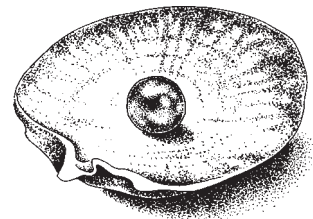




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PEARL OYSTER

INFORMATION BULLETIN

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NOTE FROM THE EDITOR

Each issue of the *Pearl Oyster Information Bulletin* usually has an underlying theme or two – a topical issue, perhaps, or a specific area of focus. This might be either by design or by coincidence, but it makes it a fairly simple task to encapsulate the salient articles of the issue in a brief introduction.

This issue is different in that there is no chorus, there is just a cacophony of clamouring voices: dissonant, dissenting, bordering on downright contrariness.

The pendulum swings in the pearl market articles in this issue are typical. The South Sea pearl prices seemed at first to be falling, resulting in stronger demand, yet the opposite was happening with the Akoya pearl market. Another article three months later pointed to better production and improved sales all over, with an end to the recession-dominated market.

Several other articles present similarly contradictory perspectives on industry development and long-term stability. New opportunities appear to be opening up, with hatchery successes with the black-lip pearl oyster in Hawaii, and research and developments planned or under way in Mexico and Venezuela.

A couple of other articles sound a more cautionary note. There is the ominous news from the St Louis symposium on freshwater mussels last October. The future for the mussel fishery looks grim, yet no-one can even begin to guess how a reduced supply of beads will impact the pearl culture industry. (cont. page 2)

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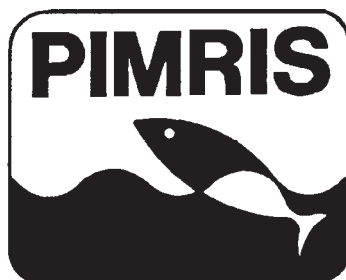
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PIMRIS is a joint project of 4 international organisations concerned with fisheries and marine resource development in the Pacific Islands region. The project is executed by the South Pacific Commission (SPC), the South Pacific Forum Fisheries Agency (FFA), the University of the South Pacific's Pacific Information Centre (USP-PIC), and the South Pacific Applied Geoscience Commission (SOPAC). Funding is provided by the International Centre for Ocean Development (ICOD) and the Government of France. This bulletin is produced by SPC as part of its



Pacific Islands Marine Resources Information System

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.

Pearl culture is highlighted as Australia's leading aquaculture industry in one article, yet another perspective suggests that the Australian industry may be due for a vigorous shake-out, with expanded hatchery production of *P. maxima* and growing competition from the new culture areas in South-East Asia. And almost inevitably, as if to complete the picture, another article yet again raises the spectre of artificial pearl production – only this time the bogeymen are biotechnology's bold new gene-splicers, rather than the old adversaries from the plastics industry.

These widely contrasting perspectives and wildly differing scenarios underline the obvious message that the industry is undergoing a dramatic restructuring. The traditional areas of pearl production are meeting more competition, from new countries and new island groups with unsullied resources, cheaper production costs or better market access.

Increased access to pearl culture technology and wider availability of hatchery methods will mean increasingly rapid growth. This will produce changes in the areas where pearl farming is feasible, in the availability of beads and the technicians to seed them, and in the established avenues by which pearls are graded and sold. The industry restructuring could mean either a massive slump is imminent, or a resounding boom is about to occur. There are two things that reinforce my optimism. These might be worth remembering as you sort

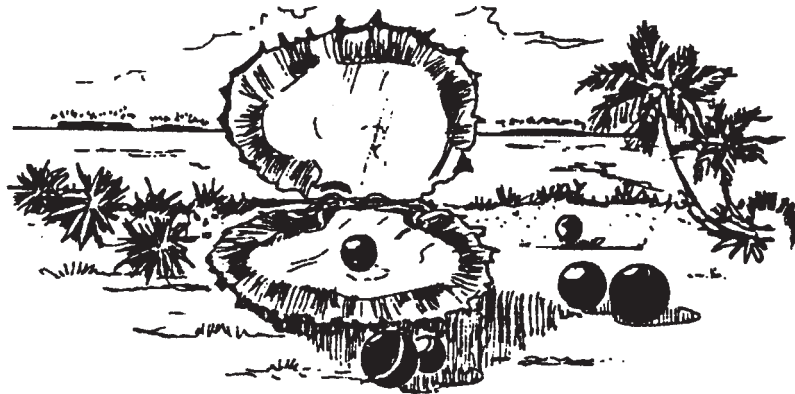
your way through the melange of this issue. The first is to dig right back to *Pearl Oyster Information Bulletin* #2, to Seamus McElroy's article on the pearl market – still the only serious market study on South Pacific pearls to be published. 'Some producers believe the acceptability of black pearls on the market depends on an annual output of at least 1,000 kg jewellery-grade pearls per year being attained.' (p. 7).

According to McElroy, the market was constrained by a lack of consumer awareness about the product. Martin Coeroli points out in this issue (p. 7) that French Polynesian production has already reached this level, but that prices are still falling. These markets shifts should begin to show some benefits soon, as the world moves out of recession. South Pacific pearls may then be somewhat less expensive, but this will make them affordable to a wider market. There may also be more black pearls out there, but this should increase the market awareness.

The second thing you might want to do is to pick up a fashion magazine or similar fashionable rag the next time you are in the dentist's or doctor's waiting room. As you thumb through it, count the number of full-page glossy advertisements for De Beers and their diamonds. At the same time, count the number of advertisements for pearls. Then think about how much room there is yet to grow.

Neil A. Sims

NEWS FROM MEMBERS



The need for protocols for the transfer of pearl oysters throughout the Pacific: adding weight to the arguments for care and consideration

*by Neil A. Sims
Black Pearls, Inc.
Kona, Hawaii*

With the gathering momentum of pearl culture development across the Pacific, and the wider availability of hatchery culture techniques, there is increasing interest in transferring pearl oysters to new culture areas.

This option may appear to be commercially attractive, but history suggests that careful consideration is needed: the long-term detriments often far outweigh any short-term benefits. This has been repeatedly demonstrated for introductions of bivalves and other marine species around the world, with diseases or parasites from introduced stocks often

decimating local species, or with hybridisation or genetic blurring of local varieties (Sindermann, 1986).

Cultured pearl oysters are particularly vulnerable to diseases, and the causative agents are usually not identifiable.

It is therefore virtually impossible to guarantee that introduced stocks are 'disease-free'. Even pearl oyster movements within island groups or areas can result in disease problems: e.g. shipments of *P. maxima* within N.W. Australia (Dybdahl & Pass, 1985) and transfer of *P. margaritifera* spat between islands in French Polynesia (Cabral, 1989).

There is accumulating evidence that there are genetically discrete stocks of bivalves across the Pacific (Benzie & Williams, in press). This is significant for pearl culturists: as hatchery methods become more widely available, cross-breeding experiments might well produce faster-growing, better coloured, deeper-valved or more disease-resistant strains. The potential gains from cross-breeding would be seriously impaired if the different populations of pearl oysters became melded into one genetic gumbo.

In addressing these issues, it is worth considering the codes of practice employed for similar tropical bivalves. The pearl culture community should take note of the protocols established by the giant clam culture fraternity. Excerpts from two recent initiatives by the ACIAR and ICLARM Giant Clam Projects are presented below: a working paper

presented to the 1991 SPC Regional Technical Meeting on Fisheries, and a report from the 1992 Giant Clam Genetics Workshop, held in Manila.

Despite our own best intentions, some of us are still faced with political pressures or arguments of economic expediency. In presenting the case for care and caution in pearl oyster transfers, these protocols are a useful reference. They are also a good starting point for discussion. It could well suit the Pacific pearl industry's long-term interests to adopt similar protocols.

References

- Benzie, J.A.H. & S.T. Williams. (in press). Endangered giant clam (*Tridacna gigas*) populations in the Pacific are genetically different.
- Cabral, P. (1989). Some aspects of the abnormal mortalities of the pearl oysters, *Pinctada margaritifera* L. in the Tuamotu Archipelago (French Polynesia). Advances in Tropical Aquaculture: Tahiti, Feb. 20 – March 4, 1989. AQUACOP. IFREMER. *Actes de Colloque* 9: 217–226.
- Dybdahl, R. & D.A. Pass. (1985). An investigation of mortality of the pearl oyster, *Pinctada maxima*, in Western Australia. Fisheries Department of Western Australia Report No. 71. Fisheries Department, Perth. 78 p.
- Sindermann, C.J. (1986). Strategies for reducing risks from introductions of aquatic organisms: a marine perspective. *Fisheries*, 11 (2): 10–15.

Consideration related to the transfer of biological material from aquaculture facilities

Source: South Pacific Commission
23rd Regional Technical Meeting on Fisheries
Working Paper #13

Issues arising from the ACIAR Giant Clam Project Leaders Meeting February 1991

At a recent (February 1991) meeting of project leaders from the ACIAR Giant Clam Project, at which five Pacific Island countries (Fiji, Tonga, Tuvalu, Kiribati, Cook Islands) were represented, a number of issues and concerns related to the transfer of giant clams were discussed.

During this exchange, several regional initiatives were suggested that called for the specific involvement of the South Pacific Commission or which required the broader consideration of all Pacific Island countries. The South Pacific Commission has graciously consented to the introduction of these proposals to the RTMF for consideration and possible action.

1. Update of the RTMF interim guidelines for the introduction and translocation of giant clams

In 1985, within a broad-ranging discussion of recent developments in pearl culture and the then embryonic giant clam mariculture in the Pacific Islands, the 17th RTMF considered at some length the potential hazards associated with the introduction and translocation of exotic species.

It was broadly agreed that there was a clear need for more detailed examination of the subject, covering both the disease and genetic impact aspects of such transfers, with a view to developing appropriate protocols to transfers of all aquatic biological

material within the Pacific Islands region. The meeting confined discussion to the transfer of adult and juvenile giant clams, and agreed on interim guidelines recommended for adoption by SPC member countries.

Since that time, the technical feasibility of clam mariculture has been effectively demonstrated and the potential for village-level clam culture is now under active investigation in many Pacific Island countries and in the Philippines. As a result, large numbers of live clams, predominantly settling larvae or early juveniles, are routinely shipped between countries in support of culture or stock replenishment programmes.

The 1985 RTMF guidelines have played a very useful role over the last six years but it would now seem appropriate to re-examine the suggested procedures and perhaps reshape them in the light of the knowledge and experience accumulated over this period.

To assist this process, the original guidelines are presented below together with comments and suggested changes where appropriate for consideration and possible adoption by the meeting. These comments reflect the broad group experience of collaborating institutions and partner countries within the ACIAR Giant Clam project.

RTMF interim guidelines for the introduction and translocation of giant clams

- (i) *No species of clam should be introduced to areas outside its known recent distributional range.*

Comments: This restriction has been widely ignored. While there is as yet no evidence of any adverse environmental or biological effects resulting from past translocations of giant clams, it should be recognised that each introduction has implications for any subsequent introductions, either of possible genetically superior strains or individuals that are disease- and parasite-free.

- (ii) *Where transfers are to be effected within the natural range of a species, the spat should be reared in seawater filtered to one micron and be maintained in ultra-filtered, recirculating, ultra-violet irradiated seawater in the four weeks preceding the transfer.*

Comments: Under these conditions clams lose condition. Supplementary feeding and nutrient additions for larvae and small clams in ultra-filtered recirculating seawater are essential.

- (iii) *Giant clams should be transferred at the earliest possible stage in their life history.*

Comments: Clams are now routinely distributed as late settling larvae (pediveligers) or early juveniles of a few months old, greatly reducing the risk of accidental introduction of disease and parasites.

- (iv) *The receiving institution should maintain the spat or seed in quarantine tanks or raceways, preferably supplied with filtered seawater, for at least six months. The overflow water from the tanks or raceways must flow to waste in to a septic tank or other in-ground sump and must not be drained back into the sea.*

Comments: This isolation procedure remains imperative and is applicable to introductions of all marine organisms. Recent observations suggest that for clams at least three months may be a sufficient quarantine period for known parasites and disease to become evident.

- (v) *In the event that during the quarantine period any disease, parasites or predators appear in the introduced stock, the stock should be destroyed by boiling, all equipment sterilised and a fresh start made.*

Comments: This is a standard quarantine procedure.

- (vi) *The country exporting the clam seed or spat should accept the responsibility of ensuring that the above-mentioned guidelines are adhered to and undertake to issue a certificate to that effect.*

Comments: This is not a national function. The hatchery or institute concerned must take full responsibility for health certification of clams exported from their facility. A formal certificate of health should accompany shipment of clam seed or spat.

2. Regional translocation register and disease [information] clearinghouse role for SPC

It was proposed that a centralised regional register to document all transfers and introductions of marine and freshwater organisms into and between countries in the Pacific would provide a valuable database.

It was further suggested that the South Pacific Commission could play a key role in:

- providing a clearinghouse for information and advice related to disease outbreaks and reports in cultured animals; and
- taking a leadership role in establishing appropriate quarantine protocols.

3. Further action

With interest in mariculture spreading rapidly within the region and an increasing range of

organisms under culture or targeted for future investigation, the need to examine the broader biological and ecological issues associated with the introduction of exotic species is becoming more urgent. Consideration of this topic with a view to developing appropriate translocation protocols relevant to all aquatic organisms may be a useful agenda item for a future RTMF gathering.

Giant clam genetics workshop

*Source: Clamlines
(Number 11, December 1992)*

The giant clam genetics workshop held in Manila in June 1992 was attended by scientists participating in the Giant Clam Research Group of the ICLARM Coastal Aquaculture Network. Additionally there were geneticists from Canada and Australia and members of ICLARM's headquarters staff. Funding was provided by ACIAR, IDRC, ICOD, ODA and ICLARM. The genetic issues which cultivation and translocation of giant clams raise were discussed, and the application of genetics to farming systems for molluscs was considered.

It has been recognised for some time that although giant clams are found throughout the Pacific, they should not be moved around the region without adequate quarantine precautions and some thought for the genetic consequences (Munro et al., 1985).

The recent work of Benzie's group at AIMS (Benzie & Williams, in press) shows that there is fundamental genetic structuring of giant clam stocks in the Pacific. The impact of cultured stocks on wild populations which are genetically distinct needs to be considered, and the existing wild stocks need to be evaluated before they are irreversibly changed by mariculture.

For the hard-headed giant clam entrepreneurs there was good news from the breeders who pronounced it easy to produce a 'superclam', given a founder stock of wide genetic variation and time. The hard part is to avoid damage to the wild populations.

Participants at the conference were anxious to avoid the mistakes made in developed countries in setting up aquaculture and fisheries industries, and to become aware of the pitfalls in supportive breeding programmes.

There was a consensus that as giant clam farming is in its infancy, a unique opportunity exists to 'do the right thing'. Where there are still good local stocks

of tridacnids, these may well be swamped by hatchery-produced clams, which may or may not possess the genes to resist endemic but episodic disease. Farmers cannot afford to forego the opportunities presented by improved breeds, so there may be a conflict of interests: the conservation of genetic diversity versus improved production.

In some places giant clams are extinct or nearly so, due to the ease with which they are harvested and their traditional importance for Pacific peoples. The various strategies and problems in re-establishment of stocks were discussed.

The presence of symbiotic algae, which are acquired from the environment by the larvae of tridacnids, is a complicating and interesting factor in their genetic constitution. These algae are important in themselves as the extraordinary productivity of coral reefs is thought to be due largely to them, and the giant clam provides a good vehicle to study them.

Given the awareness of the issues which this workshop clearly demonstrated and fostered, what is now needed is the patience and finance to monitor carefully the condition and transfers of stocks, and their genetic fitness.

Genetic markers and sterile releases are two expensive but worthwhile lines of investigation to follow urgently. Co-operation between the various groups growing giant clams in the Pacific is excellent and essential for the further development of giant clam farming.

Two sets of guidelines were drawn up by working groups and discussed at the final plenary session of the workshop, one set dealing with practices based on sound genetic principles for hatchery managers, and the other dealing with the genetic implications of translocations.

1. Guidelines for hatchery managers on sound genetic practices for cultivation of giant clams

- a. Present hatchery procedures, e.g. grading (up to about six months of age) within batches, use of antibiotics, fertilizers, feeds etc., probably do not affect genetic variance. As in other bivalve species, the quality of the eggs is probably a paramount factor in initial growth performance. Care should be taken however not to reduce the diversity of the gene pool when broodstock replenishment is done, and as many different parents as possible should be used to produce the F1 generation.
- b. Clear records of spawning regarding parentage should be kept, and these records should be standardised. Traits of economic importance (e.g. growth rates) should be recorded, and a database should be developed and maintained.
- c. Some individuals from each successful spawning should be maintained. Representatives from as many batches as possible, each from as many parents as possible, should be maintained in each hatchery.
- d. The terminology used in giant clam cultivation (e.g. batch, cohort, family, etc.) should be standardised, and advice from the ICES Working Groups on Genetics Mariculture Committee is being sought. (In the meantime, 'line' should be avoided as this term has a very specific meaning in breeding terminology.)

2. Guidelines to be adopted for translocations

For all that follows it is assumed all translocations are subject to standard environmental and quarantine procedures.

- a. It is strongly recommended that a code of practice be developed to standardise environmental and aquaculture procedures.
- b. Transfers for re-establishment should be accompanied by detailed records of source, constitution, parentage (including identity numbers) disposition, and destination, and these records should be maintained in a central database. ICLARM would be a suitable place for the database to be kept, and databases maintained at various hatcheries should be compatible.
- c. Introduction of exotic species should only be effected when all necessary precautions have been undertaken and in accordance with accepted international protocols.

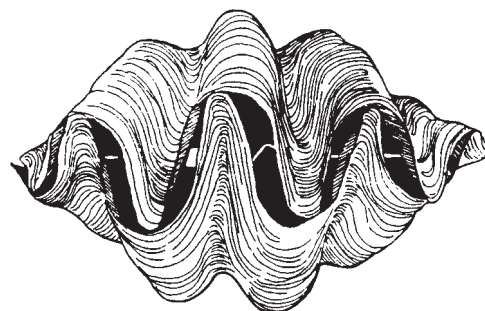
- d. Where translocations are effected to depleted areas, all relic stocks should be tagged and identified, and where possible reproduced to maintain their genetic identity.
- e. International introductions of conspecifics to areas with abundant wild stocks should be discouraged.
- f. For the purpose of re-establishing a stock, the largest genetic diversity should be sought. Successive cohorts imported from a given source should be small and derived from different parents on each occasion.

The proceedings of the workshop will be published early in 1993, and will consist of discussion papers presented by John Benzie (AIMS), Gary Newkirk (Dalhousie University), John Munro (ICLARM), Mark Gervis (ICLARM), and Julie Macaranas (Queensland University of Technology, formerly of UPMSI), subsequent discussions at the workshop, and a series of country papers presented by delegates from the Philippines, Australia, Solomon Islands, the Federated States of Micronesia, Palau, and Fiji. Unfortunately participants from Tonga and the Cook Islands were unable to be present.

The publication of these proceedings will be financed by ACIAR and IDRC.

References

- Benzie, J.A.H. & S.T. Williams. (in press). Endangered giant clam (*Tridacna gigas*) populations in the Pacific are genetically different.
- Munro, J.L., J. Lucas, A. Alcalá, E.D. Gomez, A.D. Lewis & J.C. Pernetta (1985). Considerations regarding the introduction or transfer of tridacnid clams. Working Paper 17, 2 p. South Pacific Commission Seventeenth Regional Technical Meeting on Fisheries, New Caledonia, August 1985.



The cultivated pearl market in Tahiti

by Martin Coeroli
EVAAM
Tahiti, French Polynesia

The cultivated pearl market in Tahiti has suffered a price decline of more than 38 per cent since 1991 (see table below), caused by internal and external factors in the Polynesian pearl culture sector.

Year	Weight exported (kg)	Value (million CFPs)	Average price (CFP/gr)
1990	575	3,731	6,490
1991	786	4,303	5,475
1992	1,069	4,194	3,925

Outside French Polynesia, two main factors can be identified as being responsible for current developments in marketing of pearls:

- the world recession which affects the principal clients for Tahitian cultivated pearls; and
- competition from Indonesian pearl producers.

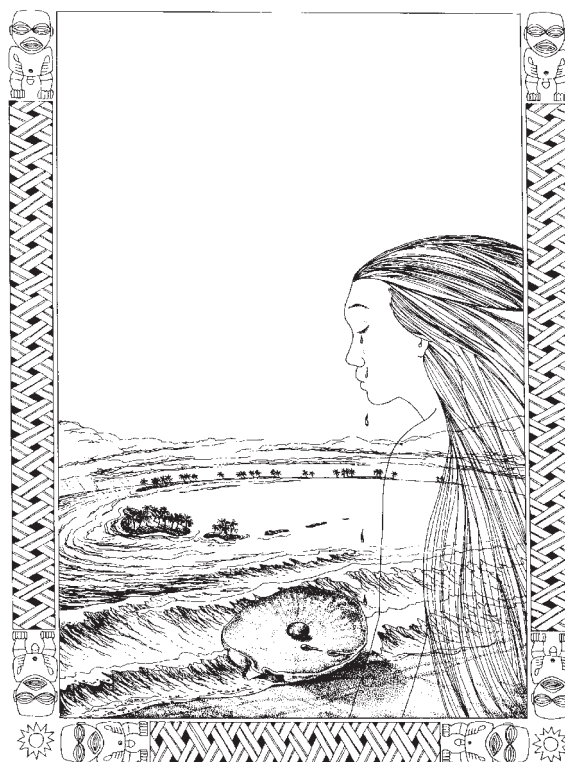
In French Polynesia, a very significant increase in production (more than 27 per cent over 2 years) and an increase in the number of producers have led to highly competitive pricing in a depressed external market.

This trend seems to be continuing in 1993, forcing Polynesian producers to consolidate and restructure in order to survive the pricing crisis.

Exports of Polynesian pearls seem to have reached the level of maturity on the classic curve of product life cycle as described by Dean.

Contrary to certain claims, it appears therefore that the annual production level of 1 tonne is not enough to encourage product acceptance at the best market price.

Indeed, the present situation shows that a maturity level has been reached where supply and demand cancel each other out and the price meets the break-even point of pearl producers.



Update on ICLARM Coastal Aquaculture Centre pearl culture trials

Source: ICLARM

Funding for Mark Gervis to undertake a short term preparatory study on pearl oyster cultivation was provided by the British ODA. The funding ran from November 1990 to March 1991 and resulted in the preparation of two publications, a bibliography and a review of the biology and culture of pearl oysters, the latter in co-authorship with N.A. Sims.

Preliminary spat collection trials were undertaken and showed that a very diverse array of species of pearl oysters are present in Solomon Islands.

Sixty *Pinctada maxima* broodstock were collected by staff of the Solomon Islands Fisheries Division and are being held on racks at the CAC's reef for use in future work.

Excerpt from ICLARM Coastal Aquaculture Centre's Annual Report

Successful hatchery culture of the Hawaiian blacklip pearl oyster

by Dr Dale Sarver and Neil A. Sims
Black Pearls, Inc.
Kona, Hawaii

Black Pearls, Inc. has reported some early successes with its hatchery trials with the Hawaiian variety of *P. margaritifera*. Larvae have been cultured through to settlement in each of three successive trials, with several thousand spat now in grow-out.

Refinements in the hatchery techniques have reduced the larval cycle to as few as 19 days post-fertilization. This is far less than has been reported for other *Pinctada* species, and might indicate an adaptive response to the shorter larval retention around the lagoonal reefs of the main Hawaiian islands. Some of these spat are now up to 6 mm shell diameter after only 1 month post-settlement.

We are now examining the feasibility of land-based grow-out at the OTEC facility here on the Kona Coast in Hawaii.

Further research is being carried out to determine the best conditions (densities, flow-rates, cleaning regimens, etc.) and feed levels for producing

optimal growth and nacre quality. We are also looking at opportunities for ocean-based grow-out in Hawaii and other island groups using hatchery-produced spat.

Black Pearls, Inc. has been awarded two R & D grants to further its work. The first grant, from the National Science Foundation, provides for the refinement of hatchery methods and evaluation of the feasibility of a commercial-scale hatchery.

A further grant, from the National Oceanic and Atmospheric Administration, will fund expansion of earlier spat-collector trials and pearl oyster grow-out work at Namdrik Atoll in the Marshall Islands.

This project will conduct further pearl culture trials and establish a small demonstration facility (refer to POIB #4, p. 10), with the aim of fostering the growth of small-scale black pearl farms on Namdrik and other atolls throughout the Marshall Islands.

Stock assessment, spat collector and pearl culture trials in the Gulf of California, Mexico

by Dr Mario Monteforte,
Centro de Investigaciones Biologicas,
La Paz, Peru

Dr Mario Monteforte, of the Centro de Investigaciones Biologicas in La Paz, writes:

I am working with two local species of Pteriidae: *Pinctada mazatlanica*, the mother-of-pearl, and *Pteria sterna*, the nacreshell. This programme is being carried out, under my direction, in the Centro de Investigaciones Biologicas at La Paz, South Baja California, with grants provided by the International Foundation for Science (IFS, Sweden) and the National Council of Science and Technology (CONACYT, Mexico).

Our research mainly deals with the development of extensive culture technology aiming to produce cultured adults that are being used for grafting and nucleus implantings, and for the repopulation of natural beds in strategic sites. The programme involves both conservationist foresight and a productive alternative for regional socio-economic development.

So far, we have defined the scientific and technological pathway for the extensive culture of both species into a proportion approaching 100 per cent, from the seed (capture) to adults. Repopulation experiments have also been very successful and we

have recently started practical studies on pearl culture. We are using specialised surgical instruments acquired in India (a set just arrived a month ago) and nucleus manufactured by local artisans (shell beads from *Tivela stultuorum*, *Pinctada mazatlanica*, *Strombus galeatus* and marble).

We have built up our grafting methodology from very abundant information: publications (Japan, French Polynesia, Australia, India, China), some personal observations and practice in India and French Polynesia, photos, advice from surgeons and biochemists, etc. The first experiments on nucleus retention and post-surgery survival (we operated on 100 mother-of-pearl) have been fairly satisfactory.

However, I do not expect good results on pearl production from this experiment, because it was not the proper time for the operation.

The first large-scale implanting will be performed on cultured *Pinctada mazatlanica* by the end of October (the end of the reproductive cycle of this spe-

cies), and on cultured *Pteria sterna* next February or March (also the end of the reproductive cycle).

It has not been easy to arrive at this stage. There have been many previous studies on pearl oyster and pearl culture in South Baja California, but most of them have been unsuccessful, mainly because of the lack of bioecological information on the species and the application of imported culture techniques which were not suitable.

In this sense, I could say that our research is the first in 15 years to have yielded positive results concerning extensive culture and repopulation. The resource has undergone almost 400 years of unregulated fisheries and it has been under legal protection only since 1940. Many sites where once the pearl oysters were abundant are now exhausted. One of them is the area of Los Cabos.

However, in La Paz Bay, after more than 50 years of permanent protection the natural beds are recuperating, slowly and insufficiently, due to furtive

fisheries, but nevertheless noticeably. For the moment, it is however out of the question to rely on natural broodstock for fisheries or grafting; this is why the improvement of massive extensive culture techniques and the efficient repopulation of natural beds using cultured individuals are our main objectives.

The contact with scientists of the Pearl Oyster Special Interest Group would be valuable to us. We are also interested in the possibility of sending students abroad (Australia, Hawaii) to prepare their Masters, Ph.D., Postdoctoral research and/or training, on subjects related to pearl oyster, hatchery and pearl culture.

Moreover, if anyone is interested in developing particular research here in La Paz with *Pinctada* and *Pteria*, we would be delighted to provide all kinds of facilities.

(Ed: see also pp. 24–27 of this issue)

Company plans pearl culture trials in Venezuela

Source: Gary Kraidman
Margaronics Inc.
New Jersey, USA

Margaronics Incorporated, a privately held New Jersey corporation formed in 1986, plans to create a cultured pearl industry in Venezuela. Natural pearls were discovered by Christopher Columbus in 1498 during his third voyage near Venezuela. Margaronics will be the first company to develop cultured pearls from the native Venezuelan pearl oyster *Pinctada radiata*.

The mother-of-pearl layer (nacreous portion) of the Venezuelan pearl oyster is thick and displays iridescence (orient) above that seen in the shell of the Japanese variety.

The Venezuelan oyster is consumed solely for its food, and although there is a small natural pearl market, the mollusc faces extinction due to overfishing. A research foundation in Venezuela, near the natural pearl oyster banks, is currently doing paid service work for Margaronics Inc. to cover such topics as distribution, habitat, legal issues, and other matters.

The President of Margaronics, Gary Kraidman, has a Master of Science Degree in Biology and a pearl certificate from the Gemological Institute of America as well as an established track record in microbiology. Substantial publicity has been given to the pearl project both in the United States and overseas. A preliminary study for the basis of future

work was completed by the Venezuelan research foundation with positive conclusions.

Mr. Kraidman is a member of many scientific societies as well as the Venezuelan-American Association of the United States of America, Inc. He is planning his third visit to the pearl banks and the research foundation in late 1993 or early next year to begin the feasibility farming project.

A spherical or baroque Venezuelan cultured pearl could offer a high quality jewel. The market for high-quality pearls increases and our company believes that a Venezuelan cultured pearl could capture a significant portion of the market currently estimated at 1.5 billion dollars a year.

Margaronics Inc. hopes to focus on small spherical cultured saltwater pearls and hopefully can fill a market for high-lustre 5–6 mm pearls where there will be a continued shortage of supply. The pilot feasibility study, when funded, should focus on nucleating a *Pinctada radiata* with a 4.5mm bead nucleus so that a high-quality 5.5mm pearl can be produced with fine lustre and orient within two years of nucleation.

A recent expedition to the Venezuelan pearl banks undertaken by Margaronics Incorporated revealed sufficient pearl oysters to begin oyster farming in a

site also located near the banks. At this site the pearl oyster would be cultured in captivity for one year

with a co-study in nucleation or implantation to determine pearl production capability.

Calling mainland China

by *C. Dennis George Cairns, Australia*

C. Dennis George, of Cairns, Australia, writes:

The recent reference to China in *Pearl Oyster Bulletin* # 5 is appropriate. What about the Korean pearl, which is also of significance? I need a contact with mainland China (for historical/record purposes). Please, can you assist me? Many years back I had a contact but I lost it.

I am pleased with the initiative to preserve the 'grey' literature, as I have plenty of that. As my days are coming to an end, I would like to see better utilisation of my accumulated files/library/experiences and I feel they would be more effective if sold to someone who will appreciate them. Do you know anyone who could be interested?

Dissertation studies management of the Tuamotuan pearl culture industry

Source: *M. Rapaport Honolulu, Hawaii*

Moshe Rapaport, of the East-West Center and the University of Hawaii at Manoa, has recently completed his PhD dissertation, entitled Defending the Lagoons: Insider/Outsider Struggles over the Tuamotuan Pearl Industry. This dissertation is the product of five years of research at the University of Hawaii and the East-West Center. The fieldwork, conducted primarily on Takarua Atoll took place during 1990-91, at the height of a black pearl boom, and was sponsored by a Fulbright study abroad grant, an East-West Center scholarship, and a research contract from the Institute for the Promotion of Aquaculture and Maritime Activities (EVAAM), French Polynesia. An abstract of his thesis is given below.

Because of their natural stocks of black pearl oysters, Tuamotuan lagoons have attracted the covetous interests of external society since the early 19th century. Under the French colonial administration, land was individualised and lagoons were declared public domain. Island populations responded to these intrusions through hidden and open forms of resistance.

Nevertheless, pearl oyster stocks were over-exploited and became nearly extinct on many atolls.

By 1970, the mother-of-pearl industry had ended. It was replaced by a pearl farming industry, now pitting Tuamotuan populations against the Tahitian administration.

The struggle over land and sea resources parallels a deeper struggle over ideology and meaning. External administrations, entrepreneurs, and local populations have contrasting ideologies of rights and different conceptualisations of environment, society, and the nature of their interrelationships.

Notes on the Pearl Oyster (*Mutiara*) production in Maluku Province, Eastern Indonesia

by *Rick Braley, Nell Tetelepta and Bob Mosse Pattimura University Poka-Ambon, Maluku, Indonesia*

Pearl oyster farms make up the largest number of aquaculture businesses in the Maluku Province of eastern Indonesia. Here, suitable areas for culture are relatively distant from high density human populations.

The greatest concentration of farms is located in Maluku Tenggara (S.E. Maluku) – the Aru Islands, some in the Kei Islands and in the Tanimbar Islands.

The main farms are joint ventures with Japanese companies. The Indonesian-owned companies are new, small, and susceptible to any short- or long-term disasters.

The Provincial Government Fisheries Department (Dinas Perikanan – Ambon) produces annual statistical records for Maluku Province. The drop in production of whole shell in 1990 to about half the

production seen in 1989 (Figure 1a) may indicate that overharvest has occurred, particularly since the same production figure was also obtained in 1991, despite a considerable increase in the value of the shell between 1989 and 1990/1991. Pearl oyster beds have been quite heavily fished to supply mother-of-pearl for the implantation operation for most of the farms in Maluku Tenggara (and one hatchery/farm in Maluku Tengah. Loose pearl production has steadily increased since 1988 (Figure 1b). Although not included in Figure 1b, the half-pearl production was only recorded for 1987. There were 20 kg of half-pearls produced, valued at US\$ 540,000.

Major mortality of pearl oysters

A very serious mortality rate of stocks held in baskets hanging from rafts, as well as of new stocks collected from the wild, has plagued the industry in the Aru Islands since November 1992. It is estimated that 85-90 per cent of all stocks have succumbed to the unknown 'disease'. The *Pos Maluku* (newspaper) stated in mid-February that Rp 80,000,000 (2,000 Rp = 1 US\$) were lost by the combined pearl oyster businesses. Oysters which contract the unknown 'disease' look healthy, but within two or three days only a gaping shell with dead soft tissues remains.

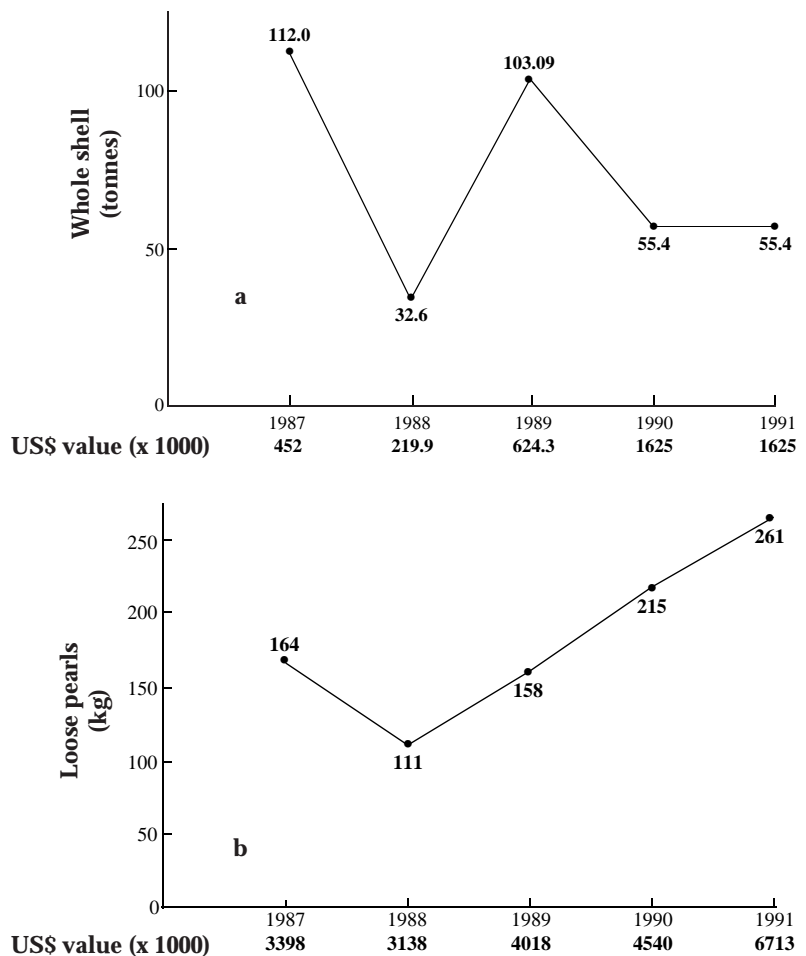
A similar mass mortality occurred at Aru farms about 40 years ago.

It was suggested to us that a certain farmer in Aru has not lost stocks of oysters like many other businesses and that he reputedly handles them better after harvest from the bottom. This would result in less stress on the oysters and perhaps these oysters could maintain resistance to the 'disease' especially if it were an opportunistic pathogen rather than a primary pathogen. Heavy rains at the end of the year and the resultant lowered surface salinity may have stressed oysters which were collected from deep water and held at the surface in a *parahu* (outrigger canoe) for up to several hours before being transported to the rafts for holding.

Diver deaths

Not only is the industry suffering from loss of product, but a quite serious mortality rate of divers occurs here in the Aru Islands. Many divers, though accustomed to deep snorkel dives, are taught to use scuba gear (although not to PADI or other standards) and coerced to dive to depths of 50-70 m up to five or more times per day. There were 18 deaths among divers in 1992 and 4 by the end of January 1993.

Figure 1: Pearl oyster production in Maluku Province, Indonesia 1987 - 1991; (a) Whole shell, (b) Loose pearls



Responses to the questionnaire

by Neil A. Sims
Black Pearls, Inc.
Kona, Hawaii

We received only 22 responses to the questionnaire appended to the last issue. While perhaps a little thin, those who did reply represented a fair cross-section of our mailing list.

The respondents ranged geographically from Vladivostok to New Zealand, and New Jersey to the Seychelles. More importantly, those who replied covered the diverse aspects of the industry, from librarians and taxonomists, to fisheries development officers, marketing folk and seeding technicians.

There were wide and varied suggestions for improvements to the *Pearl Oyster Information Bulletin*. Most of these focused on specific topics or areas of concern. The most common request was for more marketing research.

Please note the progress being made in this area at the 24th SPC Regional Technical Meeting on Fisheries, last August (report on page 31).

Many respondents also requested that the Pearl Oyster SIG facilitate manuals of basic farming methods and procedures for nucleation, either through illustrated manuals or in video format.

Other suggestions included :

- publications on pearl oyster diseases and treatments;
- descriptions and standardisation of grading methods;
- discussion of concerns for oyster biodiversity;
- broader environmental aspects of pearl oyster lagoons and pearl farming;
- evaluation of the social impacts and history of pearl culture developments; and
- aspects of pearl oysters relating to anthropology and archaeology.

Several respondents also commented on the South Pacific emphasis, and asked if an industry-wide perspective would be of more value to the readership.

There were some useful suggestions for inclusion to the format: an index to topics in earlier POIB issues, a more active letters section, English summaries of articles in French (and vice versa?), and 'Work wanted' or 'Job vacancy' listings. We will try to include an index soon.

The translation summaries are something we have long promised, but which await a window in the time of SPC translators. (*Note from J.P. Gaudechoux: there is a good chance that this issue will be translated some time this year*). The letters and job listings are simply a factor of what we receive: you send them, we'll print them.

Several of the respondents emphasised the need for more workshops, symposia, or other training opportunities in farming, seeding and pearl oyster studies. This is an obvious area for the Pearl Oyster Special Interest Group to play a more active role, and we have been examining ways to address some of these needs.

Unfortunately, the universal climate of budgetary belt-tightening and the cost of gathering folk from throughout the region (and beyond) have meant that we have not received any interest in support for a regional meeting.

The SPC Regional Technical Meeting on Fisheries has, at each of its recent annual meetings in Noumea, discussed pearl culture development issues. This at least provides a forum for examining the major opportunities and constraints to development within the region.

While there are some opportunities for *ad hoc* study tours, these are often dependent on the ability of the individual(s) to raise the necessary funds and make the contacts themselves.

For a one-on-one, on-the-job-training exercise, a prolonged visit to a farm is usually needed. This is a considerable burden to place on the already busy schedule of a farm, when there are few reciprocal benefits.

Nevertheless, the expressed need for more training and workshops places the Pearl Oyster Special Interest Group in a better position to pursue whatever avenues may be available.

We will keep you informed of any developments. We would also welcome any suggestions or comments from other members on how we might best address these needs.

Judging from the responses, the *Pearl Oyster Information Bulletin* appears to be achieving its broader goals of getting the industry's diffuse information out to those who need it.

The only complaint was from a respondent from the scientific community, expressing some dissatisfaction with the level of commercial involvement. Of all the questionnaire replies, however, 50 per cent were from those interested in pearl oysters as a scientific or academic pursuit.

The other 50 per cent were interested in more applied work, either as direct commercial ventures, or fisheries development, demonstration projects, or other quasi-commercial enterprises.

Predictably enough, only one of the 'scientific/academic group' expressed an interest in a broader

industry directory of people, services and supplies, whereas all but one of the replies from the 'applied group' saw the need for such a publication.

If we are indeed fostering an interactive information-sharing network, then perhaps we might have expected a few more responses to the questionnaire. But then, as any public official could tell you, folk usually only write when they have something they wish to gripe about – part of the 'If it ain't broke ...' syndrome.

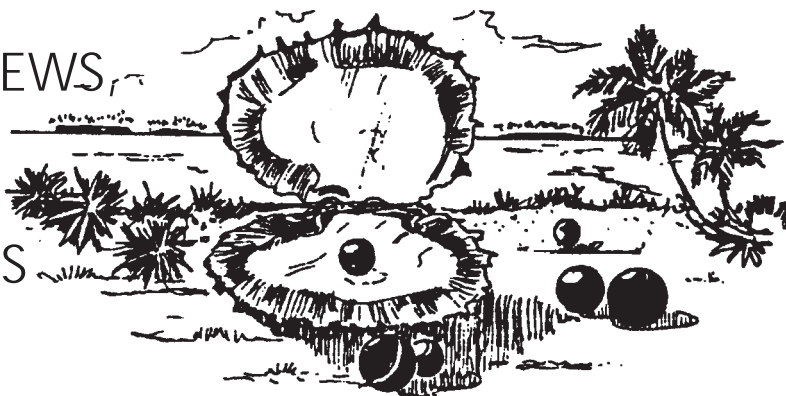
The sparse response may therefore simply be a measure of the satisfaction of the members with the way that the *Pearl Oyster Information Bulletin* is fulfilling their needs. As one respondent effused, 'You seem to be covering nearly everything already!'

We can but hope so. If you have any other suggestions or comments on how we might improve, or where else we might assist, then let us know. You don't always need an anonymous questionnaire format, do you?



PEARL OYSTER NEWS

RECENT ARTICLES, AND REVIEWS



1992: South Sea pearls fall, stimulating demand

by Russell Shor and Hedda Schupak

Excerpt from an article by Russell Shor and Hedda Schupak, entitled Prices rise, demand slows, published in the Jewelers' Circular-Keystone, October 1992, p. 56.

Supplies are tight and prices up for smaller cultured pearls, narrowing the gap between these and the now more plentiful larger goods. But quality has improved, so you may get more for your money.

Prices for larger akoya pearls are firm across the board, despite generally slow demand from the US, Japan and most other world markets, say dealers. In the market for South Sea pearls, dealers hope falling prices will stimulate demand in the US. 'There's a lot more interest, especially for South Sea pearls mounted into jewellery, now that they are more accessible,' says Albert Asher of New York City. Still, he adds, fine-quality goods are scarce.

Strategies

Lower demand and higher prices run counter to basic economic law, but dealers cite two reasons:

- Cash-flush Japanese pearl brokers can afford to sit on huge stocks until the market improves;
- The value of the US dollar is declining.

On the first point, 'The Japanese are very inflexible on prices,' says Freddie Kohn, an importer in New York City. Because they made very good profits in the mid- and late 1980s, he says, they can afford to stockpile goods until demand improves.

Kohn likens the situation to De Beers. 'Their strategy of stockpiling instead of selling helps keep prices and markets stable,' he says. 'I think that's a good thing in the long run.'

Another reason the Japanese won't budge on price is an increase in their cost of doing business. 'They

pay a lot more for labour and leasing their land – especially since the Japanese real estate boom,' says Richard Reuter of Leys Christie, New York City.

'In addition, they've had to suffer through poor weather that reduced the pearl crops.'

Ray Mastoloni of Frank Mastoloni & Sons, New York City, adds a different perspective. 'It's true the Japanese are asking the same prices as last year,' he says. 'But the crop is generally better quality than last year, so you are getting a better pearl for the same money.'

On the second point, the US dollar has declined about 7 per cent against the Japanese yen in the past year. This means US dealers have to pay at least 7 per cent more, even if all else remains equal. Dealers say they are inclined to absorb some of this increase in better quality pearls.

Complicating the matter is the yen's big decline against most European currencies, says Reuter. 'Akoya pearls are cheaper in Europe than they have been in a while,' he says. 'That may stimulate demand there in the near future.'

Speculation on crop

The current akoya crop had been the subject of speculation earlier this year because it was very late coming to market.

But Reuter says there was no mystery: 'The pearls are better quality because they are leaving them in the water longer. They are more thickly cultivated and, frankly, we think that's a good thing.' Dealers interviewed for this article don't foresee a significant upturn in pearl sales this year, but there's no sense of crisis.

'Business is slow, dull or however you want to describe it,' says Mastoloni. 'But it's not a disaster. Pearls are still a staple and there's still business, especially in the higher end where people still have money.'

1993: market is coming out of the recession

by Russell Shor

Excerpt from an article by Russell Shor, entitled 1993 pearl market: better for oysters and dealers, published in the Jewelers' Circular-Keystone, January 1993, p. 105.

Last year was terrible for oysters and not too great for pearl dealers, either. A devastating red tide in Ago Bay wiped out about a third of the molluscs that produce most of Japan's smaller akoya pearls. And pearl dealers like others, struggled with the US and Japanese recessions.

This year should bring improvements on both fronts. The Ago Bay farms will take several years to recover, but there's an ample supply of larger (7mm-plus) akoyas and demand should grow as the US economy improves.

First the bad news.

The government of the Mie prefecture in Japan reported in September that a red tide – caused by dead plankton and other ocean life – drifted into Ago Bay, wiping out six large co-operative pearl farms and decimating others. Pearls oysters, which feed on live plankton, died from starvation and pollution. Mie produces about 25 per cent of Japan's total pearl crop by volume and a much larger percentage of akoyas under 7 mm.

The government helped farmers to restock their beds, but reports say it's unlikely they'll be in production by harvest time in April. Thus, quality, high-lustre pearls under 7 mm will be very hard to get, says Jesse August of August Gems, New York, N.Y.

Dealers say farms in the warmer waters of Kyushu also produce smaller goods, but these aren't as high-lustre. Chinese akoyas have also begun to filter into the market, but their quality is generally poor. (Some dealers suspect that Japanese dealers are buying the best Chinese goods and mixing them with their own or simply keeping them off the market.)

Such shortages usually bring higher prices, but this year there are abundant supplies and stable prices.

Distributors in Japan are sitting on supplies until demand improves,' says Avi Raz of A & Z Pearls, Los Angeles.

Meanwhile, supplies of South Sea pearls are way up and prices for the best material are way down. Dealers blame the steep decline (up to 50 per cent for the best qualities under 15 mm) on unrealistically inflated prices during the 1980s when the Japanese 'prosperity bubble' fuelled the market.

While traditional producers such as Tahiti and Burma have seen static or even declining production, especially of 15 mm-plus goods, others such as Australia and the Cook Islands have more than taken up the slack. 'Australia produces black pearls with the best of them now,' says Armand Asher of Asher South Seas Pearl Co., New York, N.Y.

Asher and his colleagues stated that growing interest in South Sea pearls worldwide should keep prices from dropping lower.

Rising demand

Overall demand for pearls of all types will probably rise this year because the US economy is beginning to recover and Hong Kong and other Asian markets continue to grow.

In the US the psychological boost following the presidential election will continue into a genuine, if cautious, recovery this year, say dealers. 'The recession remains a factor,' says Rick Reuter, president of Leys Christie, New York, N.Y. 'But the demand for better quality pearls has been increasing as a percentage of sales since the late 1980s.'

The biggest question mark in pearl demand is Japan. 'The demand is there, but now it's for medium and commercial quality akoyas,' says Jesse August. 'Consumer confidence is still relatively strong there because CEOs of big companies cut

their own pay before they start discharging workers. This makes people feel more secure.'

Still Japan's struggle with recession is expected to hamper sales of pearls – especially South Sea goods – through most of this year.

The high-end market got a big boost in October when Sotheby's auctioned a South Seas pearl necklace for a record US\$ 2.1 million, says Asher. 'It's a great harbinger for the year because it showed

demand is solid and people will pay high prices for quality goods.'

Dealers once feared consumers were becoming sated with pearls, but they now blame it on recession jitters. Pearls are safe 'as long as people want to dress up,' says Reuter.

'Not everyone has a pearl necklace, and millions of girls graduate from school each year, they'll all be in the market for pearls at some point.'

Pearl culture is Australia's leading aquaculture industry

by David O'Sullivan

Excerpt from an article by David O'Sullivan, entitled *Aquaculture in Australia*, published in *Aquaculture Magazine*, July–August 1992, pp. 32–47, and September–October 1992, pp. 40–47.

Pearl culture is Australia's most valuable aquaculture industry with sales of cultured pearls, half pearls and mother-of-pearl shell being worth A\$94.5 million in 1989–90.

More than 30 operations were farming pearl oysters. The majority of production was the 'silverlip' or 'goldenlip' (*Pinctada maxima*) in Western Australia but cultivation was also under way in the Northern Territory and Queensland. Other important species included *P. margaritifera* and *Pteria penguin*.

Production difficulties included under-capitalisation, reliance on Japanese technicians, and the need for a reliable supply of shell. The fact that the industry was under the joint control of Federal and State Governments meant that changes to regulations were not simple to implement.

While the best-regarded pearl is spherical in shape, the majority of cultured pearls were not round. Most of the pearls were exported to Japan where they satisfy about 30 per cent of the market. Prices varied with quality but were approximately A\$40–45 per gram. Half-pearls were marketed independently and may be valued between A\$5 and A\$50 per piece, depending on size and quality.

Mother-of-pearl shell which had not produced half pearls was sold on a weight basis in Queensland and the Northern Territory.

It was a highly sought-after commodity, particularly by Asian and European countries, and was priced at A\$ 10,000 per ton in 1988. The meat of the adductor muscle was considered a delicacy in parts of Asia, and was priced up to A\$80 per kilogram in 1988.

The bulk of the Australian production comes from Western Australia. In 1989–90 this was conservatively valued around A\$94.5 million and was almost entirely due to pearls (see table below).

Estimates of Australian aquaculture production for 1989–90 (by species)

Species	Production (tonnes)	Value (A\$, 000)
Atlantic Salmon	1,750	21,000
Rainbow/Ocean Trout (hatchery)	NDA	1,278
(farm)	2,273	14,940
Brown Trout (hatchery)	NDA	168
(farm)	2	10
Brook Trout (hatchery)	NDA	7
Chinook Salmon hatchery	NDA	12
Native fish (hatchery)	NDA	2,715
(farm)	10	173
Barramundi (hatchery)	NDA	1,020
(farm)	33	430
Aquarium fish	NDA	828
Eels	271	1,692
Yabbies	68	724
Marron	14	379
Redclaw	31	496
Prawns (hatchery)	NDA	175
(farm)	594	6,372
Sydney Rock Oysters	4,834	27,016
Pacific Oysters	1,700	7,496
Northern Oysters	39	124
Native Oysters	+	1
Pearl Oysters	1	94,500
Mussels	747	1,679
Microalgae	NDA	3,450
Crocodiles	NDA	1,364
Total	12,366+	188,020

Sources: information provided by State and Territory Fisheries Departments and industry (figures rounded to nearest unit). Notes: (NDA) = no details available. (+) = production reported but no details available

Estimates were not available for the Northern Territory or Queensland, but together were thought to exceed A\$10 million.

While the market outlook is uncertain due to competition from overseas, increased production in Western Australia combined with the renewed

activity in the Northern Territory and Queensland suggest that the prospects should be rated as very good.

However several operations in Indonesia are reported to be undertaking successful farming trials, so there may be some overseas competition.

Pearling: bright future or sunset industry

by Bob Slight

Excerpt from an article by Bob Slight, of the same title, in *Professional Fisherman*, October 1992, pp. 15–16.

A billion dollar industry

Worth around A\$ 130 million export dollars annually and second only to the rock lobster industry in fisheries-related earning, the West Australian pearling industry is taking a look at aspects of its operations that may see changes to meet the challenge which is steadily growing from our Asian neighbours.

Western Australia (WA) has long been the centre of the world's pearling industry, producing magnificent quality pearls from the silverlip *Pinctada maxima* oyster, the world's largest pearl-producing shell.

Traditionally, Japan consumes most of the pearls produced in Australia, choosing the fine 10–13 mm whites for local consumption while the larger pearls are exported to the USA and Europe.

Sales are also made to Hong Kong, believed by some soon to become the world's largest pearl distribution centre, as well as direct to the USA and Europe.

The WA product has consistently exceeded the quality available from the Japanese producers. Though firmly denying the fact, the Japanese are believed to be dyeing and bleaching the home product to reach the natural colours found in the WA pearl.

Hatchery stock goes wanting

Now, a few Indonesian producers, using hatchery stock developed by WA marine biologist Bob Rose, have produced pearls of equivalent quality to the Australian product. Rose was originally contracted in WA to enable the pearl producers to obtain a cheaper source of animals.

Traditionally, wild stock is gathered by divers at an

estimated 50 per cent of total production costs.

Rose achieved this, then watched the industry virtually turn its back on his development. Consequently, he went to Indonesia where they were able to produce so much spat that they had to reduce production in the second year of spawning.

Hatchery-produced spat sells locally for around A\$3 each. It is then grown on for two years to reach seeding size. Total cost to seeding size is estimated to be approximately A\$7. Wild stock gathered by divers is estimated to cost A\$15 per shell.

Lindsay Joll, marine biologist with the WA Fisheries Research Centre at Waterman, believes that it is still too early to estimate the value of using hatchery-produced shell as the first harvesting of pearl is due this year. The results of that harvest will give a better indication of pearl quality from hatchery versus wild stock.

Quotas

Pearl producers operate on a quota system, which allows the industry to seed a restricted volume of wild shell annually. The volume of shell allocated determines the size of the farm. In addition to the wild catch, 20,000 hatchery shells are permitted to each operator. The current allocation is shown on next page.

One of the greatest impediments to the use of hatchery stock is the belief that without the necessity of quotas, which were introduced to conserve wild stock numbers, an overabundance of top grade pearls would severely devalue the pearl's worth.



Current annual allocation of shells

Paspaley *	100,000
Pearls Pty. Ltd. **	80,000
Roebuck Deep Pearls**	55,000
Cygnets Bay Pearls **	55,000
Deep Water Point **	25,000
Hamaguchi	15,000
Darella Holdings	15,000
Broome Pearls	55,000 (+ 5,000) ***
Arrow	25,000
Morgan	35,000
Cossack	20,000
Maxima	15,000
Clipper	15,000 (+ 2,000) ***
Total	517,000

* Paspaley is the world's largest pearl producer.

** Companies controlled by Paspaley

*** Research grant stock

Opposing this line of thought, some industry members believe that Asian production will increase regardless of what occurs in Australia and they must use all available technology to reduce costs and match the Indonesians at their own game.

Lindsay Joll argues that although labour costs may be low in Indonesia, the farms in the bays are subject to run-offs, causing freshwater dilution which may force them to revert to deepwater or bottom pearling. These areas abound in rapid drop-offs, which would make bottom farming a higher cost operation than the surface culture using the more manageable longline system.

He sees Australian producers as having an advantage in skill and resources to counteract low wage structures.

Joll agrees quotas have a twofold advantage, both in the preservation of wild stock and as a marketing exercise to prevent the trade being flooded with low-cost pearls. If hatchery-produced animals will produce the required quality of pearl, then Joll sees wild stock only being used in future to provide breeders for the hatcheries.

Australia is losing sales from the local market to the Indonesian-Philippine-Malaysian and Myanmar (Burmese) assault on the local industry.

The quota recommendations are proposed by the Pearling Industry Advisory Committee (PIAC) chaired by Bernard Bowen, ex-Director of the WA Fisheries Department. PIAC comprises members of the Pearl Producers Association and other industry-associated members, such as divers and

marketing advisers.

The Joint Authority to which these recommendations are put comprises Simon Crean, Federal Minister for Primary Industry and Energy, representing the Australian Fisheries Management Authority (AFMA), and Gordon Hill, WA Minister for Fisheries.

The recommendations of this committee determine the total allowable catch (TAC) for the season. The catch, for example, may mean a limit of 500,000 oysters to be used by the industry for that season. That amount is broken into 1,000 units of quota which then determines the size of the pearl farms.

However, if the wild stock is depleted, the TAC quota may be changed but the total number of animals that may be seeded is unchanged. Existing animals may be used up to four times but more often only twice.

The loss of animals due to cyclones, stingrays, turtles, carnivorous gastropods and the like is estimated at an industry average of 20 per cent until harvest. Harvest is two years from the time of seeding and the failure actually to obtain pearl from seeded animals is around 37 per cent.

Of the total Australian production of pearls, Western Australia produces approximately 70 per cent, with 25 per cent from the Northern Territory and Thursday Island and the east coast around 5 per cent.

Ninety-eight per cent of all Australian pearls are exported. The by-products of pearling such as oyster meat and the mother-of-pearl used in inlay and buttons are also exported. The shell brings around A\$10 per kilo.

Pearls are sold by negotiation with overseas buyers basing values on past sales. The danger lies in one producer selling cheaply and, therefore, lowering the going price.

Originally Broome was solely a supplier of mother-of-pearl shell, satisfying approximately 75 per cent of the world's requirements.

Since 1956 the industry has thrived, with the quality and quantity of its fine white pearls being the foundation stone.

The local price has dropped, according to industry sources, from A\$1,150 to A\$550 per momme (a momme = 3.75 grams and is a thousandth part of a kan) in the past two years.

In 1966 Japan reached its highest production of more than 39,000 kan.

Lindsay Joll believes that the Indonesian pearl producers are at this stage happy to run as pacemakers to the Australian producers, not wishing to force the pace as they may not yet be able to compete with the quantity/quality advantage Australian pearlers enjoy.

He believes that ten years will see the real challenge to local producers in both those areas.

One major industry source, who asked not to be named, believes that the real fight is on now. The Indonesian producers are getting some excellent prices for high-quality pearls equalling the Australian product.

The Federal Government wants to issue two new licences into the industry but it appears that the additional quota will be taken up by existing licence holders rather than new players. Even a small operation costs around A\$ 1–2 million a year before any returns are achieved.

It can be a sure-fire way to bankruptcy if prices do not remain stable, particularly for those who do not have the back-up of existing leases to support them. In the next two years there is no way of knowing where the pearling industry will be.

Whatever the answer, the industry is approaching a crossroads. Its very survival means staying one step ahead through lower operating costs and higher efficiency. Will Australia retain the position of the Number One pearling nation? Only time will tell.

Perhaps genetic engineering, which is making inroads in so many industries, will see a cloning of high-quality pearl-producing shell, creating a greater volume of perfect pearls. It's considered possible in the not too distant future – but who will do it first and what effect will this have on market prices?

Every industry today must stand back and look at itself with a view to survival. The pearling industry is no different. What is done today will help provide a more secure tomorrow. But, if we wait, will the sun set on a major export earner for this country?

Meeting challenges in pearling

by Caroline Joll

Excerpts from an article by Caroline Joll, of the same title, published in Australian Fisheries, February 1993, pp. 30–31.

Getting paid to do something he enjoyed drew Mick Buckley to work as a diver in the pearling industry 12 years ago. Now he represents pearl producers as they face the challenges of updating management practices, unifying as an industry, and meeting competition from Indonesian pearl producers.

By the summer of 1980–81 Mick Buckley had clocked up a variety of work experiences including a stint in the army. 'Until starting in this industry I tended to move on once the learning aspect levelled off,' he said.

Then his enthusiasm for diving drew him to Broome where Mick, who'd been a recreational skindiver for many years and had recently completed a scuba course, planned to get into diving and get paid for it. He obtained a job on one of the few pearl farms which used bottom culture production and ended up working as a diver for around seven years.

'You never lose the taste of diving. You certainly lose the wish to be out there in the middle of winter when it's 18 degrees,' he commented. His decision to move out of diving was not an unusual one for an experienced diver, many of whom can obtain work only seasonally and have to be away from their families for long stretches.

'It's a young industry. Few divers are still diving as they approach their '40s. It's a hard life, however once you're 'dive' fit you do not notice it so much, but there's still a certain amount of strain on the body maintaining that fitness,' Mick says.

'Because of the particular nature of the job, diving does demand strong individuals who can handle adverse conditions but that's what attracts them to it in the first place, it's the challenge.

'There are specific risks in diving but for someone who knows what they're doing I wouldn't say it's any more dangerous than getting in a car and driving on Parramatta road every day.'

After giving up professional diving Mick took up a position managing a pearling company where he stayed for four years.

By then he had lived through as many north-west Australian wet seasons as he wanted to. He decided to move south.

He based himself in Geraldton where he accepted a position as Executive Officer for the Pearl Producers Association.

The location, he says, works fine despite being hundreds of kilometres south of the main pearling areas.

In Western Australia 13 companies are licensed to fish *Pinctada maxima* pearl oyster shell, some of which is farmed in the Northern Territory. The industry employs around 300–400 people. In 1991 production was valued around A\$130million. Pearling takes place between Exmouth Gulf right around to the Queensland coast, although the most prolific beds are near 80 Mile Beach south of Broome.

Geography and climate limit the number of pearl farms. To avoid the spread of disease, farms must be at least 10 nautical miles apart, and they require protection from cyclones, which limits sites to sheltered bays. Most of the pearls produced go to Japan, although some companies are starting to develop other markets.

Mick says that the romantic image some people hold of pearling is not realistic.

'If you want to survive it's very much a business. There's no mystique about it for those that are in the industry.'

Mick says a newcomer would need access to A\$ 2–3 million to even consider starting a pearl farm, and pearling has been a limited entry fishery since 1988. Mick says newcomers are restricted to small quota. 'The last few cases have been a 10,000 shell quota with the potential to expand that to 15,000 after a five-year development period.'

One of the major issues confronting the industry is the development of pearl culture by producers in Indonesia.

'At present they are producing smaller, creamy-yellow pearls. The Broome pearl has a white, almost metallic lustre and that colour is highly prized. Some Indonesian farms are using hatchery-

produced shell, and nobody is sure at the moment whether Indonesian producers can refine that to the point where they can tackle us head on.

'Because of that and more so because of the economy, pearl prices have taken a nose dive this year (1992), up to 30 per cent in some cases for lower quality product.'

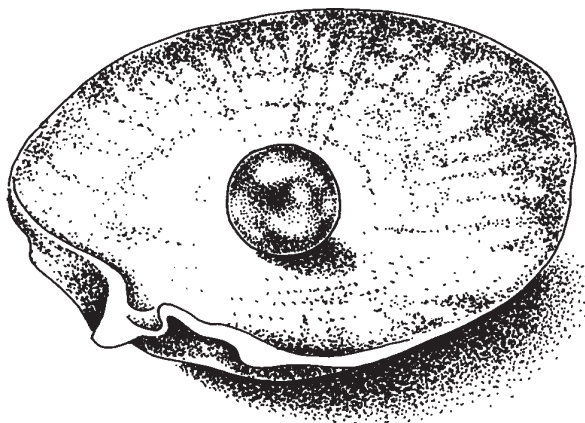
Mick, along with others, is assisting the industry move towards industry/government-based management of resources and to achieve co-operation among companies, thereby developing a more unified industry approach to issues confronting it.

'As the industry heads towards being a mature industry it has to invest in broad research to maintain the margins that it operates within,' he says.

The fishery is currently managed under Western Australian law by a joint authority of which the Australian Fisheries Management Authority (AFMA) is a member, as is the Western Australian Government.

Mick, along with the pearling industry, is keen to see the fishery managed under single jurisdiction.

'As soon as you have to confer with too many heads it slows down the process and the pearling industry has to be able to react quickly to certain situations. It's a lot more efficient if you have a single, well-structured Management Advisory Committee (MAC)-based managing authority.'



Biomimetics: producing 'natural' artificial pearls?

by Daniel Clery

Article by Daniel Clery, entitled *The mother of all pearls*, published in *New Scientist*, 28/3/1992, p. 17.

Douglas Adams wrote in the third part of his series the *Hitchhiker's Guide to the Galaxy*, 'very few things actually get manufactured these days, because in an infinitely large universe... most things one could possibly imagine, and a lot of things one would rather not, grow somewhere'. As an example, he described a forest where trees grew ratchet screwdrivers as fruit.

Adams may soon be proved right but without going so far afield. Researchers are now trying to harness the way living organisms can produce useful inorganic materials. They hope to produce thin coatings, tougher than any synthetic ceramic, that could one day be used in tiny machines.

Synthesising these organically made materials, a process called biomimetics, is relatively easy, Mehmet Sarikaya of the University of Washington in Seattle told the American Physical Society meeting in Indianapolis last week. What he is trying to do is copy the organism's own manufacturing techniques, to avoid the expensive high temperatures and pressures of synthetic methods.

Sarikaya wants to make thin films of a material called nacre, more commonly known as mother-of-pearl. The material covers the inside of shells belonging to creatures such as abalone, nautilus and bivalves, and is twice as tough as any synthetic ceramic.

Sarikaya has concentrated on abalone: its shell is made of small crystals of calcium carbonate cemented together with organic material. The outer layer of the shell consists of a matrix of hexagonal prisms of calcium carbonate. The inside of the shell is coated with nacre which consists of flat hexagonal platelets of calcium carbonate laid down in a multi-layered tiling pattern.

The cells of the abalone closest to the nacre layer produce proteins which are responsible for forming the nacre. The cells release the proteins into a thin layer of sea water between them and the shell. The water also contains calcium and carbonate ions and by some unknown process the proteins form these ions into platelets and cement them in place as a new layer of nacre.

Sarikaya has managed to isolate the proteins responsible for forming nacre and is about to set about identifying them. Once he knows the identity of the proteins, he will find the gene responsible for producing them and, using genetic engineering, insert it in the bacterium *Escherichia coli*. This bacterium will then produce the proteins in usable quantities.

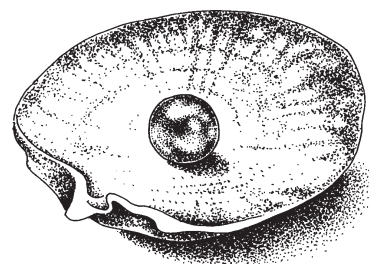
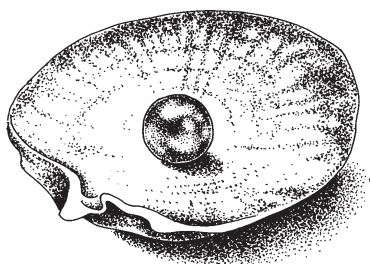
Sarikaya then hopes he will be able to cover objects with a tough coating of nacre by immersing them in a solution of the proteins and necessary ions. His work is only in its early stages and he does not expect to accomplish this for at least five years.

Myanmar pearl sales

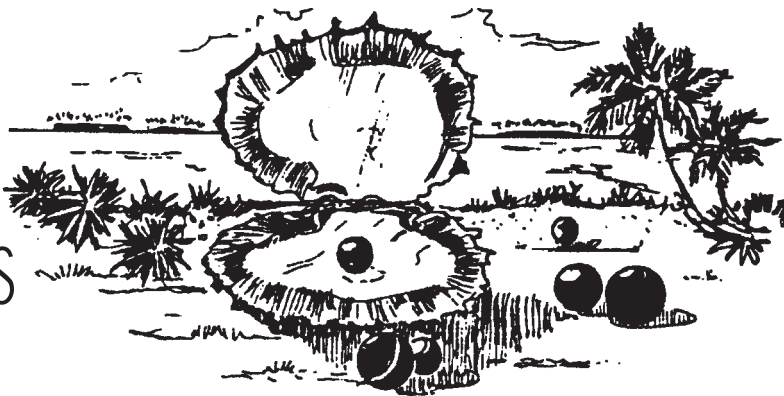
Source: Working People's Daily
(8 October 1992)

A total of US\$ 8,900,525 has been realised from the sales of jade, gems, pearls, jewellery and jade figurines at the Mid-year Myanmar Gems Emporium, held in Yangon last October.

Sixty-one lots of Myanmar pearls were sold through competitive bidding today and fetched US\$469,431. Altogether 582 gem merchants from 15 countries attended the emporium.



ABSTRACTS and PUBLICATIONS



Where do you get your pearl oyster bibliography?

by Mark Gervis
ICLARM Coastal Aquaculture Centre
Honiara, Solomon Islands

Mark Gervis, Manager of ICLARM's Coastal Aquaculture Centre in Solomon Islands writes :

I have had a barrage of requests for free bibliographies, after the review of the bibliography that you gave in *POIB* #5. Would you please let people know that the hard copy of the bibliography together with the diskette and software cost US\$10? The bibliography by itself is **not** free of charge: it costs US\$4.50 surface mail and US\$7.50 airmail. Sorry for the confusion.

Further information on the availability and cost of ICLARM publications is available from:

The Editor
ICLARM
MC P.O. Box 1501
Makati, Metro Manila
Philippines.

Both the bibliography and the review are only available from ICLARM in Manila, not from the authors.

ICLARM publishes review of pearl oysters and pearl culture

Mark Gervis and Neil Sims have co-authored a recent review entitled *The Biology and Culture of Pearl Oysters (Bivalvia: Pteriidae)*. This is a joint publication by the Overseas Development Administration of the United Kingdom (ODA) and the International Center for Living Aquatic Resources Management (ICLARM). It is No. 21 in the series *ICLARM Studies and Reviews*. An abstract is presented below.

Pearl oysters are farmed throughout the Indo-Pacific region, including the Red Sea. The biology and ecology of four pearl oyster species from the family Pteriidae – *Pinctada fucata*, *P. maxima*, *P. margaritifera* and *Pteria penguin* – are reviewed here.

The culture techniques for each of these species are described and the research needs, economics and marketing aspects discussed.

P. margaritifera and *P. maxima* culture is likely to proliferate throughout the Indo-Pacific region in the next decade and there is also good potential for developing *P. fucata* culture in India and Sri Lanka.

The culture of *P. fucata martensii* in Japan faces stagnation or reduced profitability unless remedial measures are taken to improve the culture environment and the quality standards imposed on exported pearls.

Copies of the review are available for US\$3 (surface mail) or US\$5 (airmail) from The Editor, ICLARM, MC P.O. Box 1501, Makati, Metro Manila, Philippines. Payment is requested in US\$ by international money order, bankdraft or UNESCO coupons. US\$ cheques can only be accepted if drawn from a US-based bank.

Pearl shells and pearls: a new publication from the Oceanographic Museum of Monaco

The Oceanographic Museum of Monaco has recently published a special volume, edited by François Doumenge and Anne Toulemont, entitled *Nacres et Perles*. The articles listed in the Table of Contents include:

- Avant-propos (*Foreword*) by A. Toulemont
- Nacres et perles, traditions et changements
(*Mother-of-pearls, tradition and change*) by F. Doumenge
- La perle au Japon (*Pearls in Japan*) by F. Simard
- La perliculture engendre-t-elle sa propre mort?
(*Is the pearl industry committing suicide?*) by A. Intes
- Données actuelles concernant la structure et la composition
de la nacre et des perles
(*Current structure and composition data for mother-of-pearl and pearls*) by J.P. Cuif
- Les grosses perles des mers du Sud (*Large pearls from the South Seas*) by J. Taburiaux
- Réflexions d'un perliculteur sur les perles des mers du Sud
(*Meditations of a pearl oyster farmer from the South Seas*) by J. Branellec
- Les perles noires de Tahiti (*The black pearls of Tahiti*) by M. Coeroli
- La perle de culture dans une économie de marché
(*Cultured pearls in market economies*) by M.J. Gruet
- Perles fines d'hier et d'aujourd'hui
(*Natural pearls in yesteryears and today*) by P. Levi et J.P. Poirot
- Les règles et nomenclatures françaises et internationales
en matière de perles
(*French and international regulations and nomenclatures for pearls*) by G. Grospiron
- Un laboratoire de contrôle de la qualité des perles
(*A pearl quality control laboratory*) by D. Hargett
- L'identification des perles de culture
(*Identification of cultured pearls*) by C. Schiffman
- Les perles de chez Cartier (*Cartier and pearls*) by E. Nussbaum
- Les perles dans les objets d'art du Louvre
(*Objets d'art of the Louvre Museum and pearls*) by D. Alcouffe
- Planches en couleur (*Colour illustrations*)

Source: François Doumenge and Anne Toulemont (1992). *Nacres et Perles*. Numéro spécial n°8. Bulletin de l'Institut Océanographique, Monaco. Page III.

Pearl World : a new industry newsletter

The first issue of a new pearl industry newsletter is planned for publication in March 1993. *Pearl World: The International Pearling Journal* describes itself as :

'... an international compilation of what's happening now in the pearling industry. And what the effects may well be. ... News about changes, those already here and those coming fast on the horizon. And about the changemakers.

'Articles about new products, new processes, new procedures. Who's enjoying profitability, who's not ... and why. All reported by experts in their fields. Unbiased, wide-ranging, incisive, up-to-date.'

The newsletter plans to provide statistics on production, imports and exports, as well as covering

industry trends and procedures, market developments, auctions, design contests and trade fairs, promotional materials, interviews and reviews. The price is US\$ 85 per year for an eight page bi-monthly newsletter.

For further details write to :

Richard Torrey, Editor
1822 W. Glendale Ave, Suite 401
Phoenix, Arizona 85021-8543
USA.

Tel : (602) 246-1586

Pearl culture research and development in La Paz Bay, South Baja California, Mexico

Exploration and evaluation of natural stocks of pearl oysters *Pinctada mazatlanica* and *Pteria sterna* (Bivalvia: Pteriidae): La Paz Bay, South Baja California, Mexico

Abstract and conclusion of article by Mario Monteforte & Micheline Carino, Ambio, Vol. 21 (4), June 1992, pp. 314-320.

Applied biological and ecological studies on the extensive culture of pearl oysters *Pinctada mazatlanica* and *Pteria sterna* are being developed in La Paz Bay, South Baja California, Mexico.

Exploration in several sites and a preliminary evaluation of the natural stock were carried out in order to establish the localisation and actual state of pearl oyster populations. The four densest populations of *Pinctada mazatlanica* were compared in terms of their densities and size structure.

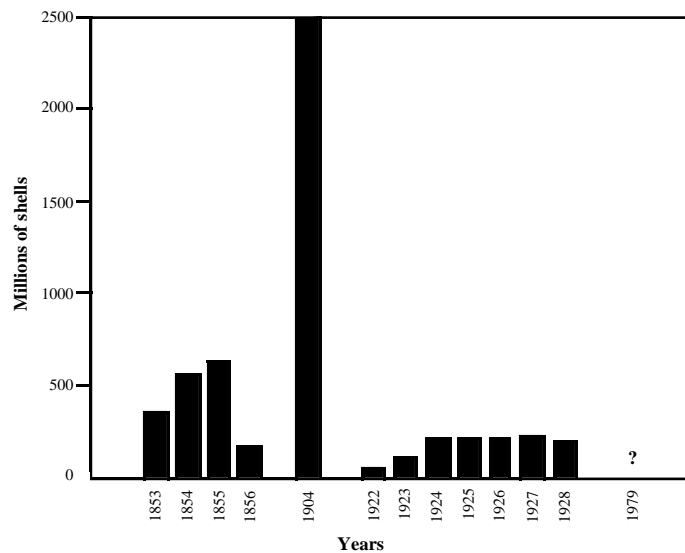
It is evident that the actual pearl oyster banks are scattered along the coast of the bay, they have low densities, and natural recruitment also seems to be low. Illegal and uncontrolled extraction of large and medium-sized individuals negatively affects the natural recuperation of the resource as well as the size structure of local populations.

The areas commonly visited by tourists and fishermen show discontinuities in size distribution and an absence of large individuals. The results of the present study will be directly applied to choice of sites for seed captation and extensive culture.

Conclusions

The pearl oyster populations in La Paz Bay have endured strong fishing pressure for a long time. The evaluation of their condition in some sites has revealed evidence of irrational extractions. Comparing the information provided by records issued in the colonial period and early 20th century concerning the estimated number of individuals that were extracted (see figure on page 24), the impoverishment present in the local populations is perceptible. Furthermore, from the list of 65 sites explored in La Paz Bay, the proportion with population densities equal to or more than 0.5 individuals per m² is only 15 per cent and it will probably be less in a few years time if uncontrolled extractions continue.

From the observations *in situ*, it has been evident that the densest populations of *Pinctada mazatlanica* are established mainly in those sites where the substrate offers shaded and protected shelters, such as hollows and crevices and where rocks merge. The presence of algae, providing supplementary camouflage, seems to be helpful. Types II and III



Estimation of the extraction of pearl oysters in the Gulf of California (1853–1879). Information condensed from documents, internal reports and personal interviews (note that some data include the years after the decree (1939) banning pearl oyster fisheries).

coastal areas are more propitious, the main condition being that they are not situated between 1.5 m and 10–15 m depth. Occasionally, individuals are found on deeper substrate (30 m depth or more); in these cases they are quite large (>150 mm width) and may be abundant: these individuals are obviously out of reach of standard fishermen, i.e. those who skindive at not more than 10 m depth. Even at this range, size zonation has been observed; smaller individuals in surface and larger in deeper areas.

The degree to which the coast is exposed to currents and the location of a particular site in relation to the identified water masses may also play an important role in the establishment of pearl oyster beds. It seems that denser populations are present in sites with a local current system, i.e. close to the inlet and outlet margins of creeks and small bays. This allows the larvae to find an adequate local substrate before they leave the littoral. In addition, the water in these sites is fairly clear with low particle contents, although this condition may vary.

The areas influenced by the water body of San Lorenzo Channel and those affected by upwellings and tidal currents heading along the coast between La Paz City and Port Balandra seem to provide propitious conditions for the colonisation of the pearl oyster, namely *Pinctada mazatlanica*. *Pteria sterna* inhabits areas with lower water dynamics and higher turbidity, preferably near sand bottoms such as the areas around Punta El Mogote and the protected areas inside Port Balandra.

However, predation by fishes, crabs and other predators seems to be the most important factor influencing the distribution, density and size structure of populations. Newly settled individuals and juveniles may be consumed by a number of predators, although this predation would have little effect on the abundance of populations since enough individuals will remain to complete the biological cycle and ensure the continuity of the species. However, the predator man, driven by the pearl myth, selects large individuals, usually far beyond the alimentary range of most natural predators. Extraction is often carried out before the specimen reproduces.

Studies have been carried out by numerous authors on the influence of selective human predation on large individuals, in relation to the size structure of intertidal mollusc populations. Assuming a non-exploited population, a theoretical size structure distribution would present a rather normal shape without noticeable discontinuities and relatively biased towards the small sizes, suggesting recruitment.

However, populations in our study show considerable inconsistency with this distribution. The most affected populations are those from El Gallo Island and San Gabriel Bay, which are areas frequently visited by tourists. El Merito Bay and Gaviota Creek, where the presence of natural banks is apparently still not known, show a size distribution more closely related to the theoretical distribution.

For the evaluation of natural stocks of pearl oysters in La Paz Bay, it is still too early to present global abundance figures; the studies so far have not been exhaustive enough.

However, the observations of this study have shown that natural populations, principally *Pinctada mazatlanica*, are seriously affected by irrational and illegal extractions. Even if it is possible to assume a natural recuperation, since an appreciable number of juveniles has been observed in a few sites, recuperation is unquestionably too slow and insufficient. It is urgent to initiate broad massive captation and extensive culture to recuperate the resource by repopulation, together with a conscientious programme of information and control addressed to fishermen and tourist services, and strict regulation of extraction. This is what we are trying to achieve in our research programme.

Experimental collection of pearl oyster *Pinctada mazatlanica* (Hanley, 1856) at Gaviota Island, Southern Baja California, Mexico: preliminary results

Abstract of an article by Alejandra Garcia-Gasca and Mario Monteforte, presented at the IV Congreso de la Asociación Mexicana de Acuicultura, 3–6 April 1990, Hermosillo, Sonora, Mexico. *Compilation of Works, Vol. 1.*

The present work deals with the study of some of the aspects having influence on the variations of seed captation of *Pinctada mazatlanica*. The main objective is to define a monitoring method to improve massive seed captation operations, comparing two different synthetic substrates, three depths of seed settlement, and four periods of different immersion times for the collectors before their recuperation. Temperatures were recorded every 15 days to relate seed incidences with this parameter.

The experimental collectors were manufactured with black REDLON screen (1.5 mm mesh). Four pairs of bags 0.01 m² were suspended in a 'long-line' system, each containing 2 gr of different substrate: monofilament nylon gillnet, most commonly used in the area for bivalve seed captation, and plastic onion bag as an alternative material.

Three depths were also evaluated: 1, 3 and 5 m. The main seed incidences are apparently concentrated in these depth levels. Finally, the optimum immersion time was evaluated comparing seed yield and size of individuals just after recuperation.

Large-scale collection and fattening of the pearl oyster *Pinctada mazatlanica* (Hanley, 1856) in Bahía de la Paz, Southern Baja California, Mexico

Abstract of an article by Mario Monteforte and Silverio Lopez-Lopez, presented at the IV Congreso de la Asociación Mexicana de Acuicultura, 3–6 April 1990, Hermosillo, Sonora, Mexico. *Compilation of Works, Vol. 1.*

This project is part of an institutional programme carried out by the Biological Research Centre called 'Spat Collection and Extensive Pearl Oyster Culture' (*Pinctada mazatlanica* and *Pteria sterna*, Bivalvia: Pteriidae), in Bahía de la Paz; funding was approved by CONACYT in 1989.

The general aim of this project is to harness the pearl oyster resource in Bahía de La Paz by large-scale spat collection and extensive culture of pearl oysters; its conservation aim is to repopulate some areas suitable for the reseeded of cultured juveniles and adults.

This paper presents the preliminary results on the large-scale collection of spats and the fattening of *Pinctada mazatlanica*. These results were principally obtained at Isla Gaviota station on the Pichilingue Coast, since this is the most favourable site for spat

Size was recorded to calculate the effective growth of individuals from the moment of settlement by means of the following formula:

$$TR = AT - AP$$

where TR is the reference size, AT is the total height (from the centre of the hinge to the opposite margin of the shell), and AP is the height of the protoconch.

The study was conducted in Isla Gaviota, from 1 July to 1 December 1989. This area was selected because of its accessibility and its oceanographic conditions allowing massive seed arrivals.

The first settlements were detected at 26.5°C (second half of July), and the last at 26.1°C (first half of November). A three-way ANOVA at 95 per cent was applied to compare the variables immersion time, substrate and depth. Results showed that the optimum immersion time seemed to be at least 60 days. Onion bags used as substrate yielded the best settlement results (83 per cent of the total seed captation). There were no significant differences among seed yields by depth.

collection. The other two stations chosen (Isla Ballena and Bahía San Gabriel on the island of Espiritu Santo) could not be used for similar trial purposes because of access difficulties and other problems due to lack of facilities. However, it was clear that the Gaviota station was the most favourable for large-scale collection.

It was observed that pearl oyster spats were more abundantly collected in the surface layers, preferably between depths of 1 and 3 metres. This pattern was repeated throughout the collection cycle (July to November).

The time distribution of the incidence of spat production showed that the optimum collection period was between the end of August and the beginning of November, coinciding with the highest annual water temperatures.

The size of spats collected at each release was relatively homogeneous. The monthly growth increase recorded in one batch of spats (IIGAVO) appeared positive (between 6.1 and 7.2 per cent per month). However, the overall size of this batch

showed an increase of up to 20 per cent from October to January. Mortality was highest in the first month of fattening and then diminished to less than 3 per cent in January.

***Pinctada maxima* data collected during Torres Strait survey**

Abstract of an article by C.R. Pitcher, T.D. Skewes, D.M. Dennis and J.H. Prescott entitled Distribution of seagrasses, substratum types and epibenthic macrobiota in Torres Strait, with notes on pearl oyster abundance, published in Australian Journal of Marine and Freshwater Research, 1992, 43, 409–419.

The benthic habitat of Torres Strait was surveyed in May–June 1989, using almost 600 transects (each 4 x 500 m) randomly dispersed over an area of about 25 000 km². The distribution and relative abundance of seagrasses were estimated visually and mapped, along with the distributions of substratum types and epibenthic macrobiota; pearl oyster abundance was also estimated.

Seagrasses were seen in most transects and, though very patchy at small scales, tended to increase from almost zero abundance in the southern and eastern areas of the survey to moderately dense in north-western Torres Strait. The epibenthic macrobiota and the substratum type also varied greatly, with the greatest diversity and abundance of biota associated with the harder substrata.

The survey area supported an estimated 1.2–2.5 million pearl oysters, and though their density varied significantly with habitat type, the latter accounted for only about 12 per cent of the variance.

Conclusions

This study has provided information on the distribution and abundance of seagrasses, substratum types, epibenthic fauna, macroalgae and pearl oysters in Torres Strait. This information will expand the database on the benthic habitat of Torres Strait and assist in ground-truthing satellite data for large-scale mapping and monitoring techniques that are currently being developed for the Torres Strait region.

The information on the pearl oyster, *Pinctada maxima*, has provided the first quantitative estimate of pearl abundance and distribution within the survey area and will complement qualitative surveys of the formerly productive fishing grounds for this species (Colgan, unpublished data); together, these data sources will facilitate decisions about the future of this industry.

A new glossy for the coffee-table

The following advertisement for a new pearl publication has come to hand:

PEARLS Ornament and Obsession

by Kristin Joyce and Shellei Addison

A visually stunning, one-of-a-kind history of the shimmering, lustrous object of beauty that has

mesmerised humankind for millennia. Featuring 210 superb photographs, 168 in full colour, *Pearls* traces the evolution of the pearl from sacred icon to timeless aesthetic symbol, a history that spans 4,000 years. (ISBN 0-671-75928-0)

Gary Kraidman reports that the book is available through the GIA Bookstore, Gemological Institute of America, 1660 Stewart St, Santa Monica, CA 90404, USA. (Fax: 1-310-828-0247)

Selected abstracts from the Symposium on freshwater mussels, St. Louis, USA, October 1992

A State-of-the-Unionids Address

by Richard J. Neves

(Virginia Cooperative Fish & Wildlife Research Unit, Department of Fisheries & Wildlife Sciences, Virginia Tech., Blacksburg, VA 24061, USA)

The freshwater mussel fauna of the United States is in serious trouble. Of the 297 species and subspecies recognised, 18 (6%) are presumed extinct, 42 (15%) are federally listed as endangered or threatened, and 69 (23%) are candidates for federal protection.

The high diversity of endemic species of the south-eastern United States is in greatest jeopardy, with depressed population levels today reflecting transgressions decades earlier. Reservoir construction and hydrologic changes in rivers such as the upper Mississippi, upper Ohio, Tennessee and Cumberland have been particularly disruptive to big-river species.

Our knowledge of the biology and ecological requirements of most species is limited and fish hosts are known for less than 70 species. We lack, therefore, the essential information and tools to recover declining populations. The next 10 years will be the most significant yet for this fauna, with chronic perturbations now intensified by the zebra mussel invasion.

An extinction spasm is inevitable; greater effort to educate and muster public support is essential for the conservation of riverine ecosystems.

Mussel harvest and regulations on the Upper Mississippi System

by Pamela A. Thiel¹ and Arnold W. Fritz²

(¹ US Fish and Wildlife Service, Environmental Management Technical Center, 575 Lester Avenue, Onalaska, WI 54601; ² 140 Lake Vista Drive, Carlyle, IL 62231)

Commercial harvest of mussels for buttons began in 1891 on the Upper Mississippi River System and continued through the 1930s. Initially, no attempts at conservation were made and mussel beds were severely depleted by excessive unregulated harvest.

From 1912 to the 1930s management techniques were initiated, but they could not offset the high harvest rates and habitat alterations, and the button industry collapsed. Harvesting was initiated again in the 1960s and continues today for the cultured pearl industry. Meaningful and uniform regulations were not adopted until the mid-1980s, when concern peaked after a major mussel die-off in the Mississippi river from 1982 to 1985. In 1989, 7.1 million pounds

of mussels were harvested from the Illinois and Mississippi rivers and had a value of \$3.2 million.

Over 7.7 million pounds of mussels were harvested in 1990 and were valued at \$6.1 million. A two- to threefold increase in the price paid for washboard (*Megaloniaias nervosa*), the most valued and increasingly less common commercial species, caused this near doubling in value despite a 23 per cent decrease in the poundage of washboard harvested. As washboard availability decreased, threeridge (*Amblema plicata plicata*) harvest more than doubled. Mussel populations may not be sustainable under these harvest pressures, and trends should be analysed carefully to determine if further regulations are required.

Why did Indiana halt commercial mussel harvest in 1991?

by Robert M. Anderson, Thomas Stefanavage and Thomas Flatt

(Indiana Department of Natural Resources, 402 W. Washington St, Rm W-273, Indianapolis, IN 46204)

Indiana has a long heritage of commercial mussel harvest. Historically, 77 species of mussels occurred within the state although five (5) species comprise more than 90 per cent of the annual harvest. Demand for mussel shell has fluctuated for decades

but has undergone dramatic increases in recent years associated, in part, with favourable collecting conditions and increased price. The sustainability of mussel harvest under existing conditions came into question, prompting a review of harvest infor-

mation.

A doubling of commercial licence sales was recorded in 1991 as compared to the 1988–1990 average. The low annual harvest of 33,904 pounds in 1985 was greatly surpassed in 1991 with 342,475 pounds harvested.

Since 1988 approximately 95 per cent of the mussels taken in Indiana originated from 1,136 river miles, however over 75 per cent of the 1991 harvest originated from less than 175 river miles.

Harvested stream segments traditionally supported

26 to 28 per cent of the annual harvest; this declined in 1991 to 12.8 per cent, while increases occurred in previously unharvested areas. Changes in the overall catch composition, away from species most harvested in the mid-1980s, were also observed.

Additionally, mussel kills, law enforcement concerns, and regional changes in mussel regulations prompted the early closure of the 1991 season. A longer-term closure has been proposed while studies are completed to assess the resource and management options are reviewed.

Freshwater mussels in peril: Perspective of the US Fish and Wildlife Service

by Larry Shannon¹, Richard G. Biggins² and Roberta E. Hylton¹

(¹ Division of Endangered Species, US Fish and Wildlife Service, 1849 C Street, 452 ARLSQ, Washington, DC 20240, USA; ² Asheville Field Office, Region 4, US Fish and Wildlife Service, 330 Ridgefield Court, Asheville, NC 28800, USA)

Of the approximately 300 species of freshwater mussel native to the United States, the US Fish and Wildlife Service estimates that 18 are probably already extinct.

Even disregarding the potential invasion of the zebra mussel, the Service estimates that as many as 45 species of mussel may become extinct within the next 10 years. The invasion of the zebra mussel may place an additional 20 species at risk within the next 10 years.

Although the Service has undertaken a number of projects aimed at conservation and research of

native freshwater mussels, the alarming decline in diversity continues.

To avoid the eventual extinction of this entire wide-ranging faunal group, the Service and other federal and state agencies, as well as private conservation organisations, need to expand current conservation and research efforts to address: (a) the zebra mussel invasion; (b) holding, propagation, and rearing of native mussels; (c) interagency co-operation; and (d) public education about the importance of mussels.

Infestation of unionid bivalves by the exotic zebra mussel, *Dreissena polymorpha*, in the Laurentian Great Lakes

by Don W. Schloesser

(US Fish and Wildlife Service, National Fisheries Research Center, Great Lakes, 1451 Green Rd, Ann Arbor, MI 48105, USA)

Attachment (i.e. infestation) of the exotic zebra mussel, *Dreissena polymorpha*, to the exterior shells of unionids in North America was first observed in 1988.

Since then, infestation has become common where the ranges of the zebra mussel and unionids overlap. European studies indicate that unionids are a preferred substrate for zebra mussels, but give little evidence that unionid populations are affected by infestations.

In the Great Lakes however, infestation of unionids may be as high as 10,000 mussels/unionid and adds up to 300 per cent wet weight biomass/unionid, prevents normal valve movements,

reduces long-term fitness, reduces diversity, and extirpates local populations.

At present, I do not know if negative impacts on unionids caused by zebra mussel infestation will occur throughout North America as zebra mussels spread. However, in one area of the Great Lakes, unionid populations disappeared within one year of the time zebra mussels entered the exponential rate of reproduction and survival.

Therefore, the ultimate fate of unionids during the next decade may depend on the development of research methods and management applications to minimise the effects of zebra mussels on unionids in North America.

Resource management: a shell exporter's perspective

by Peggy Baker

(Tennessee Shell Company, Inc., 2720 Highway 70 East, Camden, TN 38320, USA)

Tennessee Shell Company is very concerned for the protection and preservation of freshwater mussel shells.

Our industry's survival and the long-term survival of approximately 10,000 jobs is directly dependent upon this renewable natural resource, and we have a responsibility to assure its continued healthy population.

We wish to join with other interested persons in the scientific community, government agencies and our own industry to share information, identify problem areas and find solutions. Sound management is the key to proper conservation of the

resource. Determining regulations needed and their implementation in each State are only the first steps.

Support from State and Federal Government, law enforcement agencies, biologists, as well as industry leaders is essential. Our goal is to see that proper levels of concern within our industry, including the harvester (musseler), the field buyer and the exporter, are maintained.

I will also briefly cover the current mussel industry marketing conditions including information as to quantities and quality/yield requirements, and the potential impact of freshwater mussels from China.

Freshwater mussel management in the Mississippi river and pearl culture in Pacific atolls: An obligate symbiosis?

by Neil A. Sims

(Editor, *Pearl Oyster Information Bulletin*, 73-4369 Old Gov. Mauka Road, Kailua-Kona, Hawaii 96740)

This presentation gives a synopsis of Pacific pearl culture developments, and examines their relationship with the American freshwater mussel industry.

Black pearl culture represents a lucrative development opportunity for many isolated Pacific atolls, where the only alternative activities are copra-drying or fishing.

The typical pearl farm operation in these lagoons is described. Some recent and impending industry

developments are reviewed, and their possible effects on the small-scale Pacific Island pearl farmer are examined.

The status of the American freshwater mussel industry could have some significant impacts on these farmers and on the development of pearl culture; there may also be potential for direct links with the US. Rather than being a passive host, the American mussel industry could look more closely at opportunities for mutual benefit.

List of publications

Daniel S. Dev, of Tamilnadu, India, provided the following list of publications:

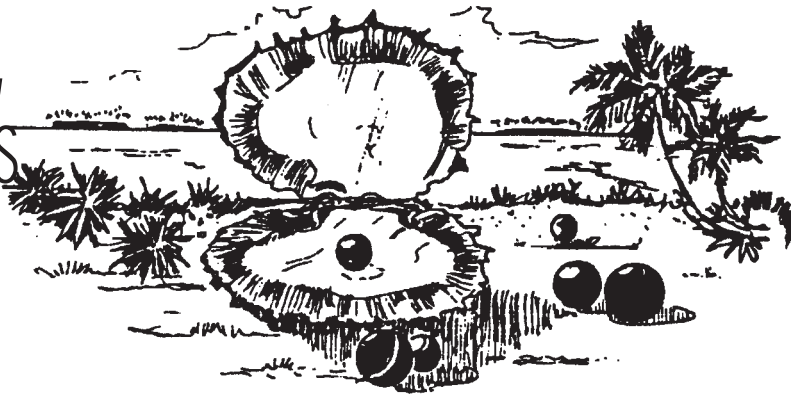
List of research publications

1. On the growth of the pearl oyster *Pinctada fucata* (Gould) under farm conditions at Tuticorin, Gulf of Mannar. *Proc. sem. coastal aquaculture, 1983, 2: 587-589.*
2. Review of the Tamilnadu fisheries pearl culture research in the Gulf of Mannar and the viability of cultured pearl industry. *Proc. sem. coastal and inland fish culture in Tamilnadu, 1980: 232-236.*
3. Observation on the heavy mortality of the pearl oyster in the farm at Tuticorin due to sudden fall in salinity. *Proc. sem. coastal and inland fish culture in Tamilnadu, 1980: 237-240.*
4. Growth of pearl oyster *Pinctada fucata* (Gould) in cage culture at Kundugal channel, Gulf of Mannar. *Indian Journal of Marine Science, vol. II June 1982: 193-194.*

5. Influence of predatory gastropods on the survival of *Pinctada fucata* in cages. *Proc. Netl. sem. cage, pen culture, 1983*: 115–117.
6. Report on cultured pearl production in *Pinctada fucata* (Gould) in Gulf of Mannar. (in press). *Madras Journal of Fisheries Ms. 1982*.
7. Observations on the growth of pearl oyster *Pinctada fucata* in cage culture in Gulf of Mannar. *Proc. Netl. sem. cage, pen culture 1983*: 11–114.
8. Economic viability of cultured pearl production in the Gulf of Mannar. *Research & Industry*, vol. 27 Sept. 1982: 245–246.
9. Culture pearls from freshwater mussel: Tamilnadu's achievement. *Fishing Chimes*, Sept. 1984: 26–27.
10. Studies on the pearl oyster population in pearl oyster grounds off Tuticorin in Gulf of Mannar. *Nat. sem. on shell fish resources and farming, 1987. CMFRI 42*: 79–83.
11. On the growth of pearl oyster *Pinctada fucata* in commercial farm at Krusadai Island. *Ibid*: 295–298.
12. Rearing of pearl oyster *Pinctada fucata* in purse-type HDPE bag at Tuticorin farm (abstract). *Ibid*: 35.
13. Observations on the bio-fouling in pearl oyster farm at Krusadai Island, Gulf of Mannar, India. *Ibid*: 306–310.
14. On the large-scale predation by the gastropod *Cymatium cingulatum* on pearl oysters. *Ibid*: 311–313.
15. On Indian pearl oysters and utilisation (abstract). *All India symp. on aquatic organisms, Poondi 1987*: 9.
16. On the distribution pattern of gonadial stages in pearl oyster *Pinctada fucata* (Gould) for pearl culture in relation to seasonality and lunar periodicity. *Indian Journal of Marine Sci. Ms. 1590. 1988*.



CONGRESSES, CONFERENCES and WORKSHOPS



Regional Technical Meeting on Fisheries discusses collaboration on Pacific Island pearl oyster resource development

*Source: South Pacific Commission
24th Regional Technical Meeting on Fisheries
Report - Agenda Item 7*

Collaboration in Pacific Island pearl oyster resources was listed as a specific agenda item at the last Regional Technical Meeting on Fisheries, held at SPC headquarters in Noumea from 3 to 7 August 1992.

An overview of the discussion is contained in the extract below.

The SPC Fisheries Co-ordinator, introducing this topic, noted the recent increase in interest in pearl oyster development in the region, stimulated largely by the success of French Polynesia in this industry. He referred the Meeting to Working Paper 8.

The Representative of Cook Islands noted that the pearl oyster industry and shell industries in general were very important to several of the smaller Pacific Island countries. He recalled that recommendation 15 of RTMF 23 had involved an offer by French Polynesia to co-operate on a regional level with respect to the development of the blacklip pearl oyster industry, and asked what actions had been taken to activate the offer.

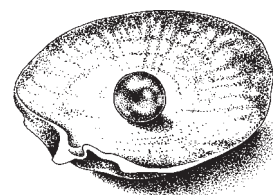
The Representative of French Polynesia described at length the role of his Government and the private sector in the development of pearl oyster farming techniques. He noted that this industry had been pioneered in French Polynesia.

The Representative of French Polynesia further noted that collaboration in the pearl oyster industry was essential. However, it was suggested that technology provided to other Pacific Island countries by French Polynesia should remain confidential and that products should be marketed, at least during the first five-year period, through the established marketing structure in French Polynesia. After questioning, the Representative of French Polynesia explained that confidentiality was thought to be necessary to reassure the established

industry in French Polynesia. He also explained that a common marketing structure was not designed to control production but to ensure that a high-quality product would be maintained.

The Representative of ACIAR outlined that organisation's recent initiatives in pearl oyster research. ACIAR was particularly interested in the areas of disease diagnosis, health management and population genetics, and was co-operating with SPC on pearl oyster stock assessment and resource enhancement. It was currently developing a project with SPC, Kiribati and Cook Islands on developing simple but robust techniques of spat production as the basis for rehabilitation of wild stocks and to sustain possible future culture operations.

The Representative of the Cook Islands expressed a wish for shell industry research to become part of the work programme of SPC, subject to the availability of funding. The co-ordination of research on resource enhancement, farm management and control and marketing were suggested as key areas of SPC involvement. It was further suggested that the development of a regional marketing strategy might be an appropriate starting point.



The prognosis for Mississippi mussels is not good

by Neil A. Sims
Black Pearls, Inc.
Kona, Hawaii

The Upper Mississippi River Conservation Commission convened a symposium on freshwater mussels in October 1992 in St Louis, Missouri, USA, to discuss the status of these resources, and to review conservation and management strategies. We are all aware of the importance of these mussels to the cultured pearl industry, and we are becoming increasingly concerned with reports of wide and varied threats to this resource.

During the symposium, we were disappointed to learn of the very real and imminent nature of many of these threats. These mussels must contend with:

- habitat losses due to mining, impoundment, dredging and other channel alterations;
- inadequate water quality standards, and a lack of information on the susceptibility of the mussels to contaminants;
- competition with exotic species, most notably the zebra mussel and the Asian clam;
- lack of information on the life history, nutritional and environmental requirements; and
- an inability to produce and culture juvenile mussels.

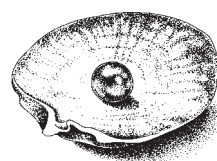
Over the three days of the symposium, a growing sense of pessimism developed. As well as many of the smaller or more obscure species being driven to extinction, there is a diminishing supply of larger, commercial-grade shells. Some attempts are being made at captive holding, propagation and reintroduction programmes, but it all felt a little like a

'finger in the dyke'. The host fishes are often not known, and the larval stages are complex. The animals are painfully slow-growing (some species take 20–30 years to reach marketable size), and are quickly smothered by invading zebra mussels.

There are some hopeful signs for the industry. A few of the thicker-valved species show resilience to zebra mussel smothering, and appear to be reproducing fairly well in dam reservoirs. Large size beads used in *P. maxima* and *P. margaritifera* pearl culture may therefore still be available – although no-one wanted to guess what the production prospects were like for the long term.

It was surprising to see and hear how little the freshwater mussel folk knew of the pearl culture end of their industry. Nevertheless, more of the mussel men and women are interested in setting up their own bead-making plants, and marketing direct to the pearl farms themselves.

In a presentation for the Japan Pearl Exporters' Association, and the Cultured Pearl Association of America, Devan McNow provided an estimate for overall value of the worldwide pearl culture and pearl jewellery industry of US\$3 billion per year. Between 8 and 12 per cent of all jewellery traffic is pearls, with around 300,000 jobs reliant on the industry. With so much at stake, there is an added imperative to find solutions for the beleaguered mussel resource.



Pearls '94: First International Pearl Conference

Source: Richard Fassler
Aquaculture Development Programme
Honolulu, Hawaii

Pearl meeting to address industry problems and opportunities

Hawaii will be the site for **Pearls '94**, an international pearl conference and exhibition. This will be the first truly international gathering of pearl producers, jewellers, government officials, distributors, equipment suppliers, scientists and investors.

The conference comes at a time when the world's pearl industry is going through a period of significant change. Japan is losing its long-held domi-

nance. China is becoming a powerful player, with much good-quality, low-priced product. Japanese implanters may be replaced by far cheaper technicians from China and other nations.

Black pearl culture remains strong in French Polynesia, but Tuamotu farmers will experience increased competition from other Pacific Islanders. Australia, with emerging labour problems, is being

challenged by the dramatic increase in Indonesian production of *P. maxima*. Africa and Latin America, two areas of the world without a tradition of pearl farming, are getting ready to take the plunge. International economic assistance organisations are recognising the development potential of pearl farming and are evaluating where to invest million of dollars.

Important questions are emerging. What does the entry of low-cost Chinese product and labour mean for the future of the pearl industry? If the Japanese can no longer maintain their top position, what will happen to price and quality control? How should black pearls be promoted - 'Tahitian'? 'South Seas'?

What can we expect from technical breakthroughs in the areas of disease prevention and hatchery production? Can the industry be assured a steady supply of nuclei from American mussels? What will be the effect of many new countries starting pearl farming operations? And is an international pearl association needed to stabilise the industry?

Pearls '94 will attempt to answer these questions - and more. In the words of one long-time observer of the pearl industry, 'This conference is desperately needed!'

More than 500 people from throughout the world are expected to gather in Honolulu at the Sheraton Waikiki Hotel from 15 to 19 May 1994, to meet and hear industry leaders; exchange information; buy, sell and trade pearls; and participate in an exhibition that will feature pearls of all colours, shapes and sizes. Experts from Japan, China, French Polynesia, Australia, the Cook Islands and Indonesia will address the conference.

Pearls '94 will be divided into three sessions:

- Technical production;
- Jewellery/marketing; and
- Government/international agency assistance.

The technical production sessions will be organised by Dr John Rowntree and Mr Ken Craib of RDA International Inc., Placerville, California, and Mr Neil Sims and Dr Dale Sarver of Black Pearls Inc., Kailua-Kona, Hawaii. The sessions will include such topics as site assessment; farm layout; grow-out; hatchery production; water quality analysis; disease prevention; equipment purchase and use; environmental considerations; and implant techniques.

A call for technical paper will be issued by mid-June.

The jewellery/marketing sessions will be handled by the Hawaii Jewellers Association, assisted by the Gemological Institute of America. The focus will be on such areas as quality control; educating the buyer; pricing; distribution; retail and wholesale sales; and advertising and promotion.

The government/international agency assistance sessions will be headed by Mr John Corbin and Mr Richard Fassler of the Hawaii State Aquaculture Development Programme, with Mr Garry Preston of the South Pacific Commission co-operating. Sessions will include strategic planning research and development analysis; project feasibility evaluation; investment considerations; research funding; financial assistance; extension support; and technical information dissemination.

Conference organisers will be asking Hawaii Governor John Waihee to declare the week of 15 May 'Pearl Week' in the Islands. They are planning a jewellery design contest, a Pearl Princess competition and a reception and major exhibit at the Bishop Museum, which will feature traditional uses of pearls and mother-of-pearl in Polynesian society. They are also exploring the possibility of holding a pearl auction, and discussing opportunities for field trips to local manufacturers of pearl jewellery and to pearl farms in French Polynesia.

The principal hosts for **Pearls '94** are the Aquaculture Development Programme of the State of Hawaii Department of Land and Natural Resources, and the Hawaii Jewellers Association.

Anyone seeking information on the conference or wishing to be placed on the mailing list should contact conference organiser:

Mr Richard Fassler
Aquaculture Development Programme
335 Merchant Street, Room 348
Honolulu, Hawaii 96813
Telephone: (808) 587 0030; Fax: (808) 587 0033.

Anyone wishing to become a **Pearls '94** sponsor should contact:

Ms Robin Crest
President
The Crest Organisation
940 Emmet Avenue, Belmont
California 94002, USA
Telephone: (808) 415 2625; Fax: (415) 595 3379.

Welcome to new members

by J.P. Gaudechoux
South Pacific Commission
Nooumea, New Caledonia

The Pearl Oyster Special Interest Group is growing. We had received additional completed questionnaires from the individuals listed below. The previous lists of members are available in the five issues of the *SPC Pearl Oyster Bulletin*.

If you are on the list and your name and address is wrong, please send us a correction. If you are not on the list and would like to be, fill in the form enclosed with the bulletin or write to us for a new one.

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