl with pinkish overtones which sold for USD 4,137. Over 20 lots of baroques on offer were bid for strongly. Lot #552 containing nine baroques of 20 mm and above fetched USD 35,284.

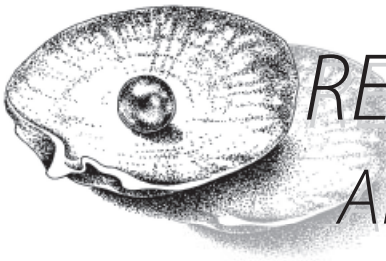
ROBERT WAN: Marked price increases were reported at the 39th Robert Wan Tahiti Perles Auction, which fetched 3.89 million Euros, or USD 5.94 million for the 124,633 pearls (283.3 kg) sold at an average price per pearl of 31.04 Euros/USD 47.67. Robert Wan was very happy with the auction because not only was the price maintained, more pearls of better luster and better colours and more larger pearls were available. A larger quantity of 12–14 mm pearls were on offer.

Prices were considerably higher overall due to higher overall pearl quality, more bigger sizes and better sorting said Mr Shimuzu of Hosei. President of Wong's Diamond and Pearls Co Ltd in Hong Kong, Wong Yik Nin, estimated an average price increase of 10%. Buyer attendance was high with Japan remaining the top buying market followed by United States and Great Britain

POE RAVA NUI: The 8th Poe Rava Nui Tahiti Pearl Auction sold 77% of pearls on offer, with a total sale value of around 3 million Euros, or USD 4.6 million. The average size of the pearls on offer was about 1.4 g. Larger pearls of the 13 mm to 18 mm sizes received strong bids especially from buyers in Europe and the US.

Poe Vira Vira — Cook Islands Pearl Industry Newsletter

"Poe Vira Vira" means "lustrous or shiny pearl" in the Manihiki/Rakahanga dialect. The newsletter is published monthly by the Cook Islands Pearl Authority (CIPA), in association with the Ministry of Marine Resources as an information service for the benefit of pearl farmers and stakeholders in the industry. For further information, contact CIPA at Tel: +682-29055; Fax; +68229045.



RESEARCH NOTES AND REPORTS

Support for the Tongan pearl industry

Antoine Teitelbaum[1] and Poasi N. Fale[2]

Source: Adapted from SPC *Fisheries Newsletter* #125, April/June 2008

In May 2008, SPC's Aquaculture Officer went to Tonga to provide assistance to two projects aimed at stimulating the small-scale half pearl (mabe) industry in Tonga's Vava'u group.

A pearl shell carving training workshop was organised by SPC in Vava'u and involved local craftsman and woman who wished to improve their pearl shell and mabe handicrafts production. Tokerau Jim, a master carver from Rarotonga, Cook Islands, was contracted by SPC to deliver the highest possible quality, hands-on, training.

Following the workshop, a hatchery rearing run of the winged pearl oyster (*Pteria penguin*) was undertaken in Tongatapu at the Sopu maricultre center. This was conducted as part of an Australian Centre for International Agricultural Research (ACIAR)-funded project lead by Paul Southgate of James Cook University (JCU), Australia. The spat produced will be used to supply the Vava'u pearl farmers and thus increase the supply of pearl oysters to the industry and addressing a current bottleneck. They will also be used in experiments to refine culture and mabe production methods.

History of pearl farming in Tonga

Cultured pearls in the Pacific are dominated by the black pearl, which is produced from the black-lip pearl oyster (*Pinctada margaritifera*). In Tonga, pearl oyster culture began in the early 1960s. In 1975, an experimental venture was set up by the Tongan government. Broodstock of the winged pearl oyster, *Pteria penguin*, were imported from Japan for initial culture trials. The FAO South Pacific Aquaculture Development Project (SPADP) provided assistance in 1989 in carrying out stock assessment, spat collection surveys and undertaking preliminary pearl production.

Commercial feasibility of pearl farming in Tonga was initiated in 1993. Japanese specialists estimated that an area of approximately 850 ha in the Vava'u islands could be farmed for half-pearl production, supporting annual production of around 750,000 pearls, with approximately 30% of these being first-grade. They assumed a value of around USD 30 each for first-grade half-pearls, and therefore a potential annual revenue from an area of 850 ha of around USD 7.5 million (Finau 2005).

Tonga is in a relatively unique position to diversify the range of pearl products because Vava'u has *Pteria penguin*, from which half-pearl (mabe) can be produced. One of the advantages of producing half-pearls is the lower capital and technological investment required (compared with round pearl production) and the value-added opportunities through jewellery and handicrafts. Already there is a small but thriving niche market selling mabe pearls and pearl shell handicrafts to tourists in Vava'u.

1. Aquaculture Officer, Seceretariat of the Pacific Community. Email: AntoineT@spc.int
2. Deputy Secretary for Fisheries, Ministry of Agriculture & Food, forests and Fisheries, Tonga. Email: poasif@tongafish.gov.to

Transferring unique carving technologies from Rarotonga to Vava'u

SPC's Aquaculture Section targets livelihood opportunities. Mabe pearls and carved shell products are one of the lucrative opportunities supporting sustainable and profitable small-scale and rural development, especially in areas where tourism is developing.

In June 2006, in Kiribati, SPC's Aquaculture Section, together with JCU, organised a similar carving workshop to introduce the basics of those techniques (Teitelbaum 2007). This present carving workshop was a more advanced course and had two major goals: 1) to provide an overview of the fundamentals involved in pearl jewellery and handicraft (tools and craftsmanship, jewellery and handicraft design, pearl handicraft preparation and setting and marketing techniques) and 2) to pay particular attention to the domestic market opportunities and local cultural carving and handicraft traditions of the Vava'u.

Tokerau Jim (www.tokeraujim.com) the master carver hired for this exercise, runs a successful business in the Cook Islands. For the occasion, he brought in some specific tools that he uses in his workshop in Rarotonga. The Taurus ring saw and the Foredom hand drill were the most noticeable technological improvement that were brought to Vava'u.

Traditionally, carvers use hand-grinders and hacksaws to produce their crafts, taking over 30 minutes to cut shapes from a shell when a ring saw can do the same job in less than a minute. Furthermore, the Foredom hand drill (with a 45,000 rpm rate compared with 30–33,000 rpm for a standard hand drill) allows carvers to be much more precise in their motifs and carvings.

Over this three-day event, trainees learned how to handle the new tools and how to produce better quality products with a true finished luster on them. Drawing and cutting shapes, designing pendants, earrings or whole shell art was demonstrated. Half-pearls (mabe) were also used for the carving exercises. Tokerau Jim demonstrated how to best use each shell and each mabe to reveal its best colour and true nature. Thanks to Tokerau Jim, trainees also learned how to incorporate traditional Tongan motifs into their carvings, thus producing uniquely Tongan products.

One of the bottlenecks to handicraft activity is the lack of supply of mabe and pearl shells, which limits handicraft production. How can handicraft and mabe production be improved given the current state of farming in Vava'u?

The need for spat

Recently, pearl farmers from Vava'u (regrouped under the Pearl Grower Association PGA) have

Carved mabe pearl and shell (photo: A. Teitelbaum).

Turtle carved from trochus shell (photo: A. Teitelbaum).

only grown a limited number of oysters that result from natural spat collection. Poor recruitment of spat to spat collectors has resulted in the harvesting of adult oysters from the wild, which has further impacted recruitment. Natural spat fall of *Pteria penguin* in Vava'u is now extremely limited.

ACIAR is funding a new research project involving collaboration between JCU, Tonga's Fisheries Division and SPC. The project will focus on the development of appropriate hatchery culture techniques for *Pteria penguin* and the use of hatchery-propagated oysters for pearl production in support of the Tongan cultured pearl industry. This project links in with SPC's Pacific Aquaculture Plan.

Further development of the pearl industry in Tonga is hindered by a lack of knowledge of *Pteria penguin* culture requirements and methods for optimising pearl production from this species. For example, only one preliminary study has reported on hatchery or nursery culture of *Pteria penguin* (Beer 1999), and while limited information is available relating to half-pearl production from the related *Pteria sterna* (Ruiz-Rubio et al. 2006), similar information is not yet available for *Pteria penguin*. Research is required to optimise culture methodology and pearl production from *Pteria penguin* as a basis for sustainable industry development. The ACIAR project will address the following major points:

- Hatchery culture of *Pteria penguin* and optimisation of hatchery culture techniques;
- Nursery culture and grow-out, optimising culture techniques;
- Half-pearl production and aspects affecting pearl quality (position, location, time);
- Training of Tonga Fisheries Department staff in culture methods and pearl production; and
- Training farmers and members of PGA.

Production of high quality half-pearl from *Pteria penguin* in Tonga has been clearly demonstrated and existing pearl farming expertise in Tonga provides considerable opportunity for this project to have immediate impact.

A successful spawning at SOPU mariculture facilities

In May 2008, the hatchery at Sopu was upgraded and a hatchery run with *Pteria penguin* was conducted by Tonga Fisheries aquaculture staff assisted by one of the authors (A. Teitelbaum, SPC), Paul Southgate and Andrew Beer from JCU.

A batch of 30 broodstock was induced to spawn using thermal "shock", and sufficient eggs were produced to allow stocking of all available tanks in the hatchery. The temperature requirement of most pearl oyster larvae is between 26°C and 29°C,

Andrew Beer and Vea Kava draining down a hatchery tank stocked with *Pteria penguin* larvae (photo: A. Teitelbaum).

Overview of the Sopu pearl oyster hatchery. Note the spawning tanks with broodstock in the foreground (photo: A. Beer).

but ambient water temperature in the larval culture tanks reached as low as 20°C overnight. This problem was rectified with a heat-exchange system where 40–45°C water was pumped from a heated "header tank" through a hose that ran through each of the larval culture tanks. This system helped maintain tank temperatures between 26°C and 30°C.

A large proportion of the micro-algae fed to larvae was provided as a commercially available algal concentrate obtained from Reed Mariculture in the USA. The species used were *Pavlova* sp. and T-ISO. The encouraging results indicate that algal concentrates may be of considerable benefit to hatcheries in the region by reducing the requirement to culture live micro-algae for larval pearl oyster culture. This would simplify hatchery production and reduce the need for specialised culture facilities and technical capacity.

More than 500,000 eyed larvae were placed into settlement tanks, and spat collectors containing spat were transferred to an ocean-based longline two weeks later. About 60,000 spat were harvested from spat collectors in September 2008, and were used to establish nursery culture experiments adjacent to the Sopu aquaculture facility and in Vava'u.

Both the spawning and larval rearing run of *Pteria penguin* and the shell carving workshop complemented each other in the sense that they assisted in increasing the supply of spat to the industry in Vava'u as well assisting in diversification of the products of the Tongan pearling industry. In the near future this sustainable activity should gain in popularity and provide greater opportunity for alternative livelihood in Tonga.

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A small-scale floating raft farm for cultured *Pteria penguin* in Vava'u (Photo: A. Teitelbaum).

Does gametogenesis occur naturally in pearl oyster mantle tissue?

Pedro E. Saucedo and Eliana Gómez-Robles

Importance of mantle tissue

In marine and freshwater bivalves, mantle tissue is responsible for a number of specialized functions, such as sensorial capacity, nutrient storage, direction of feeding currents, and synthesis of substances that participate in shell mineralization and pearl formation (Addadi and Weiner 1997; Checa 2000; Barik et al. 2004; Acosta-Salmón and Southgate 2005). Furthermore, mantle tissue plays another important role in Mytilidae as the main sustaining means for gametogenesis (see Lowe et al. 1981; Bayne et al. 1982). So far, Mytilidae is the only known bivalve family in which gonadal development occurs naturally in the mantle tissue at the expense of stem cells and stored reserves (Mourazos et al. 2001). Several studies have characterized the microscopic anatomy of *Mytilus edulis* mantle tissue, and have reported the presence of cellular elements such as amoebocytes with glycogen that provide energy for gametogenesis (Lozada and Reyes 1981; Gabbott and Peek 1991). In the same species, other kinds of storage cells, such as adipogranular (ADG) cells and vesicular connective-tissue (VCT) cells have been reported to participate during gametogenesis, not only as sources of energy, but also as precursors of neurosecretions (Peek and Gabbott 1989; Lubet and Mathieu 1990; Mathieu and Lubet 1993; Mathieu et al. 1991). Some of these precursors are proteins called mantle connective tissue polypeptides (MCTPs), located in the ADG cells of the mantle, and whose expression directly relates to the mantle connective tissue volume and inversely relates to gonad acini volume (Mikhailov et al. 1996).

In pearl oysters, studies of histological, histochemical, biochemical, and ultrastructural composition of mantle tissue have focused more on aspects of shell mineralization and pearl formation than on reproduction. This is true for *Pinctada maxima* (Dix 1972, 1973; Dong 1999), *P. margaritifera* (Jabbour et al. 1992), *P. fucata* (Wada 1973), and *P. mazatlanica* (García-Gasca et al. 1994; Vite-García 2005).

First report of gonad development in *Pinctada mazatlanica* mantle tissue

As part of a broad project studying reproduction of the pearl oyster *P. mazatlanica* (Hanley, 1856), we report the first evidence of gonad-in-mantle tissue. Out of 180 samples analyzed during an annual cycle, 1.1% (two oysters) showed incidence of female acini in the marginal zone, where a diffuse connective tissue matrix with abundant packages of longitudinal and radial muscle fibers were evident (Fig. 1). In these samples, collected in January when the water temperature was 20.5° C (corresponding to spent or undifferentiated sexual stages), the integrity and development of female gametes appeared normal, and several groups of stem cells, oogonias, previtellogenic (small, immature gametes lacking yolk), vitellogenic (still immature, but growing peduncle-shaped cells), and postvitellogenic (fully ripe, free polygonal-shaped) oocytes could easily be observed lining up or filling acini (Fig. 2).

To our knowledge, this is the first report, worldwide, of a marine bivalve other than Mytilidae showing gametogenic activity in the mantle tissue. However, since male or female acini do not occur naturally in the mantle of Pteriidae, we are uncertain of the origin and expression mechanism of this phenomenon. Unlike the mantle tissue of Mytilidae, where the presence of stem cells and other types of storage cellular elements (amoebocytes and VCT and ADG cells) and active substances such as MCTPs has already been confirmed (Lozada and Reyes 1981; Peek and Gabbott 1989; Lubet and Mathieu 1990; Gabbott and Peek 1991; Mathieu and Lubet 1993; Mathieu et al. 1991; Mikhailov et al. 1996), we can only speculate at this point on the following: If the mantle tissue in Mytilidae favors the occurrence of gametogenesis at the expense of its own stem cells and reserves, the mantle of other bivalves, such as pearl oysters, may have similar cellular and reservoir elements or genetically non-expressed stem cells that become active under particular circumstances, such as culture conditions (e.g. density) or the oyster's reproductive, physiological, and/or epidemiologic condition (e.g. sex reversal, stress, disease or parasite infections). Although this hypothesis cannot be confirmed yet, previous observations in mantle tissue of *P. mazatlanica* support this likelihood. For example, García-Gasca et al. (1994) identified different cell-types in the marginal and paleal area of mantle tissue that not only synthesize enzymes related to the mechanism of shell mineralization, but also store glycogen, protein, and lipid reserves that may, under appropriate conditions, activate and sustain gametogenesis. In pearl culture opera-

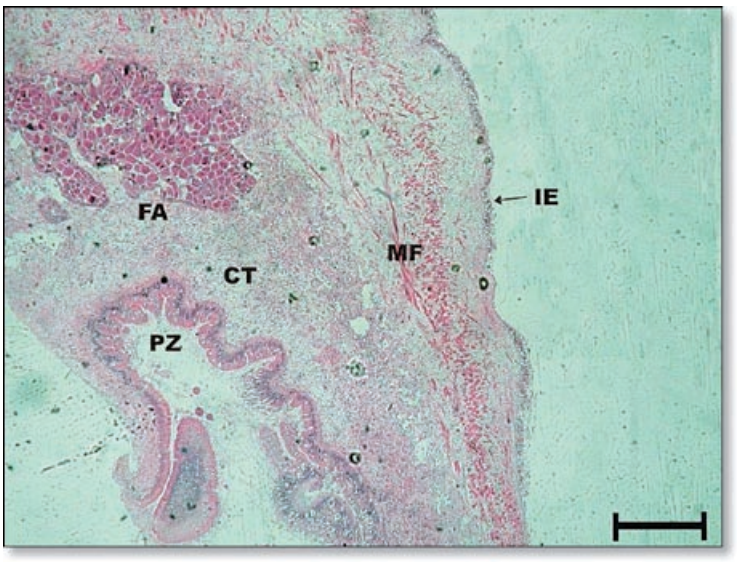

Figure 1. Photomicrograph of a longitudinal section (4X) of the marginal zone of *Pinctada mazatlanica* mantle tissue, showing evidence of female acini (FA). CT = mantle connective tissue matrix; PZ = paleal zone; IE = internal epithelium; MF = radial and longitudinal muscle fibers. Scale bar = 100 µm.

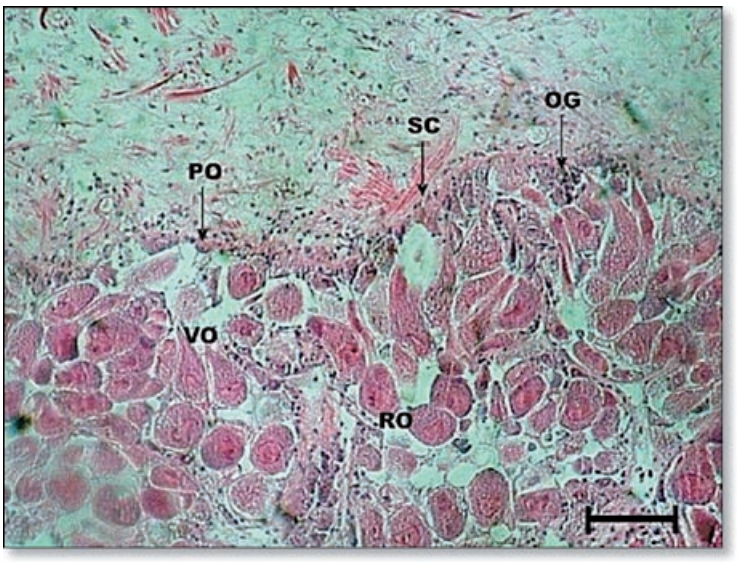

Figure 2. Photomicrograph of longitudinal section (20X) of the marginal zone of *Pinctada mazatlanica* mantle tissue, evidencing development of female gametes. SC = stem cells; OG = oogonias; PO = previtellogenic oocytes; VO = vitellogenic oocytes; RO = postvitellogenic (ripe) oocytes. Scale bar = 100 µm.

tions, Saucedo et al. (2001) observed that oysters inserted in the gonad with a mantle allograft, as part of the procedure to induce round pearl formation, were in better reproductive condition (greater gonadal development and more and larger postvitellogenic oocytes) and showed significantly different biochemical composition (higher protein, lipid, and triglyceride content in the gonad and less protein reserves in the muscle) compared with ungrafted oysters. The biochemical trend observed in treated oysters indicates redirection of energy flows from adductor muscle to acini to favors an active proliferation of gametes and rapid maturation of the gonad (Saucedo et al. 2001). In contrast, recent studies of seasonal changes in biochemical composition of mantle tissue suggest that internal storage reserves are not used during gametogenesis (Vite-García 2005).

Implications for mariculture

Previous results obtained by Saucedo et al. (2001), together with our gonad-in-mantle finding, may have a potential application for commercial hatchery production of spat, particularly to ensure gonadal maturation without depending on traditional broodstock conditioning under "controlled" conditions. In other words, these preliminary results may set the basis for a biotechnology that uses mantle tissue from donor oysters to induce gonadal maturation in receiver oysters. Although this perspective requires further validation, its application is relevant given that traditional gonadal conditioning usually faces serious problems, such as: 1) maintaining broodstock for long periods of time (average of 30–50 days), 2) supplying large quantities of microalgae diets, which is laborious and expensive, and 3) providing diets with suitable levels of lipids and highly unsaturated fatty acids, which is a necessity for producing high quality gametes, viable larvae, and continuous and sufficient yields of spat under hatchery conditions.

So far, our digital images represent the first evidence of gonadal development in mantle tissue of a pearl oyster species. Further investigations of the effects of mantle allografts on cycles of energy reserves, endocrine regulation of gametogenesis, physiological response and energy balance of grafted and ungrafted specimens should confirm our hypothesis and provide elements for validating a biotechnology to induce broodstock maturation through mantle allograft. Such a technology may sustain programmes for reproducing subtropical and temperate mollusc species requiring conditioning at times other than the short natural season for reproduction. This approach applies for most shellfish species inhabiting the shallow waters of the Gulf of California.

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Pearl farming in Zanzibar

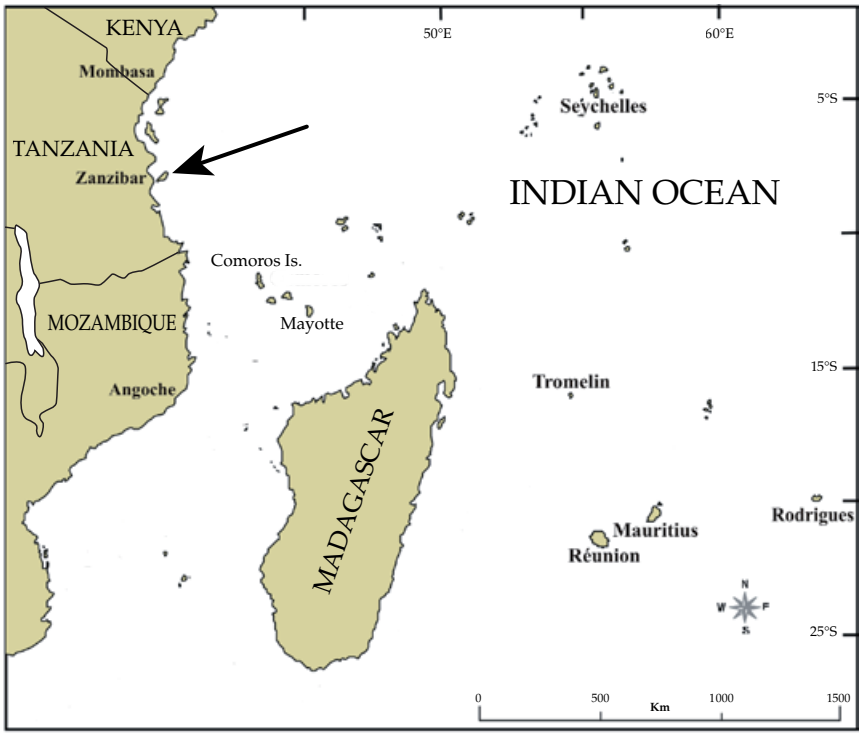
Narriman Jiddawi

Source: Coral Reef Targeted Research Program newsletter, May 2008

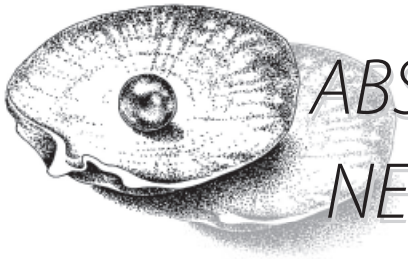
Pearl farming is new to Zanzibar, and is demonstrating how scientific research can successfully support environmentally and economically sustainable projects. In 2006, Dr Maria Haws (University of Hawaii) and Dr Narriman Jiddawi (Institute of Marine Science-IMS) introduced pearl farming technology to women's groups of Fumba peninsula. This USAID-funded project, Sustainable Coastal Communities and Ecosystems (SUCCESS), has enabled the Western Indian Ocean Marine Science Association (WIOMSA), the IMS and their partners to work with women's groups in four villages surrounding Menai Bay to pilot half-pearl (mabe) farming. These women have traditionally been seaweed farmers, agriculturists and shellfish gatherers who would typically earn USD 40–50 in a good month, working 5–7 days per week. In January 2007 a trial batch of 94 *Pteria penguin* were seeded for half-pearl production, each oyster seeded with 2–3 semi-spherical nuclei. Seeded oysters in nets were then suspended at a depth of 4 m from a raft near Bweleo. This resulted in 28 high quality half-pearls after one year, some of which were auctioned at a gala event held at the Palace Museum in February this year. The auction, organised by WIOMSA and IMS and facilitated by Dr N Jiddawi and Dr A Mmochi (IMS), was launched by the Minister for Women and Youth, Ms Asha Abdulla, and raised USD 3600. Some of the remaining pearls were made up into silver and gold jewellery, which will be used to test market acceptance with the 100,000 tourists who visit Zanzibar each year.

Editor's note

This report of successful production of half-pearls from *Pteria penguin* in Zanzibar follows similar production of half-pearls from *Pinctada margaritifera* elsewhere in Tanzania, as reported in issue #17 of the *Pearl Oyster Information Bulletin* (2006). The large numbers of tourists visiting this region each year provide considerable opportunity for income generation from pearls and pearl shell products.

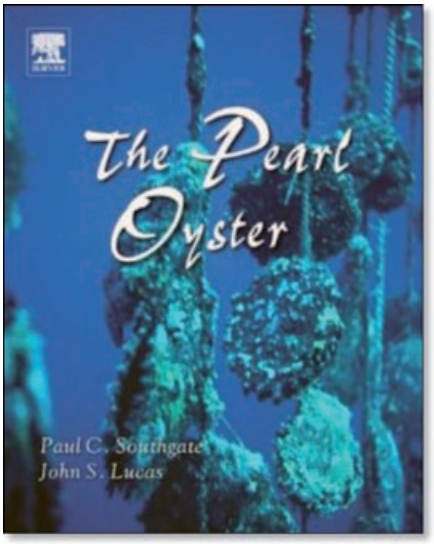


Zanzibar is part of the east African republic of Tanzania.



ABSTRACTS AND NEW PUBLICATIONS

The Pearl Oyster



Edited by Paul Southgate and John Lucas

Description

Pearls have a very long history of being valued as beautiful gems but differ of course in that they are secreted by living animals. Cultured pearls have been produced for almost a hundred years, but the methods for farming pearl oysters and inducing pearls were kept almost secret. This changed with the advent of many new pearl oyster farms in various parts of the world and with the farming of new pearl oyster species. Reflecting this expanding and diversifying industry, there has been a growth of research on pearl oysters over recent decades and substantial developments in culture techniques. However, there has not been a comprehensive publication on pearl oysters and pearl production until now. This book fills the obvious gap. It describes the taxonomy and anatomy of pearl oysters and deals with all aspects of their biology — reproduction, genetics, diseases — and their ecology, including the effects of pollution. The entire range of modern mariculture practises, from spawning and culturing larvae in hatcheries to farming adults in the ocean, are considered. The intricate details of pearl formation and modern techniques for producing cultured pearls are described. Histories of exploitation, marketing and socio-economic aspects are discussed. This is the ultimate reference source on pearl oysters and the culture of pearls, written and edited by scientists who are the world experts in their fields. It is an invaluable reading for professionals, academics, researchers, students and anyone with a general interest in bivalve mariculture.

Contents and contributors

Introduction (Elisabeth Strack); Taxonomy and phylogeny (K.T. Wada and Ilya Temkin), Soft tissue anatomy, shell structure and biomineralisation (Angelique Fougerouse, Marthe Rousseau and John Lucas); Feeding and metabolism (John Lucas); Reproduction, development and growth (Pedro Saucedo and Paul Southgate); Environmental influences (John Lucas); Pearl oyster culture (Paul Southgate); Pearl production (Joseph Taylor and Elisabeth Strack); Exploitation and culture of major commercial species (Paul Southgate, Elisabeth Strack, Anthony Hart, K.T. Wada, Mario Monteforte, Micheline Carino, Sandra Langy, Cedrik Lo, Hector Acosta-Salmon and Aimin Wang); The pearl market (Bo Torrey and Brigitte Sheung); Disease and predation (John Humphrey); Population genetics and stock improvement (K.T. Wada and Dean Jerry); Economics of pearl farming (Clem Tisdell and Bernard Poirine); Environmental impacts of pearl farming (Wayne O'Connor and Scott Gifford); Biofouling (Rocky DeNys and Odette Ison); Future developments (Paul Southgate, John Lucas and Bo Torrey).

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International Workshop on Physiological Aspects of Reproduction and Nutrition in Molluscs. 6–9November 2006, La Paz, BCS, Mexico.

Ultrastructure of tissues and cells of pearl oyster, *Pinctada mazatlantica* (Hanley 1856) associated with reproduction.

Gomez-Robles M.E. and Saucedo P.E.

In Pteridae (pearl oysters) the process of storage and use of energy reserves (glycogen, lipids and proteins) in specialised tissues (digestive gland, mantle, muscle) associated with reproduction has been poorly documented. Available information suggests so far that pearl oysters follow the same metabolic routes described for Pectinidae Mytilidae, Ostreidae. In the Mexican pearl oyster, *Pinctada mazatlantica,* apart from such specialised tissues storing large quantities of energy, there are other cellular structures such as auxiliary cells, vesicular connective tissue (VCT) cells, and the BALBIANI body that participate in gametogenesis. The aim of this study was to characterise the fine structure of tissues and cytological components that regulates the storage and mobilisation of energy throughout an annual cycle as well as to describe seasonal changes in coverage area of such cellular components observed with scanning micronscopy (SEM). Fifteen adult specimens (90 ± 10 mm shell height) were collected every three months during 2005–2006 in La Paz Bay. Changes in water temperature, salinity and chlorophyll A concentration were also recorded at the collecting site. To identify sex, stages of gonadal development and size of oocytes, samples of gonad were processed following the conventional histological techniques. To identify the fine structure of tissues and cellular components, samples of gonad digestive gland mantle and muscle were fixed in glutaraldehyde 2.5%, transferred to phosphate buffer (0.2 M, pH7), and washed in the same buffer solution. Thereafter, samples were dehydrated, imbedded in paraffin, sectioned at 5 µm. Slides were then de-paraffined and covered with metal for examination under a Hitachi S-3000N SEM. Implications derived from the gross and fine structure of tissues and cells are discussed.

Simplification of stereological methodology for the study of reproductive effort in the rainbow-lip pearl oyster, *Pteria sterna*

Caceres-Puig J.I., Caceres-Martinez C. and Saucedo-Lastra P.

Pearls have been produced from cultured rainbow-lip pearl oyster, *Pteria sterna*, since 1994 in the Gulf of California, Mexico. The optimum condition for the organism, for the tissue and nucleus implantation occurs after spawning when the oysters are energetically exhausted, becoming highly vulnerable to manipulation. In this work we investigated the relationship of stored energy in gonad, digestive gland, mantle and muscle tissue with gonad maturation stages. Twenty adult oysters were sampled monthly at a commercial farm during the year. The oysters were dissected and the tissues from different organs were analysed for energy content and were also used for the estimation of volume fractions and total body volume by a simplified stereological method. Preliminary results and a discussion of the advantages of this method are discussed.

Journal abstracts

Review of solutions for 3D hydrodynamic modeling applied to aquaculture in South Pacific atoll lagoons

Andrefouet S., Ouillon S., Brinkman R., Falter J., Douillet P., Wolk F., Smith R., Garen P., Martinez E., Laurent V., Lo C., Remoissenet G., Scourzic B., Gilbert A., Deleersnijder E., Steinberg C., Choukroun S., Buestel D.

Source: Marine Pollution Bulletin 52 (10):1138–1155 (2006)

A workshop organized in French Polynesia in November 2004 allowed reviewing the current methods to model the three-dimensional hydrodynamic circulation in semi-enclosed atoll lagoons for aquaculture applications. Mollusk (e.g. pearl oyster, clam) aquaculture is a major source of income for South Pacific countries such as French Polynesia or Cook Islands. This aquaculture now requires a better understanding of circulation patterns to improve the spatial use of the lagoons, especially to define the best area to set larvae collectors. The pelagic larval duration of the relevant species (<20 days) and the size of the semi-closed lagoons (few hundreds of km^2) drive the specifications of the model in terms of the spatial and temporal scale. It is considered that, in contrast with fish, mollusk larvae movements are limited and that their cycle occurs completely in the lagoon, without an oceanic stage. Atolls where aquaculture is productive are generally well-bounded, or semi-closed, without significant large and deep openings to the ocean. Nevertheless part of the lagoon circulation is driven by oceanic water inputs through the rim, ocean swells, tides

and winds. Therefore, boundary conditions of the lagoon system are defined by the spatial structure of a very shallow rim (exposition and number of hoas), the deep ocean swell climate, tides and wind regimes. To obtain a realistic 3D numerical model of lagoon circulation with adequate forcing, it is thus necessary to connect in an interdisciplinary way a variety of methods (models, remote sensing and in situ data collection) to accurately represent the different components of the lagoon system and its specific boundary conditions. We review here the current methods and tools used to address these different components for a hypothetical atoll of the Tuamotu Archipelago (French Polynesia), representative of the semi-closed lagoons of the South Pacific Ocean. We hope this paper will serve as a guide for similar studies elsewhere and we provide guidelines in terms of costs for all the different stages involved.

Low genetic differentiation among widely separated populations of the pearl oyster *Pinctada fucata* as revealed by AFLP

Yu Da Hui, Chu Ka Hou.

Source: Journal of Experimental Marine Biology and Ecology 333:140–146 (2006)

Genetic variation within and among five populations of the pearl oyster *Pinctada fucata,* from China (Daya Bay, Sanya Bay and Beibu Bay), Japan (Mie Prefecture) and Australia (Port Stephens) was studied using AFLR Three primer pairs generated 184 loci among which 91.8-97.3% is polymorphic. An overall genetic diversity of 0.38 among populations and an average of 0.37 within populations (ranging from 0.35 in Japanese population to 0.39 in Beibu Bay population) were observed. Genetic differentiation among the five populations is low but significant as indicated by pairwise GST (0.0079-0.0404). AMOVA further shows that differentiation is significant among the five populations but is not significant at a broader geographical scale, among the three groups of Chinese, Japanese and Australian populations or among the two groups of Australian and north Pacific populations. The low level of genetic differentiation indicated that *P. fucata* populations in the west Pacific are genetically linked. Among the five populations, the Australian one is more differentiated from the others, based on both pairwise AMOVA and GST analyses, and is genetically isolated by distance as indicated by Mantel test. However, genetic differences among the three Chinese populations are not correlated with the geographic distances, suggesting that Hainan Island and Leizhou Peninsula may act as barriers blocking gene flow.

The influence of culture method and culture period on quality of half-pearls ('mabe') from the winged pearl oyster *Pteria sterna*, Gould, 1851

Ruiz-Rubio H, Acosta-Salmon H, Olivera A., Southgate P.C., Rangel-Davalos C.

Source: Aquaculture 254:269–274 (2006)

Two groups of 96 winged pearl oysters, *Pteria sterna*, with mean (± S.D.) dorso-ventral shell height (DVM) of 75.0 ± 6.0 mm, were used to evaluate the effect of two culture methods (pocket nets and plastic cages) on the quality of half-pearls (mabe) produced from them over a period of 9 months. Prior to implantation, oysters were anaesthetized using benzocaine and two plastic nuclei were implanted on the left valve and one on the right valve of each pearl oyster. Oysters were returned to culture conditions and were sampled to determine nacre secretion and pearl quality 5, 7, 9 and 11 months after nucleus implantation. There was no significant difference (P>0.05) between growth rates of oysters cultured in plastic cages and those held in pocket nets. However, a greater yield of commercial quality pearls was produced by oysters grown in plastic cages. Nacre thickness at the top of the resulting half-pearl blisters showed no significant difference between oysters held in the different culture apparatus (P>0.05) or between different months (P>0.05). Highest mabe quality was recorded 9 months after nucleus implantation when water temperatures were low. Growth of pearl oysters during this study resulted in enlargement of adductor muscle, which in some cases grew to cover the mabe. This result indicates that *P. sterna* with a dorso-ventral shell height greater than 75 mm should be used for the production of mabe. Furthermore, the results suggest that a culture period of 9 months is required to optimize the quality of mabe produced from *P. sterna* cultured in plastic cages.

Study on cryopreservation of spermatozoa in *Pinctada martensii*

Wang M., Yu X., Liu Y., Mao Y., Yu F.

Source: Journal of Fisheries of China 30(2):170–174 (2006)

Comparing solutions of different pH (5.5-9.5) and different salinity to develop suitable basic solution for spermatozoa cryopreservation of pearl oyster *Pinctada martensii*, we chose the basic solution, which could

inhibit the activation and had less influence on the physiological characteristics (such as activity, life span and fertilizing capability) of the spermatozoa, and adopted dimethyl sulfoxide (DMSO) as antifreeze to compound diluents for protecting the spermatozoa. After combination of natural seawater with DMSO (10%) and seminal fluid at the ratios of 1:10 and 1:20, the specimens were transferred into LN2 by 4 temperature-lowering processes. The conclusion showed that cryopreservation processes were effective in which the samples were pre-frozen in 0–8°C within 30 minutes, swung at 15 cm above for 5 min and then at 5 cm above LN2 for 10min, transferred them into LN2 for prolonging period (24 h, 48 h and 5 months), and then thawed them with water at 35–40°C, the survival rate of spermatozoa.

Transport and recruitment of silver-lip pearl oyster larvae on Australia's North West Shelf

Condie S.A., Mansbridge J.V., Hart A.M., Andrewartha J.R.

Source: Journal of Shellfish Research 25 (1):179–185 (2006)

Silver-lip pearl oyster (*Pinctada maxima*) spat surveyed in the Eighty Mile Beach section of the North West Shelf have been used in conjunction with outputs from a particle dispersion model to identify likely spawning grounds. The dispersion model consisted of a 3-dimensional regional circulation model in which large numbers of individual particles were tracked over the period 1994 to 1999. From the settlement areas defined by the spat data, larvae were tracked back in time over their estimated pelagic phase of 24–31 days within the main spawning period of mid October to late December. The reverse calculation was also undertaken looking at larval dispersion from known broodstock populations. Results demonstrate that large tidal currents in the region move larvae back and forth across the shelf, whereas lower frequency currents influence their net transport. Whereas some model larvae traveled more than 60 km, most were transported less than 30 km. The model results suggest that spawning in the Eighty Mile Beach region is concentrated around the recently surveyed broodstock distribution between 8 and 15 m depth, with potential smaller contributions from the northeast. These spawning events are likely to lead to successful recruitment locally and alongshore to the southwest. They also feed larvae into neighboring shallow coastal environments (through tidal oscillations) and deeper waters to the west (similar to 20 m). However, spat abundances seem to be low in these areas, suggesting that recruitment is strongly limited by habitat availability and possibly high mortality rates in shallow water. High local abundances of broodstock and spat observed occasionally in deeper water (similar to 30 m) seem to be supported by intermittent larval transport from inshore populations. However, spawning in this area seems to contribute little to recruitment in the inshore populations.

Temperature and body size on food utilization in the marine pearl oyster *Pinctada fucata* (Bivalvia: Pteridae)

Mondal S.K.

Source: Indian Journal of Marine Sciences 35(1):43–49 (2006)

Physiological parameters such as Clearance rates, absorption efficiency, oxygen consumption and ammonia excretion were estimated for flour size groups ranging from 16 to 60 mm in Dorso Ventral Measurements (DVM) of the marine pearl oyster *Pinctada fucata* at different water temperatures and the results were integrated by means of two physiological indices, namely Scope For Growth (SFG) and Net Growth Efficiency (K2). The rates of clearance, oxygen consumption and ammonia excretion were found strongly correlated ($p = 0.01$) with size groups (as tissue dry weight) at water temperature from 18° to 31°C. Absorption efficiency ranged From 43.2 to 56.9% and was not related to body size in the tested temperature range. Oxygen consumption and ammonia excretion increased with temperature within the same size group from 18° to 31°C. Clearance rate increased with temperature from 18° to 28°C but declined with further increase of temperature to 31°C. Excreted energy contributed 2.4 to 4.0% to the total absorbed energy for different size groups and water temperatures. The SFG and K2 were higher at 26° and 28°C and were minimum at 18°C for all the size groups. The result showed that the optimum physiological conditions for survival and growth of *P. fucata* were in the temperature range of 26° to 28°C.

Historical and present status of the pearl oyster, *Pinctada margaritifera*, at Pearl and Hermes Atoll, Northwestern Hawaiian Islands

Keenan E.E., Brainard R.E., Basch L.

Source: Atoll Research Bulletin 543:333–344 (2006)

Populations of the black-lipped pearl oyster, *Pinctada margaritifera*, at Pearl and Hermes Atoll in the Northwestern Hawaiian Islands were first reported in 1928 and heavily harvested over the next 2 years. Approxi-

mately 150,000 pearl oysters were either exported or killed during the exploitation. An expedition in 1930 to assess post-harvest population status found 480 *P. margaritifera* and determined the population to be severely depleted. Limited surveys in 1994 and 2000 found only a few pearl oysters and led to the conclusion that the population was still depleted. In 2003, the National Oceanic and Atmospheric Administration (NOAA)-led multi-agency marine debris removal team spent several months conducting surveys at Pearl and Hermes Atoll that included quantitative observations of *Pinctada margaritifera*. Data were collected on location, size, depth, habitat, and orientation of individual pearl oysters on the reef. Analyses of the 1930 and 2003 data sets revealed similar size-frequency distributions of the *P. margaritifera* population. The population has a spatial distribution within the Atoll similar to the 1930 post-harvest distribution, and some sustained level of reproduction. Density and depth distribution comparisons from the two survey periods suggest that pearl oysters are significantly more abundant in the shallow waters where they were harvested during the fishery but at a similar density overall as they were during the 1930 survey. Although no estimates of absolute population size are available for any time period, the large number of oysters harvested prior to the 1930 survey, together with estimates of oyster density in 1930 and 2003, suggest that the population may never have recovered to its pre-exploitation level.

Differential community development of fouling species on the pearl oysters *Pinctada fucata, Pteria penguin* and *Pteria chinensis* (Bivalvia, Pteriidae)

Guenther J., De Nys R.

Source: Biofouling 22(3):163–171 (2006)

A field experiment documented the development of fouling communities on two shell regions, the lip and hinge, of the pearl oyster species *Pinctada fucata, Pteria penguin* and *Pteria chinensis*. Fouling communities on the three species were not distinct throughout the experiment. However, when each species was analysed separately, fouling communities on the lip and hinge of *P. penguin* and *P. chinensis* were significantly different during the whole sampling period and after 12 weeks, respectively, whereas no significant differences could be detected for *P. fucata* . There was no significant difference in total fouling cover between shell regions of *P. fucata* and *P. chinensis* after 16 weeks; however, the hinge of *P. penguin* was significantly more fouled than the lip. The most common fouling species (the hydroid *Obelia bidentata*, the Bryozoan *Parasmittina parsevali*, the bivalve *Saccostrea glomerata* and the ascidian *Didemnum* sp.) showed species-specific fouling patterns with differential fouling between shell regions for each species. The role of the periostracum in determining the community development of fouling species was investigated by measuring the presence and structure of the periostracum at the lip and hinge of the three pearl oyster species. The periostracum was mainly present at the lip of the pearl oysters, while the periostracum at the hinge was absent and the underlying prismatic layer eroded. The periostracum of *P. fucata* lacked regular features, whereas the periostracum of *P. penguin* and *P. chinensis* consisted of a regular strand-like structure with mean amplitudes of 0.84 µm and 0.65 µm, respectively. Although the nature and distribution of fouling species on the pearl oysters was related to the presence of the periostracum, the periostracum does not offer a fouling-resistant surface for these pearl oyster species.

Microsatellite variation in Australian and Indonesian pearl oyster *Pinctada maxima* populations

Benzie, J.A.H., Smith-Keune, C.

Source: Marine Ecology Progress Series 314:197–211 (2006)

Eight microsatellite markers were used to screen over 1700 individual pearl oysters *Pinctada maxima* from 5 Western Australian (Lacepedes, 80 Mile Beach Shallow, 80 Mile Beach Deep, Port Hedland and Exmouth Gulf), 1 northern Australian (Darwin) and 2 Indonesian (Madura and Sumbawa) populations. There was a strong and highly significant relationship between the amount of genetic divergence between pairs of populations and their degree of geographical separation. Within Australia, there was some indication for genetic differences between Exmouth Gulf and the other Western Australian populations and also between Darwin and the Western Australian populations. The Indonesian populations were significantly different from all Australian populations, suggesting little or no direct recruitment to Western Australia from Indonesian sources. Comparison of 2 year-classes of spat (0+ and 1+) in some Australian populations showed no evidence of differences among Western Australian sites. Comparison of the same recruitment class at 2 different ages (0+ spat in 1998 and 1+ spat in 1999) provided no evidence for selection at the screened, or closely linked, loci. With the possible exception of Exmouth Gulf, Western Australian populations can be considered 1 stock with a large effective population size (no 300 and more likely several 1000s).

Studies on growth traits of first generation of selective line of *Pinctada martensii* Dunker

He M., Shi J., Lin Y., Jiang Y.

Source: Journal of tropical oceanograhy/Redai Haiyang Xuebao 25(1):19–22 (2006)

The first generation of pearl oyster *Pinctada martensii* Dunker cultured at the Days Bay (DDS) was successfully obtained by selective breeding. In contrast with the progeny of normal cultured population (DDC) main traits of the two groups after one year continuous measurement were compared by f-test analysis. The result showed that the selective line (DDS) was significantly larger than the control group (DDC) in shell length, shell, shell width and total weight ($p<0.05$) in seven measurement periods except for shell length in Dec 2003 and Feb 2004 ($p>0.05$). The survival rate of DDS was 9.18% higher than that of DIE. The result of this study lays a foundation of further selective breeding for better strain in *P. martensii*.

Seasonal variations in proximate and elemental composition of pearl oyster (*Pinctada radiata*, Leach, 1814)

Gokoglu N., Gokoglu M.P.

Source: Journal of the Science of Food and Agriculture 86: 2161–2165 (2006)

Pearl oysters (*Pinctada radiata*) were investigated for proximate and elemental composition throughout the year. Oysters were collected bimonthly by hand during scuba diving from the Gulf of Antalya. Ranges of dry matter, protein, fat and ash contents were 144.7–209.8, 65.9–160.4, 4.3–10.9 and 4.6–27.0 g kg^{-1}, respectively. While the highest protein and fat values were found in the summer months, the highest dry matter and ash contents were found in the winter months. The highest element contents were found in the spring and autumn months. Cadmium and zinc were found to be over the legislative limits, while copper was below, throughout year. The highest concentration among the elements was obtained for zinc.

Pearl oyster fishery

Anon.

Source: ESD Report Series No. 5, pp. 88. (2006)

The silver-lipped pearl oyster is the only species targeted by this fishery, which in terms of economic value is the second highest grossing fishery in WA, with an average annual value of around AUD 220 million. The fishery has operated under a detailed and sophisticated management regime since 1982 when quotas were first introduced into the fishery. Management of the commercial fishery today is based on a quota system, minimum and maximum size limits, data collection, wild shell stock-hatchery quota substitution, compliance and hatchery operations. Each of these has been refined through time, and is subject to regular reviews to achieve overall aim of successful management. The Western Australian Pearling Act 1990 provides the legislative framework to implement the management arrangements for this fishery and the Pearling General Regulations 1991 supports this Act by providing the framework for the management of administrative and technical matters. The combination of having a large amount of relevant and accurate information on the biology of the silver lipped pearl oyster, extensive knowledge about the history of this fishery (in excess of 30 years for the culture shell fishery and almost 100 years for the Mother Of Pearl fishery), combined with the extensive catch and effort data and the sophisticated suite of management arrangements in place, have resulted in the maintenance of pearl oyster stocks as well as the successful continuation of the fishery. While this fishery has minimal impacts to the wider ecosystem, largely due to the selective method of fishing used, the fishery continues to take positive steps to minimise its impacts. A Code of Conduct/ Practice is currently being developed by the industry. This code once finalised, will provide instruction as well as the opportunity for the industry to minimise, or in some cases, eliminate, the potential for impacts on other species and habitats within the fishing grounds.

Aquaculture highlights from Papua New Guinea

Anon.

Source: Secretariat of the Pacific Community Fisheries Newsletter. 117:19–23 (2006)

This article gives an overview of current aquaculture in Papua New Guinea (PNG). In Bougainville Province, most farmers raise tilapia or carp. In Milne Bay Province, there is already a low level of fish farming along the inland north coast with fish fingerlings provided by the National Development of Agriculture and Livestock (NDAL). The government also has interest in trialing *Kappaphycus* seaweed and sea cucumber

farming. On Samurai Island where the largest pearl farm in PNG has been established by Coral Sea Mariculture Pty. The farm is cultivating the silver-lip pearl oyster (*Pinctada maxima*), which produces the translucent white South Seas pearl. In the Western Province, at 2000 meters there is a mine pit where rainbow trout (*Oncorhynchus mykiss*) are housed in pens for restocking into the surrounding lakes. The trout are an important fishery to local tribes. At Tabubil's aquaculture facilities, staff have recently succeeded in breeding a local fish - sooty grunter (*Hephaestus fuliginosus*)-which, along with barramundi (*Lates calcarifer*), are the two main species targeted for farming in the lower elevations. Feed formulation trials are being carried out at the feed station using local crops. In East New Britain Province, the provincial governor's office had approached SPC to assist in Macrobrachium farming on Rabaul. Ten, one hectare ponds have been dug and local sources of *Penaeus monodon* prawns will be farmed. In New Ireland Province, the National Fisheries College in Kavieng is planning a joint mariculture education programme with Vudul University.

Development and characterization of six new microsatellite markers for the silver- or gold-lipped pearl oyster, *Pinctada maxima* (Pteriidae)

Evans B.S., Knauer J., Taylor J.J.U., Jerry D.R.

Source: Molecular Ecology Notes 6 (3):835–837 (2006)

Six di-, tri- and tetranucleotide microsatellite loci were developed for the silver- or gold-lipped pearl oyster *Pinctada maxima* using a linker-ligated, magnetic bead enrichment protocol. Based on a minimum of 134 Indonesian pearl oyster samples, number of alleles and observed heterozygosity at each locus ranged from six to 17 alleles and from 0.172 to 0.813 (mean = 0.448), respectively. Mean polymorphic information content for the six loci was 0.562. These loci should be very useful in DNA parentage analyses and population differentiation of *P. maxima* in Australia and Indonesia.

Genetic variation in wild and cultured populations of the pearl oyster *Pinctada fucata* from southern China

Yu D.H., Chu K.H.

Source: Aquaculture 258:220–227 (2006)

In order to provide information for selective breeding program in China, the genetic variation in wild and cultured *Pinctada fucata* populations from southern China was studied using AFLP markers. Three pairs of primers generated 182 loci among 179 individuals in populations from Beibu Bay, Daya Bay and Sanya Bay. A high level of genetic diversity, ranging from 0.367 in a wild population in Sanya Bay to 0.393 in a wild population in Beibu Bay, and high level of proportion of polymorphic loci were observed within both wild and cultured populations. Yet cultured populations in Sanya Bay and Beibu Bay had more fixed loci than the corresponding wild populations. Genetic differentiation in most pairwise comparisons of populations was significant. AMOVA indicated that genetic variation among populations was very low (1.77%) though significant, while more than 98% variation resided among individuals within population. These findings provide no evidence to show that hatchery practice of pearl oyster in China to date has significantly affected the genetic diversity of the cultured populations, and suggest that all populations are competent for selection. Yet the significant genetic differentiation among most populations implies that any translocation of individuals for genetic improvement program should be managed with caution for the preservation of genetic diversity in natural populations.

Stable isotope and chemical composition of pearls: biomineralization in cultured pearl oysters in Ago Bay, Japan

Kawahata H., Inoue M., Nohara M., Suzuki A.

Source: Journal of Oceanography 62(4):405–412 (2006)

The δ18O, δ13C and trace element composition of pearls collected from Ago Bay, Japan, were investigated in order to evaluate biomineralization in the cultured pearl oyster (*Pinctada fucata martensii*). The oxygen isotopic data suggest that the pearls were produced around 23–24°C, mainly in June to early July, which is consistent with their occurrence in the field. Therefore the pearls were produced under or close to isotopic equilibrium conditions, although they showed high calcification rates (higher than 0.2–1.0 g $cm^{-2}yr^{-1}$) under which, for example, coral skeletons (calcification rate 0.28 g cm^{-2} yr^{-1}) often show non-equilibrium isotope partitioning. The δ13C values were approximately .9[per mill] lower than those calculated for offshore

waters under equilibrium conditions. This may be due to low-δ13C bottom waters resulting from the degradation of organic matter (OM) or to a contribution of low-δ13C food. In the latter case, a simple mass balance calculation gives a respiration component of 14%. Twelve trace elements of bulk pearl samples were classified into four groups on the basis of their enrichment/depletion patterns relative to seawater and inter-element relationships: group 1, Co, Cr, Pb; group 2, Ba, Cs, U; group 3, Cu, Sn, V, and group 4, Mn, Rb, Mo. Comparison with coral skeletons suggests that Ba and Mn (groups 2 and 4) were definitely much enriched in proteinaceous OM relative to aragonite crystals in pearls and that V (group 3) in pearls showed only slight enrichment in the organic-rich layer. By contrast, the other elements showed small differences between both layers (enrichment factor of <3), suggesting that these elements occur largely in aragonite crystals.

Stocking density dependent bacterial load and its influence on the production of pearl oyster *Pinctada fucata* (Gould) seed

Subhashi S.K., Lipton A.P., Raj R.P.

Source: Indian Journal of Animal Sciences 77:420–423 (2007)

A positive correlation between increased bacterial load and pearl oyster larval stocking density was recorded in hatchery conditions. Survival of only 0.82% with an average bacterial load of 1.3×10^3 cfu mL^{-1} in 5000 larvae/L at 28.6 ± 0.3°C was observed. The bacterial load was low in 200 larvae L^{-1} with an average of 2.0×10^2 cfu mL^{-1} with a higher survival of 41.02%. Mortality and bacterial.load were significantly higher in the high stocking density. Of the 6 isolates of bacteria from the culture tank water during high larval mortality 5 were *Vibrio spp*. Comparatively steady state of bacterial load in low stocking density reduced the water exchange requirements and stress to the larvae which resulted in higher survival as well as spat settlement.

An experimental investigation of deformation and fracture of nacre-mother of pearl

Barthelat F., Espinosa H.D.

Source: Experimental Mechanics 47:311–324 (2007)

Nacre, also known as mother-of-pearl, is a hard biological composite found in the inside layer of many shells such as oyster or abalone. It is composed of microscopic ceramic tablets arranged in layers and tightly stacked to form a three-dimensional brick wall structure, where the mortar is a thin layer of biopolymers (20–30 nm). Although mostly made of a brittle ceramic, the structure of nacre is so well designed that its toughness is several order of magnitudes larger that the ceramic it is made of. How the microstructure of nacre controls its mechanical performance has been the focus of numerous studies over the past two decades, because such understanding may inspire novel composite designs though biomimetics. This paper presents in detail uniaxial tension experiment performed on miniature nacre specimens. Large inelastic deformations were observed in hydrated condition, which were explained by sliding of the tablets on one another and progressive locking generated by their microscopic waviness. Fracture experiments were also performed, and for the first time the full crack resistance curve was established for nacre. A rising resistance curve is an indication of the robustness and damage tolerance of that material. These measurements are then discussed and correlated with toughening extrinsic mechanisms operating at the microscale. Moreover, specific features of the microstructure and their relevance to associated toughening mechanisms were identified. These features and mechanisms, critical to the robustness of the shell, were finely tuned over millions of years of evolution. Hence, they are expected to serve as a basis to establish guidelines for the design of novel man-made composites.

Pearl formation: Persistence of the graft during the entire process of biomineralization

Arnaud-Haond S., Goyard E., Vonau V. et al.

Source: Marine Biotechnology 9:113–116 (2007)

Most bivalves species of the genus *Pinctada* are well known throughout the world for production of white or black pearls of high commercial value. For cultured pearl production, a mantle allograft from a donor is implanted into the gonad of a recipient oyster, together with a small inorganic bead. Because of the dedifferentiation of cells during the first steps of the host oyster's immunological reaction, so far the fate of the graft and its exact role in the process of pearl formation could not be determined via classical histological methods. Here we report the first molecular evidence of the resilience of the graft in the recipient organism by showing that cells containing genome from the donor are still present at the end of pearl formation. These results suggest the existence of a unique biological cooperation leading to the successful biomineralization process of nacreous secretion in pearl formation.

Growth of wild pearl oysters *Pinctada fucata, Pinctada margaritifera* and *Pinctada sugillata* (Bivalvia: Pteriidae) in Taiwan

Hwang J.J., Yamakawa T., Aoki I.

Source: Fisheries Science 73:132–141 (2007)

In order to understand growth features of pearl oysters in the genus *Pinctada*, i.e. *Pinctada fucata, Pinctada margaritifera*, and *Pinctada sugillata* in Taiwan, a total of 3062 wild individuals of these species from juvenile to adult were collected monthly from March 2001 to April 2002 in Jukeng, Pingtung County, south-west Taiwan. Quantitative measurements of live oysters were conducted for shell height (SH), shell length (SL), shell width (SW), hinge length (HL), and wet weight (WW). Different cohorts were identified through multiple length frequency analysis on SH of *P. fucata* and P. margaritifera, and growth curves with seasonal variation were estimated for these species. *Pinctada fucata* in Taiwan had a different seasonal growth pattern from the Japanese population, but had similar growth rates during the high growth period. The growth rate of *P. margaritifera* in Taiwan was slower than in French Polynesia, the Solomon Islands, and the Red Sea. Comparisons of morphological growth features among the three species show large differences in the SW-related features. *Pinctada fucata* in Taiwan had larger SW than in Japan and Korea. The differences in growth rates and morphological features suggested that the wild Taiwanese oysters may retain genetically pristine characteristics, thus genetic conservation might be urgently needed.

Towards development of large-scale hatchery cultivation of larvae and spat of the pearl oyster *Pinctada mazatlanica* in Mexico

Saucedo P.E., Ormart-Castro P., Osuna-Garcia M.

Source: Aquaculture273:478–486 (2007)

The results of a series of pilot-scale runs with *P. mazatlanica* larvae from 2004 through 2006 are reported. Preliminary runs in 2004 and 2005 used broodstock collected in summer, when massive spawning of wild populations naturally occurs. However, results of larval development were very poor and failed to produce spat in both years. In 2006, ripe broodstock were still collected in summer, but also in the spring time, based on the hypothesis that the gonads in this season were in better reproductive condition that in summer. Three larval runs were conducted in 2006: two in spring and one in summer. Larvae growth and survival greatly increased in both spring runs, ending with two successful productions of spat (similar to 20 x 10^{-3} and similar to 100 x 10^{-3} juveniles). The summer larval run in 2006 failed again to produce spat. Additionally, the first run of April 2006 refers to an experiment that evaluated two different larval culture conditions: constant temperature (27°C) and low stocking density (3–4 larvae ml^{-1}) versus variable temperature (24–28°C) and high stocking density (8–9 larvae ml^{-1}). The first trial significantly increased larval survival and growth, which in turn resulted in greater numbers of settled spat, in comparison of the second trial, where survival, growth, and settlement of spat were significantly lower. Also in 2006, the quality of seawater used at the hatchery was evaluated with microbiological and chemical tests. The implication of these tests, together with results from all experiments are analyzed and discussed in terms of the potential development of large-scale hatchery cultivation of *P. mazatlanica* larvae in Mexico.

Population dynamics of pearl oyster *Pinctada radiata* west of Lavan Island of the Persian Gulf, Iran

Ejlali Khanghah K., Abdolalian A., Rameshi H.

Source: Iranian Scientific Fisheries Journal16:1–10 (2007)

Investigation on pearl oyster, *Pinctada radiata* growth and mortality parameters was carried out from September 2001 to October 2002 in west of Lavan Island using scuba diving method. Hinge length (HL) and Dorso-ventral measurement (DVM) relationship was significantly ($r^2 = 0.98$) linear. Weight and dorso-ventral measurement relationship was shown to be $W = 0.0004\ L^{2.812}$)($r^2 = 0.98$). Asymptotic length (L_∞) and growth rate (K) were estimated at 98 (mm) and 0.96 y^{-1} respectively. More than 70 percent of the individuals were matured in April 2001. Mortality parameters including natural mortality (M), total mortality (Z) and fishery mortality (F) were estimated to be 1.21 y^{-1}, 1.68 y^{-1} and 0.66 y^{-1} respectively. Exploita-tion rate was estimated to be 0.27 in this survey.

Effects of a probiotic bacterium, Lactobacillus acidophilus, on the growth and survival of pearl oyster (*Pinctada margaritifera*) spat

Subhash S.K., Lipton A.P.

Source: Israeli Journal of Aquaculture Bamidgeh59:201–205 (2007).

The present study investigated the effect of a probiotic bacterium, *Lactobacillus acidophilus*, on the growth and survival of pearl oyster, *Pinctada margaritifera*, spat. The probiotic bacteria was fed together with a microalgal feed at 1:1 or 2:1 while control groups received no probiotic supplementation. The probiotic groups had significantly higher survival (78.7 ± 8.1 and 85.7 ± 2.9%, respectively) than the control groups (60.7 ± 1.2%). Weight and length also increased significantly. The weight gains in the probiotic groups were 349.8 ± 0.44 mg (1:1 level) and 396.8 ± 0.49 mg (2:1 level) mg, compared to 300.9 ± 0.51 mg in the control. The increases in dorso-ventral measurement were 20.08 mm (1:1 level) and 21.04 mm (2:1 level) in the probiotic groups, compared to 14.22 mm in the control.

The effect of different substrates on pearl oyster *Pinctada martensii* (Dunker) larvae settlement

Su Z., Huang L., Yan Y., Li H.

Source: Aquaculture 271:377–383 (2007)

In the present study, the effect of various substrata on the settlement of a pearl oyster, *Pinctada martensii*, was evaluated. The settlement of the larvae in the experiments with four different color substrata was compared and showed that deep color plastic sheets (red and blue) attracted significantly more larvae ($P<0.05$) than light color (green and yellow). In addition, the influence of biofilm substrata was compared with that of non-film substrata of smooth or rough texture. Number of settled larvae was highest on biofilmed plastic sheets, either rough or smooth, then rough plastic sheets without film, the least recorded was on smooth plastic sheets without biofilm. Substrates of plastic sheets coated with tissue extracts of the same species appeared to attract larval settlement. The number of settled larvae on substrates with tissue extracts was significantly greater ($P<0.05$) than that on the control.

Changes in the use of the pearl oyster *Pinctada mazatlanica* (Bivalvia: Pteriidae) in the Great Temple of Tenochtitlan

Source: Revista Mexicana de Biodiversidad 78 Suplemento, 71–76 (2007)

The nacreous shell of the tropical Pacific mollusc *Pinctada mazatlanica* was widely used by the ancient inhabitants of Mexico. Around 600 pieces made of this shell have been found in offerings buried in the Great Temple of Tenochtitlan. Most of these objects come from the IVth construction stage (1440–1481), prior to the conquest of the Pacific Coast by the Aztecs. It was previously thought that the considerably smaller numbers found in the following stages were due to the greater degree of destruction suffered by the temple. Nevertheless, the almost complete absence of this material in nine offerings found recently corresponding to the VIIth construction stage (1502–1521), raise other possibilities. In this work two different hypotheses are presented to explain this observation.

Effect of fouling on feeding, oxygen consumption and waste excretion of pearl oyster *Pinctada martensii* in Daya Bay cultivation

Su Z., Yan Y., Huang L.

Source: Marine Science Bulletin (Beijing) 9(2):34–42 (2007)

Biofouling is a particular problem in the pearl oyster culture. It may reduce the growth and survival rates of the cultured species. Foulers are often themselves filter feeders, and are therefore potential competitors for food resource with the cultured species. Fouling organisms may also reduce the oxygen supply. A study was conducted to measure the impact of foulers on feeding, oxygen consumption, and waste excretion. POM, ammonia, phosphate and oxygen concentration were measured in various treatments (cultured species. foulers). This study showed that fouling organisms had significant effect on food uptake. oxygen consumption and waste excretion. The clearance rate, ammonia and phosphate release rate, oxygen consumption rate of the fouled pearl oyster were greater than those of the clean pearl oysters. Other foulers that settled on cages or buoys also contributed much to phytoplankton depletion, oxygen consumption and concentration increase of ammonia and phosphate in water. Therefore, this study showed us that foulers were important competitors in the pearl oyster cultivation of Daya Bay in November 2005.

Reproductive cycle of the pearl oyster *Pteria sterna* (Pteriidae) in the Ojo de Liebre Lagoon, B.C.S., Mexico

Hernandez-Olalde, L., Garcia-Dominguez, F., Arellano-Martinez, M., Ceballos-Vazquez, B.P.

Source: Journal of Shellfish Research 26(2):543–548 (2007)

The reproductive cycle of a wild population of the oyster pearl *Pteria sterna* living in the Ojo de Liebre lagoon was analyzed from February 2001 to February 2002. The gonadic development was studied both qualitatively (through histological analysis) and quantitatively (through an analysis of the percent follicular area). *P. sterna*'s gonadic development consists of five stages (undifferentiated, developing, ripe, spawning, and spent). The percent follicular area turned out to be an adequate quantitative indicator of reproductive activity, with significantly higher values in the ripe months (August to September) and with a decrease directly related to spawning. The reproductive cycle of *P. sterna* is synchronic and is influenced by temperature and food availability. The reproductive season can be regarded to range from October to April, starting when temperature drops. The size at first maturity was determined at 117.1 mm SH and 106.6 mm SH for females and males, respectively. However, the smallest ripe female and male measured 73 mm SH and 26 mm SH, respectively, and both were undergoing the spawning phase. Differences in the reproductive cycle of *P. sterna* were found between the one reported here and reports for other Gulf of California's localities.

Sizing and theoretical configuration of a longline for growing pearl oysters (*Pinctada imbricata* Mollusca: Bivalvia) in the Bay of Charagato, Cubagua Island, Venezuela

Trujillo E., Martinez G., Leon L.

Source: Investigaciones Marinas 35(1):39–54 (2007)

A farming longline was sized by theoretically analyzing the system's hydrodynamic resistance and configured using analogue simulation with the help of scale models. The variables determined were mother line tension (TLM), the relationship of the anchoring aspect (R_A), and movement (P_R) of the mother line. These resulted in anchoring system tension (T_2) and attack angle ($alpha_2$), and the vertical tension for a section of the mother line (TF) and the attack angle of the catenary (alpha). The model of the anchor end and a section of the mother line were constructed using lineal scale factors of 40 and 18.86 and force scales of 9,776.3 and 1,233.13, respectively. The minimum tensions (T_2) obtained for R_A were 1/4 and 1/5 based on the theoretical tension (T_1) 777.15 kgf, with attack angles of 84.9 degree and 90 degree. A longline section with six lanterns and loaded with adult organisms had central units 3 and 4 at an operational depth of 7.37 m, an average P_R of 93.6%, and an attack angle of 55.86 degree. A tensiometer should be used for an in situ validation of the theoretical results in order to determine the structural equilibrium of the system with minimum investment and maximum performance.

Use of tropical microalgae as food for larvae of the black-lip pearl oyster *Pinctada margaritifera*

Martinez-Fernandez E., Southgate P.C.

Source: Aquaculture 263:220–226 (2007)

This study determined the nutritional value of tropical microalgae for black-lip pearl oyster (*Pinctada margaritifera*, L.) larvae. One-day old larvae were fed the flagellates Pavlova salina, *Pavlova* sp., TISO and *Micromonas pusilla* in binary and ternary combinations in Experiment 1. In a second experiment, umbo-stage larvae were fed the best binary combinations from Experiment 1 with the addition of one diatom species (*C. muelleri*, *Chaetoceros* sp. or *Skeletonema* sp.) per combination. The best two ternary combinations (flagellates only) from Experiment 1, *Pav. salina*/*Pavlova* sp./TISO and TISO/*M. pusilla*/*Pavlova* sp., were also assessed in Experiment 2. In Experiment 1, greater growth rate was shown by larvae fed the ternary combination of *Pavlova sp.*/*Pav. salina*/TISO followed for the binary combination of Pavlova sp./M. pusilla; however, larvae fed Pavlova sp. as a mono-specific diet performed as well as those fed the ternary combination of *Pavlova* sp./*Pav. salina*/*M. pusilla* (P=0.001). The addition of a diatom to microalgae diets composed of flagellates resulted in increased growth rates and survival of umbo-stage *P. margaritifera* larvae when compared to combinations without a diatom (Experiment 2). The results showed that *Pavlova* sp. supported a high growth rate of D-stage *P. margaritifera* larvae which was equivalent to that of larvae fed plurispecific diets. For umbo-stage *P. margaritifera* larvae, the best growth rate was achieved when the binary combination of *Pavlova* sp. and *C. muelleri* was used. Based on these results, *Pavlova* sp. and *Pavlova* sp./*C. muelleri* are recommended as diets for D-stage and umbo-stage *P. margaritifera* larvae, respectively.

Survey on polychaete verminosis in farmed pearl oyster (*Pteria penguin*) in Liusha Bay, Leizhou, Guangdong

Liang F., Liu Y., Deng C., Mao Y.

Source: Marine fisheries research/Haiyang Shuichan Yanjiu 28(2):84–89 (2007)

Survey was carried out on polychaete verminosis in cultured pearl oyster (*Pteria penguin*) in Liusha Bay. The results showed that the infection rates were 39.13%–44.98% and 26.67%–35.63% for the adult pearl oyster of 2–4 years reared in cone cage and for those in opening culture, respectively. Adult pearl oyster of different ages in same culture method did not exhibit obvious diversity in infection rates. However, significant differences of infection rates were found in pearl oyster in between different culture methods. The left-shell of *Pteria penguin* reared in cone cage was liable to infection of polychaete verminosis. Nevertheless, infected pearl oyster was not significantly different from the healthy pearl oyster in growth.

The genetic diversity of cultured population *Pinctada martensii* Dunker by ISSR marker

Jiang Y., He M., Lin Y.

Source: Marine Science Bulletin/Haiyang Tongbao26(5):62–66 (2007)

One big group (D group) and one small group (X group) of pearl oyster *Pinctada martensii*, selecting from the same one artificial population, were analyzed by ISSR (intersimple sequence repeats) markers to determine the genetic variations among within the groups. A total of 72 loci, including 71 polymorphic loci, were amplified using 5 primers. Polymorphic loci were 98.61% in the two groups. The result of POPGENE analysis indicated that the level of genetic variations of the big group of P. martensii (PPB = 94.44%, I = 0.3523, h = 0.2181, na = 1.9444) was higher than the small group (PPB = 80.61%, I = 0.3008, h = 0.1915, na = 1.8056). A total of Gst (Coefficient of population differentiation) 0.0948 showed that there was 9.48% of genetic differentiation between the two groups, The dendrogram of genetic relationships among groups and individuals were constructed based on Jarrced's genetic distance. The 47 of 50 big individuals clustered together, the 50 small individuals clustered another group.

Production of Akoya pearls from the Southwest coast of India

Kripa V., Mohamed K.S., Appukuttan K.K., Velayudhan T.S.

Source: Aquaculture262:347–354 (2007)

The Indian pearl oyster *Pinctada fucata* (Gould) is typically capable of producing pearls of 3-5 mm diameter. The feasibility of production of pearls similar to Akoya pearls of 6-8 mm diameter was studied from the southwest coast of India. Along with this, mortality and retention rates of implanted oysters, rate of nacre production, thickness of nacre deposited, quality and type of pearls produced and effect of hydrographic variations on the mortality of implanted oysters were also studied. A total of 706 oysters were implanted, 311 with 5 mm, 395 with 6 mm nuclei and stocked in 30 cages for a period of 317 days. The mortality rates were highest, 0.173 ± 0.22 for the 6 mm nucleus implanted oysters followed by 5 mm nucleus implanted oysters at 0.107 ± 0.025 during the first 30 days after implantation. These rates were significantly different ($P<0.05$) from the mortality rate of the control oysters (0.042 ± 0.04). The retention rates based on the surviving oysters, ranged from 33 to 61% (average 45.9 for 5 mm) and 31 to 60% (average 48.9% for 6 mm). The nacre deposition rates on the nuclei were found to be 4.0 ± 1.0 mu m day^{-1} and 3.0 ± 1.0 mu m^{-1} for 6 and 5 mm nuclei respectively. Of the total 131 pearls obtained, 27.6% were A-grade, 31.3% B-grade, 19.8% C-grade, 7.6% baroques and 13.7% rejects or trash. The total suspended solids (TSS) in the water were found to be positively correlated ($P<0.05$) with the monthly mortality rate of the implanted oysters. The study showed that it was possible to obtain relatively thick nacre within a short period of 10 months, the deposition rate being about 9 times higher than that observed in Japanese waters and 2.2 to 2.3 times more than that along the Indian southeast coast.

Effects of cryoprotectant agents and freezing protocol on motility of black-lip pearl oyster (*Pinctada margaritifera* L.) spermatozoa

Acosta-Salmon H., Jerry D.R., Southgate P.C.

Source: Cryobiology54:13–18 (2007)

Gamete cryopreservation techniques have been applied to several bivalve mollusc species. However, research activity in this area has primarily focused on cryopreserving gametes from edible oysters (Ostreii-

dae). Few studies have examined the effect of cryoprotectants and freezing protocols in the preservation of spermatozoa from cultured pearl oysters (Pteriidae). Pearl oyster producers are increasingly looking towards the development of improved family lines and, as a consequence, the ability to cryopreserve gametes would bring about significant benefits to the cultured pearl industry. In response to this need, we evaluated the effect of three cryoprotectant additives (CPA) on motility of spermatozoa from the black-lip pearl oyster, *Pinctada margaritifera*. These additives have previously been used to cryopreserve gametes of other bivalve species. The following CPA mixtures were evaluated: (1) 0.45M trehalose and 0, 0.64, 1.02 and 1.53 M dimethyl sulfoxide (Me_2SO); (2) 0.2M glucose and 2M Me_2SO and (3) 1.31 M propylene glycol (PG). The effects of four different freezing protocols on motility of *P. margaritifera* spermatozoa were also evaluated (slow, medium, medium-rapid and rapid cooling). This study showed that total motility was best retained when spermatozoa were cryopreserved in 0.45M trehalose and 0, 0.64, 1.02 or 1.53M Me_2SO and frozen using slow to medium-rapid cooling rates (2.1-5.2°C min^{-1}). Rapid freezing through direct plunging of spermatozoa into liquid nitrogen resulted in the lowest overall retention of motility regardless of the CPA additive; however, CPA mixture also influenced retention of motility, with 0.2M glucose in 2M Me_2SO and 1.31M PG retaining the lowest levels of motility for the CPAs evaluated.

Effects of cryopreservation methods on post-thaw motility of spermatozoa from the Japanese pearl oyster, *Pinctada fucata martensii*

Kawamoto T., Narita T., Isowa K., Aoki H., Hayashi M., Komaru A., Ohta H.

Source: Cryobiology 54:19–26 (2007)

In order to develop cryopreservation techniques for Japanese pearl oyster spermatozoa, the effects of various cryopreservation conditions on post-thaw motility were examined. Spermatozoa cryopreserved with 10% methanol (MET), dimethylformamide or dimethylacetamide plus 90% diluent comprising 80% seawater and 20% fetal bovine serum (FBS) showed higher percentages of post-thaw motility than those cryopreserved with 10% dimethylsulfoxide or glycerol. When spermatozoa were cryopreserved with various concentrations (0–20%) of MET and 100–80% diluent, 10% MET showed the highest percentages of post-thaw motility. When spermatozoa were cryopreserved with 10% MET and 90% diluent comprising various concentrations (0–100%) of FBS or Ringer solution mixed with seawater, the percentages of post-thaw motility peaked at 20% FBS or Ringer solution, and were significantly higher for 20% FBS than for 20% Ringer solution. The percentages of post-thaw motility increased with increasing dilution ratios from 2.5- to 50-fold. Spermatozoa cooled to -50°C and then immersed in liquid nitrogen (LN) showed higher post-thaw motility than those cooled to -30°C or -40°C. When spermatozoa were cryopreserved to -50°C at various cooling rates by changing the sample height above the LN surface, the post-thaw motilities of spermatozoa cooled at 10cm (cooling rate: -21.3°C/min) and 12.5cm (-15.6°C/min) from the LN surface were higher than those at 5, 7.5 or 15cm. These results indicate that 10% MET plus 90% diluent comprising 80% seawater and 20% FBS is a suitable extender for cryopreservation of Japanese pearl oyster spermatozoa and that samples should be cooled to -50°C at a cooling rate between -15 and -20°C/min for efficient storage.

Growth and biometric relationship of the Indian pearl oyster *Pinctada fucata* (Gould) under long term onshore rearing system

Syda Rao G.

Source: Journal of the Marine Biological Association of India 49(1):51–57 (2007)

No abstract.

The pearl oyster *Pinctada maxima* (Jameson, 1901): an atlas of functional anatomy, pathology and histopathology

Humphrey J.D., Norton J.H.

Source: NTDPIF, Darwin, N.T. (Australia). 111 pp. (2007)

Although commercial farming of the pearl oyster (*Pinctada maxima*) and pearl production in northern Australia is entirely dependent on the mollusc, its histology, pathology and physiology remain poorly described. Understanding normal anatomic and microscopic structure is a prerequisite for recognising disease or pathological states characterised by altered structural changes at the gross and cellular level, which can lead to a diagnosis of disease. The atlas on the functional anatomy, histology and histopathology of *P. maxima* describes the normal structure and function of the oyster together with a range of inflammatory and degen-

erative processes associated with infectious and non-infectious causes of disease. It aims to provide a practical and user-friendly guide to assist the management of pearl oyster aquaculture. In addition to providing comparative pathologists with the basis for recognising and interpreting the normal gross and microscopic structure of *P. maxima* and abnormalities resulting from disease, the atlas assists biologists, aquaculturalists and farm technicians in understanding the structure and function of *P. maxima*, recognising disease processes and providing guidelines for the management, collection and sampling of oysters for disease or other investigations.

Motility of spermatozoa obtained from testes of Japanese pearl oyster *Pinctada fucata martensii*

Ohta H., Kawamoto T., Isowa K., Aoki H., Hayashi M., Narita T., Komaru A.

Source: Fisheries Science73(1):107–111 (2007)

Effects of NH3 concentration in sea water and pH of sea water on the motility of spermatozoa obtained from testes were examined in the Japanese pearl oyster. Percent motility at 30 s after dilution increased with increasing NH3 concentration in sea water from 0.75–2.0 mM. When spermatozoa were diluted with sea water containing 0.75 mM NH3, which is widely used as the insemination fluid in the hatchery of this species, the percent motility increased with time elapsed after dilution, and peaked at 5 min. For spermatozoa diluted with sea water containing 2.0 mM NH3, the percent motility increased rapidly and peaked at 30 s. The pH of sea water increased with increasing NH3 concentration from 8.2 (0 mM NH3) to 9.9 (5.0 mM NH3). When spermatozoa were diluted with artificial sea water at various pH (buffered without NH3 at 6.0–10.0), only spermatozoa diluted with artificial sea water of pH 10.0 were motile, and the percent was considerably lower than those in ammonical sea water. These results indicate that sea water containing 2.0 mM NH3 is a suitable solution for evaluating sperm motility, and that NH3 and/or ammonium ions may activate sperm motility in this species.

The mollusc health surveillance networks REPAMO and REPANUI

Joly JP., Cochennec-Laureau N., Fougerouse A., Francois C.

Source: INRA Productions Animales20(3) :229–232 (2007)

Created in 1992, the French network REPAMO is in charge of the surveillance and monitoring of the mollusc health status along the French coast according to European legislation. The missions of the network are the following: (1) the surveillance of notifiable diseases present in France, (2) the study of abnormal mortalities, (3) the surveillance of health status of cultivated and natural mollusc populations. The more recent network REPANUI has similar goals mainly focused on the pearl oyster health status to support the oyster farming industry in French Polynesia.

Element concentrations in shell of *Pinctada margaritifera* from French Polynesia and evaluation for using as a food supplement

Chang F., Li G., Haws M., Niu T.

Source: Food Chemistry104(3): 1171–1176 (2007)

Element concentrations in shell of *Pinctada margaritifera* (black-lip pearl oyster) from Manihi, French Polynesia, were measured with Inductively Coupled Plasma - Atomic Emission Spectrometry (ICP-AES). The respective average concentrations were: calcium (Ca) 396.4mg/g, sodium (Na) 5.536mg/g, magnesium (Mg) 2.136mg/g, strontium (Sr) 890.6ppm, iron (Fe) 67.89ppm, aluminum (Al) 45.74ppm, phosphorus (P) 27.19ppm, boron (B) 12.17ppm, manganese (Mn) 2.308ppm, copper (Cu) 1.050ppm, zinc (Zn) 0.7180ppm; and nickel (Ni), chromium (Cr), mercury (Hg), arsenic (As), cadmium (Cd), lead (Pb), and vanadium (V) were below detection limits with ICP-AES. The above concentrations were normalized and compared to the safety standards for human consumption determined by regulatory agencies of United Nations (UN), the European Union (EU), and the United States (US). Element concentrations detected in this study were all lower than the safety standards promulgated by regulatory agencies. These findings suggest that shells of *P. margaritifera* from Manihi, French Polynesia, do not raise any significant health concerns for human consumption. The shell of *P. margaritifera* thus potentially represents an important natural source for calcium-fortified foods, calcium supplement, and even for potential osteogenesis applications.

N40, a novel nonacidic matrix protein from pearl oyster nacre, facilitates nucleation of aragonite in vitro

Yan Z., Jing G., Gong N., Li C., Zhou Y., Xie L., Zhang R.

Source: Biomacromolecules 8(11):3597–3601 (2007)

A novel nonacidic matrix protein from pearl oyster nacre has been purified by cation-exchange chromatography. It was designated N40 for the nacreous protein of approximately 40 kDa. On the basis of the extraction method (with Tris-buffered Milli-Q water) and amino acid compositions (Gly- and Ala-rich), N40 was inferred to be a conventional "insoluble matrix protein". Crystallization experiments showed that N40 could facilitate the nucleation of aragonite drastically. So far, among the macromolecules that have been purified from the shell, N40 is an exclusive protein that can nucleate aragonite by itself, without the need for adsorption to a substrate. Thus, the present study has proposed the possibility that the nonacidic shell protein (maybe a conventional "insoluble framework protein") can also directly participate in aragonite nucleation and even act as a nucleation site. It is a valuable supplement to the classic biomineralization theory, in which the soluble acidic proteins of the shell are generally believed to function as a nucleation site.

Family by environment interactions in shell size of 43-day old silver-lip pearl oyster (*Pinctada maxima*), five families reared under different nursery conditions

Kvingedal R., Evans B.S., Taylor J.J.U., Knauer J., Jerry D.

Source: Aquaculture279:23–28 (2008)

To understand the influence the environment and associated genotype by environment interactions will exert on future silver-lip pearl oyster (*Pinctada maxima*) selective breeding programs, this study assessed the relative performance in four shell growth traits of spat from five full-sib families, when spat were communally reared at different salinities (29, 34 and 40 ppt), food availability (high, medium and low), food quality (high, medium and low), and in a hatchery vs. ocean environment for 43 days. Rearing environment was found to influence growth expression, with significant differences evident when oysters were grown at different salinities in the ocean instead of hatchery, or when fed algae of differing nutritional quality. As indicated by MANOVA, family comparative growth performances were also altered when the environment changed, with significant environment by family interactions apparent in the food quality, food availability and hatchery vs. ocean rearing treatments. Changes in salinity, however, did not affect relevant family performances. These results indicate that growth and relative family performance in *P. maxima* may change dependent on local environmental conditions and that genotype by environment effects may need to be considered in breeding programs for this species.

Impact of artificial eutrophication on coastal zooplankton communities: a comparative study of zooplankton communities receiving different human activities (fish and pearl oyster farming)

Chang K-H., Nishibe Y., Doi H., Obayashi Y., Ninomiya I., Yamamoto T., Yoshihara M., Shime M., Kihara A., Nakano S-I.

Source: Human and Climate Forcing of Zooplankton Populations. p. 90. (2007)

One central problem in coastal marine waters is eutrophication due to anthropogenic nutrient loading. Japan has a long history of aquaculture, and such farming activities often cause environmental problems in Japanese coastal waters. To assess the impact of farming activities on coastal zooplankton communities, we conducted comparative studies at coastal marine waters, Uchiumi and Fukuura Bays, neighbouring but receiving different farming effects (pearl oyster and fish farmings) at Uwa Sea, east side of the Bungo Channel. Fukuura Bay is highly eutrophic due to fish farming and other activities while the trophic status of Uchiumi Bay is oligo mesotrophic. Seasonal changes of zooplankton communities were monitored from May 2005 to May 2006. To include microzooplankton as well as mesozooplankton, a Van-Dorn sampler was used with a 40 mu m-mesh net filtering. Coastal calanoid copepods, *Paracalanus* spp. and *Temora* spp., dominated zooplankton communities at both sites, but their abundances different with higher abundances at Uchiumi Bay. Species compositions of calanoid copepods were also different with more frequent appearances of larger species such as Calanus spp. and *Eucalanus* spp. at Uchiumi Bay. The densities of microzooplankton including rotifers, bivalve larvae, and appendicularians, were higher at Fukuura Bay, however. The impact of eutrophication on zooplankton community structure and overall impact on the function of planktonic food web in coastal marine waters were analysed and will be discussed.

Spore ornamentation of *Haplosporidium hinei* n. sp. (Haplosporidia) in pearl oysters *Pinctada maxima* (Jameson, 1901)

Bearham D., Spiers Z., Raidal S., Jones J.B., Burreson E.M., Nicholls P.K.

Source: Parasitology 135(4):521–527 (2008)

An infection of pearl oysters, *Pinctada maxima*, attributed to a *Haplosporidium* sp. by Hine and Thorne (1998) has been detected on 3 occasions and is considered to represent a serious concern to the pearling industry in Australia. The spore ornamentation of the parasite was determined by scanning electron microscopy and transmission electron microscopy. Spores of the parasite were pleomorphic, or elongated 3.5-4 µm x 2.5–3.0 µm in size. Two filaments were wound around the spore and originated from 2 'knob-like' posterior thickenings. Both filaments passed up one side of the spore together until just below the operculum whereupon each split and passed obliquely under the lip of the opercula lid. Each filament wrapped around the spore 4 times. The posterior thickenings seem to appear late in the development of the spore and were composed of spore wall material. A second set of branching tubular filaments composed of a different material was observed on the spore body although not on mature spores possessing a 'knob-like' posterior thickening. The ornamentation on the spores of the pearl oyster parasite was unique amongst described haplosporidian species where spore ornamentation is known. The parasite is named in this manuscript as *Haplosporidium hinei* n. sp.

Harvest history and current densities of the pearl oyster *Pinctada mazatlanica* (Bivalvia: Pteriidae) in las perlas and coiba archipelagos, Panama

Cipriani R., Guzman H.M., Lopez M.

Source: Journal of Shellfish Research 27(4):691–700 (2008)

Four hundred years of commercial harvest of the oyster *Pinctada mazatlanica* in Pacific Panama were characterized by historical collapses and recoveries that finally ended in the 1940s; oyster populations have not recovered since then. This study provides a baseline and meta-analysis of current *P. mazatlanica* densities in Las Perlas and Coiba Archipelagos. We compared the oyster densities in relation to substrates and depths at 103 sampled sites rising randomization techniques. Mean oyster density per site ranged from 2.8–238.9 ind ha^{-1} in Las Perlas and 6.0–263.9 ind ha^{-1} in Coiba. These values are one to three orders of magnitude lower than those reported for La Paz, Baja California (3,000–12,000 ind. ha^{-1}) and Costa Rica (24.200 ind. ha^{-1}) in recent times. Substrates within the archipelagos were diverse. We found an increasing trend of density variance when regressing log-transformed densities against substrates ordered according their increasing availability of hard surfaces. In Coiba, densities in substrates including rocks plus corals and sand were statistically lower in shallow than in deep waters, probably caused by harvest. The highest densities in Las Perlas occurred southeast of Del Rev and western Saboga islands. In Coiba, we found the highest densities in Rancheria Island and on the westernmost side of Coiba and Jicaron Islands. These data will help to define the environmental framework within which future research on this important species must be conducted and can be used to improve plans to address its management and conservation.

Genetic structure at different spatial scales in the pearl oyster (*Pinctada margaritifera cumingii*) in French Polynesian lagoons: beware of sampling strategy and genetic patchiness

Arnaud-Haond S., Vonau V., Rouxel C., Bonhomme F., Prou J., Goyard E., Boudry P.

Source: Marine Biology155(2):147–157 (2008)

In order to study further the genetic structure of the pearl oyster *Pinctada margaritifera* in French Polynesia with a special consideration for the sampling scale, we analyzed or re-analyzed sets of data based on nuclear DNA markers obtained at different spatial scales. At a large scale (several 1,000 km), the remote Marquesas Islands were confirmed to be significantly differentiated from Tuamotu-Gambier and Society archipelagos, with a marked difference however for the two main islands that are different from each other. At a medium scale (several 10 to several 100 km), overall homogeneity was observed within and between these two archipelagos, with some exceptions. This could be attributed both to large-scale larval dispersal and to human-driven spat translocations due to pearl oyster cultivation. These results contrast with those observed (1) at a small scale (less than 10 km) in a lagoon heavily impacted by translocation and cultural practices, where significant genetic differentiation was detected among three laying beds, and (2) at a micro scale where we detected an important variability of the genetic composition of young spat recruited on artificial collectors. Such patterns could result from a high variance in the number of genitors at the origin of each cohort, or from pre- or post-settlement selection on linked loci. Altogether, our data support the hypothesis that under certain conditions populations of bivalves may exhibit patterns of chaotic genetic patchiness at local scale, in line with the increasing report of such patchiness in marine benthic organisms. This underlines the importance of sampling scale that should be rigorously defined depending on the questions to be answered.

Nevertheless, a survey of about 80 articles dealing with population genetics of marine invertebrates showed that only 35% of those studies disclosed details about the sampling strategy (particularly the area explored). These results emphasize the need for cautious interpretation of patterns of genetic structure at medium scale when rigorous sampling strategies are not deployed.

Monitoring of French Polynesia coral reefs and their recent development

Salvat B., Aubanel A., Adjeroud M., Bouisset P., Calmet D., Chancerelle Y., Cochennec N., Davies N., Fougerouse A., Galzin R., Lagouy E., Lo C., Monier C., Ponsonnet C., Remoissenet G., Schneider D., Stein A., Tatarata M., Villiers L.

Source: Revue d'Ecologie la Terre et la Vie 63 :145–177 (2008)

Monitoring of French Polynesia coral reefs and their recent development. French Polynesia, consisting of 118 islands in the centre of the Pacific Ocean, has more than 15,000 km^2 of reefs and lagoons managed by the local government. Tourism and pearl culture are the two main economic resources of the country. Polynesian coral reefs are extremely diverse and are among those for which we have thorough knowledge. The exploitation of local resources has been recorded for multiple decades and includes: coral materials, fishing, harvest and export of mother-of-pearl molluscs, pearl production, and ornamental fish. All over the country, many monitoring programmes have been launched to measure the health of reefs and the natural and anthropogenic perturbations that they suffer: hurricanes and seismic events, water quality, health of benthic and fish communities, pearl oyster pathology and radiobiology. These data, collected over the last few decades, allowed to define the relative importance of natural and anthropogenic degradation on reefs and lagoons, and to explain the present status of reefs at different spatial scales. Devastating hurricanes are rare (1903–1906, 1982–1983 and occasionally at other times), but they may annihilate outer slope coral communities on some islands. Bleaching events with considerable coral mortality at different geographical scales occurred mainly in 1991, 1994 and 2003. Outbreaks of Acanthaster destroyed numerous reefs (lagoons and outer slopes) from 1978–1982 and a new demographic wave began in 2006 at many Society Islands. Eutrophication events only occurred occasionally and only in some lagoons. Whereas natural catastrophic events degrade the coral reef ecosystem across many islands, at the archipelago or even regional scale, anthropogenic degradation is limited to a few Society Islands, occurring rarely on atolls and not at all on those (one third), which are uninhabited. The main causes of reef degradation in some areas of Tahiti and Moorea include the embankment of fringing zones, coral mining, overfishing, absence of urban sewage treatment and the development of leisure and tourism activities. Because of its large geographical extent, one may conclude that major reef degradation in French Polynesia is caused by catastrophic natural events. On the other hand, anthropogenic degradation is more localized. Unfortunately, the synergistic effects of these causes of degradation prevent reefs from recovering. Optimum coral cover on French Polynesian outer reef slopes is between 50–60%. After a major destructive impact (hurricane, bleaching, Acanthaster) a reef is reduced to less than 10% coral cover, however if no more major disturbance events occur a reef will recover in about 12 years. Most of the 15,000 km2 of reefs and lagoons in French Polynesia are in good health, and along with their neighbouring reefs in East and Central Pacific they are considered as the least degraded reefs worldwide and at a low risk of becoming degraded in the few next decades. However, we are more and more anxious about the future of reefs in the world particularly because present simulations predict that major impacts of climate change would include: elevation of sea surface temperatures, increase in the strength of hurricanes and acidification of seawater which will affect the formation of coral structures.

Evaluation of three phytoplankton species as food for the pearl oyster *Pinctada fucata*

Hashimoto T., Hyodoh K., Hirose T. et al.

Source: Aquaculture International 16:309–318 (2008)

In the pearl cultivation farms of the Ehime Prefecture, Japan, mass mortalities of the pearl oyster *Pinctada fucata* have occurred since 1994. The occurrences of mass mortality roughly coincided with a shift of the dominant phytoplankton from *Skeletonema* and *Chaetoceros* to *Chaetoceros* and *Nitzschia* all of which belong to Bacillariophyceae. Hence, we evaluated *Nitzschia*, together with *Chaetoceros* and *Isocrysis*, as food for the oyster. Wet weights, lengths, widths, glycogen contents, and growth rates in terms of wet weight of the oysters in all the feeding treatments were significantly higher than those in the non-feeding treatment. The highest glycogen content (2.34%) and growth rate (2.21 g month^{-1}) were found in the *Chaetoceros* treatment. Growth rate in the *Isocrysis* treatment (1.63 g month^{-1}) was also high, although glycogen content in this treatment (0.41%) was low. In the *Nitzschia* treatment, growth rate of the oyster (0.94 g month^{-1}) was the lowest and glycogen content (0.83%) was also low relative to that in the *Chaetoceros* treatment. Chlorophyll a concentration in fecal pellets was lowest in the *Nitzschia* treatment (<2.7 µg mg^{-1}), suggesting more complete digestion of *Nitzschia* by the oyster. Thus, *Nitzschia* was edible and digestible but not assimilated by *P. fucata*. We propose the following scenario for the relationship between *Nitzschia* dominance and mass mortality.

When Nitzschia dominates in a culture area, the physiological condition of P. fucata deteriorates due to low assimilation of *Nitzschia* by the oyster, followed by susceptibility of the oyster to infection by agents lethal to the oyster.

Characterization of calcium deposition and shell matrix protein secretion in primary mantle tissue culture from the marine pearl oyster *Pinctada fucata*

Gong N.P., Ma Z.J., Li Q. et al.

Source: Marine Biotechnology 10(4):457–465 (2008)

In this study, we established and characterized a long-term primary mantle tissue culture from the marine pearl oyster *Pinctada fucata* for in vitro investigation of nacre biomineralization. In this culture system, the viability of mantle tissue cells lasted up to 2 months. The tissue cells were demonstrated to express nacre matrix proteins by RT-PCR, and a soluble shell matrix protein, nacrein, was detected in the culture medium by Western blot analysis. On the other hand, 15 days after initiating culture, a large amount of calcium deposits with major elements, including calcium, carbon, and oxygen, were generated in the mantle explants and cell outgrowth area. The quantity and size of calcium deposits increased with the prolonged cultivation, and their location and nanogranular structure suggested their biogenic origin. These calcium deposits specifically appeared in mantle tissue cultures, but not in heart tissue cultures. Taken together, these results demonstrate that the mantle tissue culture functions similarly to mantle cells in vivo. This study provides a reliable approach for the further investigation on nacre biomineralization at the cellular level.

Realized heritability and response to selection for shell height in the pearl oyster *Pinctada fucata* (Gould)

He M.X., Guan Y.Y., Yuan T. et al.

Source: Aquaculture Research 39:801–805 (2008)

The common pearl oyster, *Pinctada fucata* (Gould), is the most important species that is cultured for production of marine pearls in China. Heavy mortality and the decline of pearl quality have resulted in a breeding programme being established in recent years. In this study, we conducted selective breeding for the second generation of pearl oyster *P. fucata* (JCS-2) by mass selection for shell height (SH) with a selection intensity of 1.614, and analysed the growth of the selected line (JCS-2) and the non-selected control line (JCC) during a 1-year grow-out period. The results show that the selected line grew faster than the control one in the SH and total weight (TW) (P0.05), and there were higher proportion of larger sized oysters. Coefficient of variation for SH of JCS-2 was smaller than that of JCC. The current genetic gains and realized heritability for JCS-2 averaged 16.03 ± 4.79% and 0.713 ± 0.208 at 3–15 months of age respectively. The findings indicated the selection response to faster growth for SH is markedly effective in the second generation, and there was a high correlated response of TW when selecting for SH.

The inner-shell film: An immediate structure participating in pearl oyster shell formation

Yan Z.G., Ma Z.J., Zheng G.L. et al.

Source: Chembiochem 9(7):1093–1099 (2008)

In mollusks, the inner shell film is located in the shell-mantle zone and it is important in shell formation. In this study, we found that the film was composed of two individual films under certain states and some columnar structures were observed between the two individual films. The inner shell film was separated with the process of ethylenediaminetetraocetic acid (EDTA) treatment and the film proteins were extracted. Amino acid analysis showed that the film proteins may consist of shell framework proteins. The calcite crystallization experiment showed that the film proteins could inhibit the growth of calcite, while the CaCO3 precipitation experiment showed that the film proteins could accelerate the rate of CaCO3 precipitation. All these results suggested that the film plays an important role in shell formation. It may facilitate the aragonite formation by inhibiting the growth of calcite and accelerate the shell growth by promoting the precipitation of CaCO3 crystals.

The effect of chemical cues on settlement of pearl oyster *Pinctada fucata martensii* (Dunker) larvae

Yu X., He W., Gu J.D., He M., Yan Y.

Source: Aquaculture277:83–91 (2008)

The pearl oyster *Pinctada fucata martensii* is an important aquaculture species in South China Sea and has great commercial value in the pearl culture industry. As difficulties in the commercial culturing of molluscs are mainly associated with larval settlement and metamorphosis, it is important to find a routine, inexpensive and effective technique for the induction of synchronous settlement and metamorphosis of larvae. In

the present study, the effects of 11 chemicals on inducing larval settlement of the *P. fucata martensii* were investigated in the laboratory. The larvae were exposed to the chemicals for 96 h. Among the chemicals tested, K+ (10 and 20 mM), Ca2+ (1 and 50 mM), γ -aminobutyric acid (10^{-4} M), 3-isobutyl-1-methylxanthine (10^{-4} M), choline (10^{-3}, 10^{-4} M), acetylcholine (10^{-4} M), and serotonin (10^{-3}, 10^{-4}, 10^{-5} M) induced high percentage of the larvae to settle without acute toxic effects, while Mg2+, NH4+, dopamine, and 3-(3,4-Dihydroxyphenyl)-L-alanine at all the tested concentrations were less effective. Serotonin of 10^{-4} M resulted in the highest settlement rate, but the chemical is expensive. K+ was slightly less effective, but the chemical is much cheaper, therefore maybe more economical in the commercial production.

Fertility of cryopreserved spermatozoa of the Japanese pearl oyster, *Pinctada fucata martensii*

Narita T., Kawamoto T., Isowa K., Aoki H., Hayashi M., Komaru A., Ohta H.

Source: Aquaculture275:178–181 (2008)

The aims of this study were to compare the fertility of fresh and cryopreserved spermatozoa of the Japanese pearl oyster, *Pinctada fucata* martensii and to develop artificial fertilization methods using the cryopreserved spermatozoa. The optimal egg density for the fertilization test was found to be 1.0×10^5 eggs ml^{-1} seawater. When 1.0×10^5 eggs ml^{-1} seawater were mixed with various numbers of fresh or cryopreserved spermatozoa (from 0.041 to 63×10^7 spermatozoa), high fertilization rates (about 60%) were obtained following addition of more than $3.5x10^7$ spermatozoa when using either fresh or cryopreserved spermatozoa. With reduced numbers of spermatozoa of less than 1.1×10^7 (cryopreserved) or 0.12×10^7 (fresh) spermatozoa, the fertilization rates gradually decreased to 40% or less. More than 10 times the number of cryopreserved spermatozoa was necessary to obtain similar fertilization rates to those arising from the use of fresh spermatozoa.

Isolation and characterization of the N-linked oligosaccharides in nacrein from *Pinctada fucata*

Takakura D., Norizuki M., Ishikawa F., Samata T.

Source: Marine Biotechnology (New York Springer) 10(3):290–296 (2008)

We analyzed the structure of the N-linked oligosaccharides enzymatically liberated from the organic matrix (OM) component in the nacreous layer of Japanese pearl oyster: *Pinctada fucata*. The lectin-blot analysis of the soluble OM after separation by SDS-PAGE, four components, with sizes of approximately 55 kDa, 35 kDa, 25 kDa, and 21 kDa were detected with GNA lectin, which recognized terminal mannose of high mannose and hybrid types of N-glycan. The 55-kDa component of the soluble OM detected by lectin blotting was identified as nacrein by using liquid chromatography/mass spectrometry (LC/MS). LC/MS analysis of the N-glycan liberated from nacrein detected a hybrid-type N-glycan, which contained sulfite and sialic acid at its terminus. The data strongly imply that nacrein, a sulfated OM glycoprotein, participates in molluscan biomineralization by creating a favorable environment for calcium ion uptake through sulfonic acid and sialic acid.

Energy storage and allocation during reproduction of Pacific winged pearl oyster *Pteria sterna* at Bahia de la Paz, Baja California Sur, Mexico

Vite-Garcia N., Saucedo P.E.

Source: Journal of Shellfish Research 27(2):375–383 (2008)

Seasonal variations in storage, partitioning, and allocation of energy reserves (proteins, carbohydrates, lipids, and triglycerides) between germinal and somatic tissues (gonad, digestive gland, mantle tissue, and adductor muscle), were investigated related to reproduction of Pacific winged pearl oyster *Pteria sterna*. Tissue samples were collected every three months and analyzed with histological and biochemical techniques. Energy coefficients were also calculated with data from chemical composition of tissues. Gonad samples in almost all developmental stages occurred throughout the year, suggesting that *P. sterna* is a multispawning species. The evidence indicates that the main reproductive season runs from January through April (21°C to 22°C) and was identified by higher frequency of ripe gonads, more and larger postvitellogenic oocytes and higher protein, lipid, and triglyceride levels in gonad tissue. Within this study period, there were two spawning peaks, July 2003 and January 2004. Gametogenesis was sustained from energy mainly obtained from the digestive gland and secondly from the adductor muscle. Only proteins from these two tissues were mobilized to the gonad for maturation of sex organs, because carbohydrates were stored despite the progress of gametogenesis. The role of mantle tissue was negligible. *P. sterna* appears to use a combination of stored reserves (conservative strategy) and food supply (opportunistic strategy) as an overall strategy to regulate reproduction.

Attached microalgae contribute to planktonic food webs in bays with fish and pearl oyster farms

Doi H., Chang K.H., Obayashi Y., Yoshihara M., Shime M., Yamamoto T., Nishibe Y., Nakano S.

Source: Marine Ecology Progress Series353:107–113 (2008)

Planktonic food webs are primarily dependent on organic matter derived from phytoplankton. In coastal areas, aquaculture has accelerated in recent decades, and attached algae and invertebrates proliferate on the farming cages. We hypothesized that the organic material on the farm structures is important to planktonic food webs and that the effects of aquaculture differ between fish (fertilized) and pearl oyster farms (not fertilized). To test these hypotheses, we examined the planktonic food webs at fish and pearl oyster farms using stable isotopes in the Uwa Sea, Japan. We collected zooplankton, particulate organic matter (POM, predominantly phytoplankton), attached algae, and macroinvertebrates in July 2005 and February 2006. Based on the isotope mixing model results, the attached microalgae contributed up to approximately 70% of the copepod food sources, and the contribution of attached microalgae to cyclopoid copepods was similar to their contribution to attached macroinvertebrates. Amphipods mainly fed on planktonic detritus from microalgae that had detached from the farm structures. The contribution of attached microalgae to copepod biomass was lower on the pearl oyster farm than on the fish farm. Our results show that attached microalgae from sea farms are important food sources for planktonic food webs in areas with fish farms and that the 2 food webs, attached and pelagic, are coupled through zooplankton grazing.

Food sources of the pearl oyster in coastal ecosystems of Japan: Evidence from diet and stable isotope analysis

Fukumori K., Oi M., Doi H., Okuda N., Yamaguchi H., Kuwae M., Miyasaka H., Yoshino K., Koizumi Y., Omori K., Takeoka H.

Source: Estuarine, Coastal and Shelf Science76:704–709 (2008)

We estimated the composition of two food sources for the cultured pearl oyster *Pinctada fucata* martensii using stable isotopes and stomach content analysis in the coastal areas of the Uwa Sea, Japan. The delta ^{13}C values of oysters (-17.5 to -16.8%%) were intermediate between that of particulate organic matter (POM, -20.2 to -19.1%%) and attached microalgae on pearl cages (-13.0%%). An isotope mixing model suggested that oysters were consuming 78% POM (mainly phytoplankton) and 22% attached microalgae. The attached microalgal composition of the stomach content showed a strong resemblance to the composition of that estimated through the isotope mixing model, suggesting preferential utilization of specific components is unlikely in this species. These results indicate that *P. fucata* martensii feed on a mixture of phytoplankton and attached microalgae, and that the attached microalgae on pearl cages can serve as an important additional food source.

Investigation of cell proliferation and differentiation in the mantle of *Pinctada fucata* (Bivalve, Mollusca)

Fang Z., Feng Q.L., Chi Y.Z. et al.

Source: Marine Biology153:745–754 (2008)

The mantle of the pearl oyster *Pinctada fucata* was adopted for the proliferation profile study in our work and a proliferation hot spot was found in the outer epithelia of mantle central zone using the BrdU immunohistochemistry method. This result contradicts the previous research that the mantle has numerous growth centers all over the mantle epithelium, with the same proliferation activity throughout the whole mantle outer epithelial cells. This is the first report on the different proliferation features on the whole mantle where Alcian Blue/PAS staining analysis and ultrastructural observation with the aid of transmission electron microscope (TEM) demonstrated distinct features of the epithelium in four different regions of the mantle. Results from the present investigation displayed that in the outer epithelium of the marginal zone in mantle outer fold, organelles such as mitochondria and endoplasmic reticulum (ER) were well-developed and double membrane bounded vesicles were present; in the outer epithelia of mantle central zone, stem-like cells with a high ratio of nucleus to cytoplasm and comparatively undeveloped organelles were detected. Together with the observations of the cell proliferation profile of different regions of the mantle, a hypothetic model for the proliferation and differentiation of the pearl oyster's mantle is proposed: there exists a proliferation "hot spot" in the outer epithelial cells of central zone and the proliferation ability decreases progressively from this "hot spot" towards the marginal zone; the whole mantle's differentiation occurs continuously with its growth and the direction is from the proliferation 'hot spot' (central zone) towards the marginal zone. Furthermore, another interesting result was found when the proliferation rate was investigated together with the tidal rhythm: the proliferation activity was found to be closely correlated with the tidal rhythm, indicating that the mantle outer epithelia's proliferation rhythm might be the impetus of the shell's daily growth bands.

Modelling and comparison of growth of the silver-lip pearl oyster *Pinctada maxima* (Jameson) (Mollusca : Pteriidae) cultured in West Papua, Indonesia

Lee A.M., Williams A.J., Southgate P.C.

Source: Marine and Freshwater Research 59:22–31 (2008)

A commonly used approach to quantifying growth is to fit mathematical models to length-at-age data. Growth of the silver-lip pearl oyster, *Pinctada maxima*, cultured at a commercial pearl farm in West Papua, Indonesia was expressed mathematically by fitting five growth models (Gompertz, Richards, Logistic, Special von Bertalanffy Growth Function (VBGF) and General VBGF) to length-at-age data. The criteria used to determine the best fit model were a low mean residual sum of squares (MRSS), high coefficient of determination (r^2) and low deviation of the asymptotic length (L_∞) from the maximum length (L_{max}). Using these criteria, the models were ranked accordingly: Special VBGF; General VBGF; Gompertz; Richards and Logistic models. The Special VBGF yielded the best fit (L_∞ = 168.38 mm; K = 0.930 $year^{-1}$; t(0) = 0.126; MRSS = 208.64; r^2 = 0.802; Deviation of L_∞ from L_{max} = 37.52 mm) and, accordingly, was used to model the growth of oysters cultured at three sites and two depths within the farm. Likelihood ratio tests were used to compare growth of oysters cultured at these sites and depths. Based on L_∞ and K values, favourable sites and depths could be determined that optimised growth requirements for the various stages of *P. maxima* culture. Sites with high K and L_∞ values were preferred sites for culturing juvenile oysters before pearl production, when high growth rate is essential to produce large numbers of oysters in the shortest time possible. In addition, high L_∞ may facilitate implantation of larger nuclei conducive to the production of larger, more valuable pearls. Conversely, sites with low K values were preferred sites for weakening *P. maxima* before pearl 'seeding', a process undertaken to minimise nucleus rejection after seeding.

Production of designer mabe pearls in the black-lipped pearl oyster, *Pinctada margaritifera*, and the winged pearl oyster, *Pteria penguin*, from Andaman and Nicobar Islands, India

Kripa V., Abraham K.J., Libini C.L. et al.

Source: Journal of the World Aquaculture Society 39(1):131137 (2008)

No Abstract.

Large-scale cryopreservation of Japanese pearl oyster *Pinctada fucata* martensii sperm

Aoki H, Komaru A, Narita T. et al.

Source: Nippon Suisan Gakkaishi 73(6) :1049–1056 (2008)

To develop methods for large-scale cryopreservation of Japanese pearl oyster spermatozoa, post-thaw motility and fertility of spermatozoa cryopreserved in straw and in a flat-bottomed aluminum cup were compared. Spermatozoa diluted 1:19 with an extender comprising 10% methanol, 72% seawater, and 18% fetal bovine serum were placed in the straw (0.25, 1.0, and 2.0 mL and in the cup (10 mL. The vessels were then cooled in LN vapor to -50°C at a cooling rate of - 17.6 to -20.6°C/min, and immersed in LN. The percentages of motility of spermatozoa cryopreserved in 0.25 mL, 1.0 mL, 2 mL straws, and the cup were 35.2%, 31.1%, 23.2%, and 31.8 %, respectively, of the pre-cryopreserved spermatozoa. When 100 µL of semen (pre-cryopreserved or cryopreserved in the 3 kinds of straw) was introduced to 2.5 million eggs, the percentages of fertility were invariably high, but not significantly different from one another. When fresh spermatozoa with low motility were cryopreserved, thawed, and then introduced to eggs, the percentage of fertility increased in a time-dependent fashion, until 20 min after the commencement of insemination. There were no harmful effects on growth and feed intake ability of pearl oyster larvae when the contact time of gametes at fertilization had been prolonged from 5 min to 60 min.

Changes in the use of the pearl oyster *Pinctada mazatlanica* (Bivalvia : Pteriidae) in the Great Temple of Tenochtitlan

Velazquez A., Zuniga-Arellano B., Sanchez-Gavito J.J.T.

Source: Revista Mexicana de Biodiversidad78:71–76 (2008)

The nacreous shell of the tropical Pacific mollusc *Pinctada mazatlanica* was widely used by the ancient inhabitants of Mexico. Around 600 pieces made of this shell have been found in offerings buried in the Great Temple of Tenochtitlan. Most of these objects come from the IVth construction stage (1440-1481), prior to the conquest of the Pacific Coast by the Aztecs. It was previously thought that the considerably smaller numbers found in the following stages were due to the greater degree of destruction suffered by the temple. Nevertheless, the almost complete absence of this material in nine offerings found recently corresponding to the VIIth construction stage (1502-1521), raise other possibilities. In this work two different hypotheses are presented to explain this observation.

Population genetics of a marine bivalve, *Pinctada maxima*, throughout the Indo-Australian Archipelago shows differentiation and decreased diversity at range limits

Lind C.E., Evans B.S., Taylor J.J.U. et al.

Source: Molecular Ecology16:5193–5203 (2008)

Intraspecific genetic diversity governs the potential of species to prevail in the face of environmental or ecological challenges; therefore, its protection is critical. The Indo-Australian Archipelago (IAA) is a significant reservoir of the world's marine biodiversity and a region of high conservation priority. Yet, despite indications that the IAA may harbour greater intraspecific variation, multiple-locus genetic diversity data are limited. We investigated microsatellite DNA variation in *Pinctada maxima* populations from the IAA to elucidate potential factors influencing levels of genetic diversity in the region. Results indicate that genetic diversity decreases as the geographical distance away from central Indonesia increases, and that populations located towards the centre of *P. maxima*'s range are more genetically diverse than those located peripherally ($P < 0.01$). Significant partitioning of genetic variation was identified (F-ST = 0.027; R-ST = 0.023, $P < 0.001$) and indicates that historical biogeographical episodes or oceanographic factors have shaped present population genetic structure. We propose that the genetic diversity peak in P. maxima populations may be due to (i) an abundance of suitable habitat within the IAA, meaning larger, more temporally stable populations can be maintained and are less likely to encounter genetic bottlenecks; and/or (ii) the close proximity of biogeographical barriers around central Indonesia results in increased genetic diversity in the region because of admixture of genetically divergent populations. We encourage further genetic diversity studies of IAA marine biota to confirm whether this region has a significant role in maintaining intraspecific diversity, which will greatly assist the planning and efficacy of future conservation efforts.

Social monogamy in the shrimp *Pontonia margarita*, a symbiont of *Pinctada mazatlanica*, off the Pacific coast of Panama

Baeza J.A.

Source: Marine Biology153:387–395 (2008)

A previous study predicted the evolution of monogamy in symbiotic crustaceans inhabiting scarce, relatively small hosts in tropical environments where predation risk away from hosts is high. This prediction was tested in the shrimp *Pontonia margarita*, which inhabits the pearl oyster *Pinctada mazatlanica*. A total of 68 oysters were collected from the intertidal and shallow subtidal at two islands (Islas Secas [N 27°55′, W 82°03′] and Isla de La Coiba [N 27°50′, W 97°03′]) off the eastern tropical Pacific coast on 15 and 17 March 2007, respectively. The population structure, distribution, male-female association pattern, and relative growth of the major claw and pleura of the second abdominal segment of each shrimp retrieved were examined. Shrimps were found as heterosexual pairs in the mantle cavity of hosts more frequently than would be expected by chance alone. Males occurred with females in the same host, independent of the reproductive condition of the female or the stage of development of brooded embryos. This observation, and strong correlations between the host and shrimp body size in both males and females suggest a long-term association between males and females in each host. Sexual dimorphism in body size was minor, with males being just slightly smaller than females. In agreement with predictions for monogamous species, the major claw of males did not display positive allometry, which has been generally reported for polygamous shrimps. In turn, the pleura of the second abdomen presented negative allometry in males but positive allometry in females. All available information suggests that *Pontonia margarita* has a socially monogamous mating system with males and females forming exclusive pairs in their hosts.

Original text: English

Secretariat of the Pacific Community, Marine Resources Division, Information Section
BP D5, 98848 Noumea Cedex, New Caledonia
Telephone: +687 262000; Fax: +687 263818; cfpinfo@spc.int; http://www.spc.int/coastfish