



**Fisheries Information
Project
South Pacific Commission
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PEARL OYSTER

INFORMATION BULLETIN

NUMBER 1

FEBRUARY 1990

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ABOUT THE PEARL OYSTER SPECIAL INTEREST GROUP

Greetings, and welcome to the inaugural edition of the Pearl Oyster Information Bulletin. This newsletter is the medium, catalyst and standard-bearer for the Pearl Oyster Special Interest Group (SIG). The Group has been established with the aim of promoting co-operative research and information exchange between pearl oyster workers in the Pacific, and outside the region.

Most of us who work in the Pacific Islands have, at one time or another, felt hampered by our isolation in our respective countries and fields. Communication difficulties have been recognised as one of the principal constraints on fisheries research in the Pacific. The SPC Workshop on Pacific Inshore Fishery Resources, held in Noumea in early 1988, identified the establishment of SIGs such as this one as an appropriate means of redressing this problem. Further impetus to the formation of this particular group was given by the recent SPC Regional Technical Meeting on Fisheries, held in Noumea in August, 1989. The meeting highlighted the burgeoning interest in pearl oyster development among Pacific Island countries, and recommended the prompt formation of a pearl oyster research and development group.

The Pearl Oyster SIG is intended primarily to address your needs. Do you want to find out what spat-collec-

tor materials other folk are using? Thinking about designing a stock assessment survey? Need to know who

else is culturing your species? Want a guiding hand towards the major references on pearl oyster diseases, death, and other disasters? If the answers are not in the pages of the Information Bulletin, then at least there should be the name and address of someone you could write to and find out. The Editor, or staff of the SPC Fisheries Information Project will be happy to assisting in answering questions.

As a newsletter, the bulletin should be informal and informative. It is a co-operative venture; you are encouraged to share what you are doing with all of us, and thereby become part of the wider network of pearl oyster people. Any and all contributions are welcomed. We are interested in news, reports of recent progress (or lack thereof), formal announcements, recent publications, reviews or abstracts. Contributions should be forwarded to the Editor at the address above, or to SPC. Requests for copies of papers, further details on news items, or other correspondence with specific workers should be addressed direct to the individual or institution concerned.

As an information service, we hope to include a regular listing of recent publications in each 6-monthly issue of the Pearl Oyster Information Bulletin. If you

have published recently, or are aware of a recent paper that has not been listed here, please let us know. In future issues we hope to publish reviews of the most relevant literature, to help make it more accessible.

As a multi-lingual fraternity, Pacific pearl oyster workers also need to have access to translation services. There is a limited capacity for French-English and English-French translations of important pearl oyster papers through the Inshore Fisheries Research Project at SPC. There is also a need for

Japanese-English translations, and we are presently trying to identify an avenue for having these done.

As you have received a copy of the inaugural issue, your name is already on the mailing list. If you have only "borrowed" this copy from someone, or if you know of someone who is involved in pearl oyster research, development, or management who would be interested in participating, then please forward name and address to the Editor, or to SPC.

Neil SIMS

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We had received completed questionnaires from the individuals listed below at 31 January 1990. 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 want to be, fill in the form enclosed with this bulletin or write to us for a new one.

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PEARL OYSTER NEWS

Pearl culture techniques

Source: Austasia Aquaculture Magazine

Cultured pearl production is difficult and requires skilled technicians to perform the "seeding". The method of operating a pearl oyster shell involves the insertion of a round shell bead and a small piece of mantle into a host oyster. Almost all round pearl operations are carried out by Japanese technicians. The majority of half pearl operations are also carried out by Japanese technicians. However, the half pearl operation is less difficult than for round pearls.

On completion of the operation, the shells are promptly returned to the water for post operative care before being transported by sea to grow-out structures on the farm. The oyster develops an envelope of nacre-secreting tissue, a pearl sac, around the nucleus and begins to deposit nacre as mother of pearl on it. This continues for the development time of the pearl. During the culture period, the shells are held in baskets on rafts or in on-bottom rafts, and are regularly cleaned.

Another type of cultured pearl, the seedless or "keshi" may form in the pearl sac after a nucleus has been rejected. These are sometimes grown deliberately by conducting the normal round pearl operation short of introducing the nucleus.

After two years, the shells containing the pearls are retrieved. Some shells are used again – the re-operation involves the insertion of a new nucleus the same size as the pearl harvested. Some shells have been known to produce four round pearls before being considered unsuitable for round pearl production.

After harvesting, the pearls are washed in fresh water and detergent to remove mucus and other biological material which may adhere to them. They are then polished in a tumbler filled with table salt after which they are washed again in fresh water and dried prior to final polishing in a tumbler filled with bamboo chips. The pearls are finally graded by experienced workers for valuing and sale.

Any shells considered by the technician to be not worthy of a second operation are set aside for the production of "mabe", or half pearls. These are produced by gluing plastic nuclei onto the insides of both halves of the shell.

The shells are then returned to the water and require minimum care until they are harvested between eight

and twelve months later. In that time, a layer of nacre is laid down over the nuclei in a response similar to that described earlier. The shells are killed during the harvest of half pearls and the half pearls are removed using a hole saw. Around seven half pearls can be harvested from each pair of shells. Popular shapes include half round, tear drops and heart shapes.

Gold-lip (*Pinctada maxima*) In Torres Strait And Northern Territory, Australia

The Fisheries Research Branch of the Bureau of Rural Resources has been involved in the pearling industry in Australia since 1986. The role of the branch has been to provide scientific advice to the managers of the pearl fishery, the Australian Fisheries Service. The Branch has also been involved with collecting biological information on gold-lip pearl oyster, *Pinctada maxima*. Two pearl bed surveys have been undertaken in 1989 in Torres Strait and the Northern Territory. A technical paper is being prepared on this species.

Torres Strait: At present there are 5 pearl farms operating in Torres Strait. Since the early seventies, the amount of shell being collected in Torres Strait has declined dramatically, and this has been of great concern. Between March and June of this year a survey was undertaken in Torres Strait targeting areas where shell had been found in the past. The survey was based on a stratified random sampling technique, and at each site the following information was collected:

- A video camera was used to photograph the sea bed during each 30 minute drift
- At the same time, 2 divers accompanied the camera. 1 diver recorded the benthic fauna, sediment type, and depth every 5 minutes. The second diver collected shell.

- A benthic dredge was used to sample the bottom fauna. These samples were later sorted and identified in the laboratory.

- A sediment sample was also collected at each dive site for grain size analysis.

The aim of the project is to develop a model for the occurrence of shell using visible markers of habitat type. These data have not been analysed yet.

Northern Territory: *P. maxima* was collected in the Northern Territory up until the late 1960's. There is one farm operating in this area, but shell for this farm is collected in Western Australia. In 1986 a decision was made to develop the pearl culture industry in the Northern Territory and 6 research and development licenses were issued. In order to collect base-line information on this fishery, a survey will be undertaken between October and December, 1989. The techniques used will be the same as for the Torres Strait survey.

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Shark Bay Management Review

The Fisheries Department of Western Australia has published a Fisheries Management paper (No. 27) by Dr Don Hancock, entitled "A review of the Shark Bay pearling industry". The culture of pearls in Shark Bay is only a recent development, and only two permits had been issued. With the imposition of limited entry in the Broome culture industry for gold-lip (*Pinctada maxima*), however, increased interest has been focussed on the culture of the Shark Bay pearl oyster (*P. albina albina*).

This review addresses the issues associated with managing an expanding culture industry. As a whole, it provides a comprehensive overview of management issues and possible solutions. The perspectives it carries are not always applicable to

the Pacific Island situation (eg. how appropriate, at the developmental stages, are ceilings on the number of farm licenses where traditional tenure is at least implicit?), but some worthy points are made. The issues of conflict between pearl culture and other maritime user-groups are highlighted. The establishment of a self-regulatory association of pearl producers is also recommended. Copies are available from the Department of Fisheries, P.O. Box 20, North Beach, W.A., 6020, AUSTRALIA

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Cook Islands Pearl Industry Developments

By 1985, the viability of small-scale simple technology pearl-oyster culture in the Cook Islands had been proven. The first crop of cultured black pearls was harvested from eight privately-owned farms in Manihiki, this past April. The harvest took place 18 months after the Japanese seeding technician had operated 10,000 oysters. Quality of pearls was mixed, with some exhibiting excellent colour. Pearls harvested from oysters originally collected on artificial spat-collectors were superior in every respect to those produced from pearl oysters which had been collected from the wild.

A further return from this harvest has been the heightened interest among neighbouring islands in the development of their own pearl farming activities. Requests for assistance in this area have been directed to the Ministry of Marine Resources through the Island Councils of Penrhyn, Rakahanga, and Pukapuka. Particularly pleasing is the increased dialogue between central government and the various Island Councils on matters relating to pearl farming.

Developmental work in pearl farming is also being undertaken on Suvarrow to establish a government-owned pearl farm. This facility will have a research and training component which could have significant regional implications, particularly with respect to collaborative training and extension work.

The Ministry of Marine Resources is in the process of putting in place a national management regime for the cultured pearl industry. It is envisaged that the plan will, through discussions with those involved at all levels, lead to the acceptance of the basic concepts for a broad management plan which could then be tailored to meet the specific needs of each island.

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Pearl Oyster surveys in the Marshall Islands

Freshly returned from his participation in the survey of pearl oyster resources in Christmas Island (see article this issue), Marshall Islands Fisheries Officer Ron Alfred carried out another survey, this time in Namorik atoll in his home country, and assisted by colleague Nena Kilma. The survey followed a request from the Namorik Island Council for help from the Marshall Islands Marine Resources Authority (MIMRA) in assessing the potential for pearl oyster culture activities there.

Pearl oysters have been reputed to be abundant in Namorik for some time, but no controlled assessments have previously been made. Some limited survey work was carried out by a Japanese team in 1984: as well as Namorik, this survey included the atolls of Ailinglaplap, Maloelap, Likiep, Mili and Arno. Namorik was the only one of the 6 atolls found to have shell in any abundance (during two of the four survey dives carried out, the numbers found were 34 and 10: during the other two, the divers noted that pearl shell were "abundant" or "sufficient"). The only other atolls where pearl oysters were found during the survey were Likiep (4 shell in a single dive) and Mili (1 shell in each of two dives, with some dead shell being noted). No shell were found at Arno, despite the fact that a small private pearl oyster farm now operates there.

Subsequent attempts by a Japanese company to negotiate a lease to farm pearl shell on Namorik came to nothing, mainly because agreement on the terms could not be reached with the islanders, who wanted to be more involved with the development of their own resources. It was in order to support this independent approach to development that the present survey was carried out, as a precursor to the development of culture activities.

A total of 28 4m x 100m belt transects were laid in the lagoon in depths down to 6m. The transects were searched by free-diving and all pearl oysters found inside them were measured (dorso-ventral shell length). A total of 148 oysters were found and measured. Average density inside the transect areas was 1.3/ 100 m²: extrapolation of this to the total area of the lagoon gives an estimated standing stock of some 520,000 oysters in the 40 km² lagoon. This can only be considered as a rough guess, however, since the area of actual pearl oyster habitat in the lagoon is not known. Nevertheless the contrast between the survey results from Namorik and from Kiritimati is clear. The culture options in Namorik appear to be good, and the next step is to start looking at these in more detail.

Garry Preston

Spat collector construction costs

Spat collectors are an essential part of any farming operation for the black-lipped pearl oyster, *Pinctada margaritifera*. Putting out spat collectors should be one of the first steps in setting up a farming operation. They increase the amount of settlement of pearl oyster juveniles spawned in the lagoon, thus providing a source of supply of oysters for farming purposes, and relieving the pressure on the wild stock, as well as the labour of collecting from the wild. The oysters they provide are generally of better quality for farming purposes than stock collected from the wild:

the mother-of-pearl they secrete often has a better colour and more lustre, and growth rates may be better. Spat collectors are also simple and fairly inexpensive to make and deploy. A typical spat collector unit consists of a main-line, which may be from 30m to 500m or in length, and from which are hung individual spat collectors every metre or so. The collectors may be made from a variety of materials, as shown in the figure below. These include branches of rot-resistant bushes, coconut husks or plastic sheeting inside mesh bags, or shade cloth tied up into strips, cylinders or bundles.

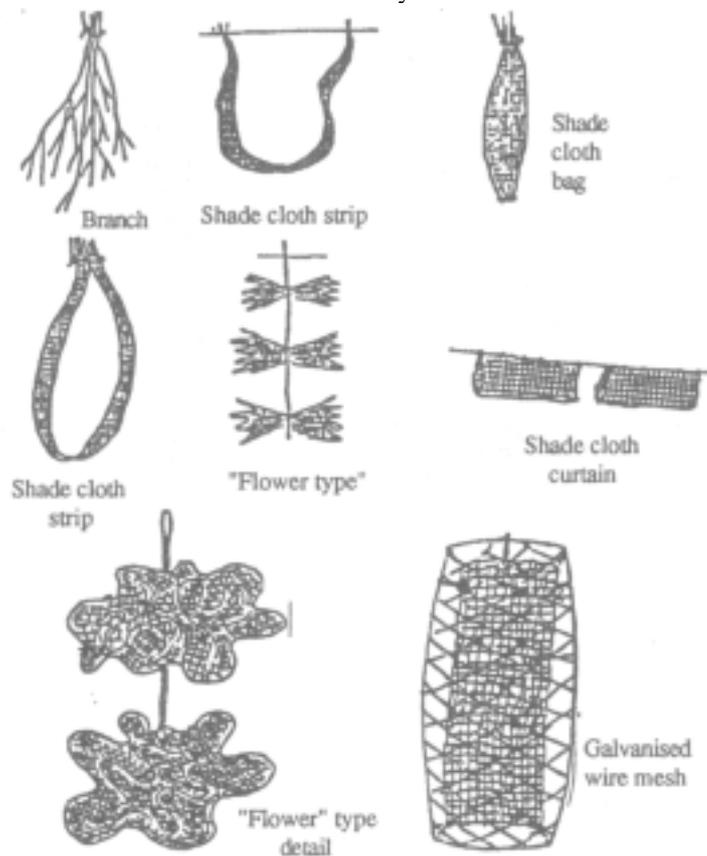


FIGURE 1 Spat collectors types (after Hauti et al, 1987)

The main-line is deployed a couple of metres below the sea surface inside the lagoon. It is kept in place by using short lengths of rope to tie it to coral heads, rocks, or, if necessary, specially placed cement blocks

or other moorings. The line is kept from sinking by buoys, often used longline floats, attached to it at intervals. A typical spat collector arrangement is shown below.

In 1985/86, the average cost of materials used in constructing a spat collector line 50m long in Takapoto, French Polynesia, was estimated at 90,000 CFP (Hauti et al, 1987).

Cost per 50m of spat line in each of the three sample locations was therefore as follows:

Rarotonga, Cook Islands	NZ\$	218
Christmas Island, Kiribati	A\$	190
Takapoto, French Polynesia	CFP	90,000

The use of galvanised wire mesh bags to cover the collector has been abandoned in French Polynesia. Originally intended to protect juvenile pearl oysters from predation, it was found that they prevented settlement of pearl oyster larvae by becoming clogged with other growth.

According to the French Polynesian experience, pearl oyster larvae seem to prefer the folded configuration of the "flower" collector shape (see figure 1 above). Some collectors of this type in Manihi had settlement of over 1,000 larvae each. As the larvae grow into juveniles, they must be harvested and transferred to

US dollar exchange rates for the currencies quoted in these articles were as follows in February 1990:

US\$ 1.00 = CFP 111 = A\$ 1.26 = NZ\$ 1.58.

proper grow-out conditions, preferably by the time they are 30mm in diameter. If this is not done, crowding will cause the number of spat will diminish, either by dispersal (small pearl oysters are capable of movement) or mortality due to competition. The number of spat on one collector in Manihi was observed to fall from over 1,000 to 30 as the juveniles grew (Hauti et al, 1987).

Garry Preston

South Pacific Commission

Exchange rates have varied widely over the period covered by these articles. Costings should therefore be taken as indicative only, and confirmed independently if necessary.

Christmas Island (Kiribati) Survey

A survey of pearl oyster stocks was recently undertaken in Christmas Island, Kiribati, by Being Yeeting (Research Unit, Fisheries Division, Ministry of Natural Resource Development, Kiribati), Garry Preston (Inshore Fisheries Research Project, South Pacific Commission), Ron Alfred (Marine Resources Authority, Ministry of Resources and Development, Marshall Islands), and Neil Sims (Zoology Department, University of New South Wales, Australia). Funding for the work was provided by the SPC Inshore Fisheries Research Project, UNDP, and the Kiribati Government.

Commercial quantities of shell had been taken from Christmas lagoon in the last century. Earlier this year, some trial purchases of shell had been made by the Marine Exports Division. The Fisheries Division needed to know if a commercial shell fishery was sustainable, and what management was appropriate.

Pearl oysters were concentrated in the deeper areas of the lagoon, close to the open passages in the west. The survey involved use of belt-transects, with stations selectively sited to obtain a broad picture of the pattern of distribution of pearl oysters. Unbiased estimates of maximum densities were obtained by randomly sited stations in the areas of greatest abundance. Spat-collector trials were initiated, with five lines each of 50 collector bags set through the lagoon. Unfortunately, insufficient younger pearl oysters were

found to permit any meaningful growth trials being established.

A total of only 34 pearl oysters were found during the survey, in densities that did not exceed 1 animal/100m² and averaged only 0.54/100m² in areas where pearl oysters were present. Extrapolation of average densities to the estimated 11 km² of suitable pearl oyster habitat in the lagoon gives a projected standing stock of about 60,000 shells – 23,000 (95% confidence limits). The population is therefore depauperate: this is probably attributable to the heavy harvests of the last century, and the more recent harvesting at lower levels, which, combined with heavy predation and poor conditions for juvenile settlement, has prevented population re-establishment. There is little or no potential for commercial exploitation of the wild stock in its present condition, and the survey team recommended a moratorium on further harvesting.

The potential for establishment of pearl farming activities was also assessed. Provided that steps are taken to re-establish the wild stock – deployment of spat collectors, juvenile on-growing, and perhaps broodstock aggregation – there is probably potential for farming activities, although not for several years. Nevertheless, conditions are not ideal in Christmas Island lagoon: large passes to the west and hypersaline conditions to the east and south mean that larval loss will probably be high, while the shallow, exposed

lagoon means that sturdy platforms will have to be used for shell growing, rather than the cheaper and easier to construct long-lines.

hauling. This will hopefully provide enough pearl oysters for initiation of grow-out trials.

Being is currently acclimatising to the weather at Bangor, on the north coast of Wales, where he is to undertake a Masters degree. On his return next year, the spat-collectors in Christmas should be ready for

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Pearl Oyster culture in three French Polynesian atolls, 1986-1987

Introduction

This information is extracted from two 1987 publications by A. Hauti et al (see reference listing this issue) of the French Polynesian Service de la Mer et de l'Aquaculture (SMA). All information relate to the black-lipped pearl oyster, *Pinctada margaritifera*. We hope to update and expand the information in the next issue of the bulletin.

Table 1 below gives details of the number of licenses issued by the French Polynesian government for activities related to pearl culture. Field studies by the SMA have helped to verify the true extent of culture activities (for a variety of reasons, some licensed operators do not always carry out culture activities, while others exceed their license entitlements).

Table 1: Pearl culture licenses in FP in 1987 (and since 1977)

Number of licenses								
Island group	Collecting		Ongrowing		Pearl farms		Total	
Society	0	(2)	0	(2)	0	(0)	0	(4)
North Tuamotu	340	(488)	174	(279)	53	(97)	567	(864)
South Tuamotu	53	(99)	23	(45)	10	(15)	86	(159)
Gambier	10	(23)	8	(21)	2	(14)	20	(58)
Total	403	(612)	205	(347)	65	(126)	673	(1085)

The three atolls described in the two reports are Takapoto, Ahe and Manihi, all in the Tuamotu islands. Pearl culture operations fall into three categories - spat collection, juvenile ongrowing (for sale to other farmers) and pearl culture. A brief description of the situation at each atoll is given below.

Takapoto

The first spat collectors were deployed in Takapoto in September 1976. Because of the good results obtained, spat collection and ongrowing activities became extensive and the island became the principal supplier of seed oysters to pearl farmers in other islands of the Tuamotu group, notably Manihi, Arutua, Ahe and Aratika. The business of producing juveniles was lucrative, and local pearl farmers would import their preferred spat collector material, branches of a bush called 'mikimiki', from Tahiti.

Following the cyclones of 1983, which destroyed most coconut trees in the Tuamotu Islands, many small farmers turned to pearl oyster culture. Additionally, some Takapoto residents living in Tahiti

have been encouraged to return home after seeing the success of pearl culture operations there. Since the establishment of the industry 10 years ago, the population has nearly doubled. Most pearl oyster culture activity continued to be in ongrowing juveniles for sale to pearl farmers elsewhere. The price paid locally for live pearl oysters varied from 120 CFP for a 50mm individual, to 350 CFP for a 110mm shell.

In June 1985, massive mortalities occurred because of an unidentified disease. Signs of the disease were still evident in 1986, in both cultured and wild shell, and it seemed to be associated with increased production of faeces or pseudo-faeces by the oysters. Another recent development at the time was a noticeable increase in fouling of the shells by other marine organisms. In particular, growth of a particular kind of colonial tunicate was very heavy: this sometimes extended inside the edges of the shell valves, preventing their closure.

To prevent the spread of the disease, the government banned export of live pearl oysters out of Takapoto in 1986. As a result, some of the farmers principally

involved in spat collection and ongrowing were forced to turn towards pearl culture proper, and this involved greater capital outlays. Others left the island, either to look for alternative income-earning opportunities, or to set up farms on neighbouring islands such as Takaroa and Arutua.

Spat collector success was variable, and clearly linked to upkeep and general cleanliness. Typical average settlement rates observed in different parts of the lagoon were between 12 and 23 spat per collector bag. However, taking into account that many of the collectors were only newly deployed, and others appeared abandoned, it was estimated that an average settlement rate of about 30 spat per bag would be typical of a clean, properly maintained collector.

Spat are normally removed from the collector bags at a size of about 30mm diameter. However, manpower shortages and other reasons sometimes cause the spat to be left until they reach 50 or even 70mm diameter. The pearl oysters are then transferred to platforms (made from galvanised steel piping) or long-lines for ongrowing in individual bags, lantern baskets, or attached to hanging strings by a hole drilled through the base of the shell. In some cases, the shell are left on the lagoon floor or in cages to grow loosely. Most of the shell are grown on for sale to other farmers, while a smaller proportion are used for pearl culture proper.

Finally, the season for wild pearl collection in Takapoto was opened during February 1986, with an overall maximum quota of 30,000 shell authorised to be taken. The season lasted for 7 days and resulted in a harvest of 56,422 shell. On the first day the harvest was 14,261 shell: by the last day it had declined to 4,020.

Overall, pearl oyster growers on Takapoto were concerned about the future, particularly in view of the disease problems they had experienced. SMA staff judged that there were too many operators active in some parts of the lagoon and that farming effort needed to be distributed more evenly. Many collecting and growing stations, even those bearing oysters that had been operated, suffered greatly from neglect and some appeared to have been abandoned. This was partly due to the recent ban on transfers, but also partly due to poor management and lack of technical training.

Ahe

Ahe has the smallest population and lowest level of culture activity of the three atolls described. Local pearl oyster farmers had not abandoned the use of galvanised mesh grills over spat collector bags: this has been found to be inappropriate because fouling organisms soon block the mesh, inhibiting settlement, respiration and feeding by pearl oysters.

Additionally, when juvenile pearl oyster were harvested from the spat collectors (after reaching a diameter of about 50mm) they were drilled and attached to a string which was also placed inside a galvanised mesh bag intended to protect them from predators. Rapid and heavy fouling of the mesh by other organisms led to high mortality of the oysters inside due to suffocation or inadequate food supply.

Because of the use of the protective mesh, many oysters were observed to be moribund, some of the signs including abundant mucus secretions, necrosis of the outer mantle, infected adductor muscle, deposition of brownish material on the inside of the shell valves, and twisted or irregular growth spines. This was clearly to the detriment of pearl culture activities, which was the ultimate aim of most operators, and which requires healthy oysters if good quality pearls are to be produced. The operators on Ahe had not really mastered pearl oyster farming techniques by 1987, and needed further training in this area.

Manihi

The first pearl oyster farm on Manihi was established in 1968. Between then and 1986, 21 pearl farms had been set up. The natural stock soon proved inadequate to supply all these farms, but fortunately the development of spat collection activities in Takapoto provided an adequate supply. During that period, the experimental introduction of "flower" type spat collectors enabled good spatfalls. Sometimes settlement rates exceeded 1000 (range: 18 to 1054) spat per collector bag since the galvanised mesh type was replaced by the "flower" type. However, by 1987 these had still not been fully adopted by local farmers, and the termination of juvenile transfer from Takapoto meant that there was once again a growing reliance on wild stock to supply the farms. Manihi appeared to be just as much in need of training and technical support as the other two islands.

Summary

Vital statistics on pearl farming activities in the three islands (number of operators, number of pearls under culture, etc) are given in table 2.

The total investment in pearl oyster farming activities in the three atolls is substantial, at an estimated 439 million CFP, part of which is provided as government development subsidies or loans. Some of the costs used to derive this figure include the costs of pearl nuclei (50 CFP each), cost of operating the shell (200 CFP each) and cost of the pearl oysters themselves (350 CFP each). No allowance is made for ancillary costs such as labour, boats, motors, diving gear, compressors, fuel, etc., or for the value of shells that may die during culture.

Table 2: Pearl culture operations in three French Polynesian atolls in 1986/87

	Takapoto	Ahe	Manihi
Total number of farmers	82	32	71
Collection			
Number of operators	69*	26	34**
Number of spat lines	444	83	186
Total spat line length (m)	54,979	7,205	22,740
Total investment (millions of CFP)	90	5	16.4
Ongrowing			
Number of operators	26*	14	20**
Number of culture platforms	130	8	391
Total culture platform area (m ²)	4,694	–	–
Number of shell on culture platforms	151,175	2,830	49,953
Number of long-lines	67	42	155
Total long-line length (m)	5,995	4,413	17,847
Number of shell on long-lines	82,236	48,973	116,082
Number of lagoon floor culture sites	5	?	0
Number of shell cultured on lagoon floor	61,500	1,060	0
Investment in materials (millions of CFP)	25	4.6	42.5
Investment in shell stock (millions of CFP)	72	12.2	43.3
Pearl culture			
Number of operators	14*	6	20**
Number of culture platforms	150	?	21
Total culture platform area (m ²)	?	432	–
Number of shell on culture platforms	72,428	3,960	8,033
Number of long-lines	19	?	81
Total long-line length (m)	?	4,474	?
Number of shell on long-lines	19,674	26,868	42,014
Investment in materials (millions of CFP)	11.6	6.15	6.05
Investment in shell stock (millions of CFP)	55	18.65	30.55

* Of 73 surveyed

** Of 52 surveyed

Most operators became involved in pearl oyster farming on their own initiative, with no prior experience or training and no technical support from government or elsewhere. There is a strong need for training and government assistance to pearl oyster

farmers on all three islands. Technical improvements in general needed to be disseminated more effectively.

Garry Preston

South Pacific Commission

Australia's pearl oyster industry

(Source: Austasia Aquaculture Magazine)

The culture of pearls is by far Australia's most valuable aquaculture industry. The last official figures for production were from Western Australia in 1988 – valued at an estimated A\$ 63 million, although the actual figure may be higher. According to the Chairman of the Licenced Pearl Producers Association, Mr Bruce Brown, the 1989 production season may be worth in excess of A\$ 80 million. Since the time the pearling industry was established in Western Australia in 1850, it has gone through many changes, from the original hand gathering of shell for pearls at low tide to the present day sophisticated culturing of pearls.

The history of the pearling industry has been marked by a frequency of Government commissions and investigations, high losses of men and boats through cyclones and diver's paralysis (bends), labour problems, racial tensions, fluctuating prices, depleted stocks, economic instability, shut downs through war years, murder and lawlessness, theft and illegal trafficking in pearls, boat losses from enemy wartime action and finally, through man's ingenuity, to the extensive culturing of pearls.

The industry began with the Shark Bay pearl oyster (*Pinctada albina albina*), with the collection of shell from the banks during low tide. Originally the tiny pearls were the important products, the relatively small shell was merely the by-product. Following this early success, pearlery began to venture northwards and harvest from Nichol Bay on the newly discovered stock of larger shell. This pearl oyster was known as the "Silver Lip" or "Golden Lip" (*Pinctada maxima*), which was the largest of the Australian mother-of-pearl shells and produced the largest high quality pearls.

By 1910 Broome, in Western Australia was renowned as the biggest pearling centre in the world and from which operated some 350-400 luggers with over 3,500 employed in the industry. Thirteen pearl buyers from many different countries were also located in Broome whose population had grown to 5,000. Unlike the Shark Bay industry, the shell itself was the lifeblood of Broome, which supplied 75% of the world output. Any natural pearls found were an additional and keenly sought after bonus.

When World War I broke out in 1914 the world price for pearl shell dropped although throughout the war years 1915-1918 the total production of pearl shell was slightly higher than the 4 years preceding the war. After the war the production gradually declined as did the price for mother-of-pearl, which was being

substituted with the early synthetic (plastic) products. World War II brought about the virtual cessation of all pearling. The industry started up again in 1946 but with an average of only 15 boats per year operating with only about 200 workers.

In 1956 a joint Australian-Japanese pearl culture farm, Pearls Proprietary Ltd, was established at Kuri Bay, 420 km north of Broome. By 1973 Kuri Bay was reported to be producing around 60% of the world's finest round pearls, as well as half pearls and baroque pearls. Nowadays, the majority of production comes from Western Australia, although recently there has been some renewed activity in the Northern Territory and Queensland. Table 1 gives information on some of the farms.

Collection of shell takes place by divers, mostly along the Eighty Mile Beach area, in the north west of WA. Since 1969 pearl diving techniques have been transformed with rubber suits, flippers and hooker breathing apparatus giving divers greater mobility in the water, an increased catch rate and a decreased risk factor. Each lugger is given a quota of shells to fish for the season, which runs between March and September. A diver is paid on the number of shells he picks up, thus competition on the bottom is fierce. Here the divers work in close proximity, often racing towards the same shell. Once collected, the shells are cleaned, sized and placed in basket for storage until they are transferred to the carrier vessel for shipment to the pearl culture farm.

Several species are cultured – the majority of the production is for the gold lipped pearl oyster (*Pinctada maxima*) mostly for cultured pearl, although the shells have been used for mother-of-pearl and some oyster meat has been produced. In the past there has also been some limited production of the Shark Bay pearl oyster (*P. albina albina*) for small pearls, as well as interest in blacklip (*P. margaritifera*) and the winged oyster (*Pteria penguin*).

The traditional Japanese method of pearl culture (see article this issue) is practised by some companies, and involves holding pearl oysters after operation in wire cages or baskets suspended in surface waters from an extensive system of rafts. However, there have been considerable changes in the technique in recent years. The major departure is the holding of pearl oysters on the seabed, both at the collecting grounds and at the leases, where they are less vulnerable to cyclonic conditions than when held on rafts.

Table 1: Some Australian pearl oyster producers

Name	Address	Contact	Collection site	Ongrowing site	Years in operation	Species	Products*
South Seas Pearling Co	P.O. Box 1999, Darwin 0801, Tel: (089) 47-0063, Fax: (089) 47-2103	NDA	NDA	NDA	2	<i>Pinctada maxima</i>	MOP, cultured, meat
A & B Broome Pearl Traders	23 Rokeby Rd, Subiaco 6008, Tel: (09) 382-4077, Fax:(09) 388-1404	W. Reed	Shark Bay	NDA	2	<i>Pinctada albina</i>	seedless, half
Cygnets Bay Pearls	P.O. Box 70, Broome 6725, Tel: (091) 92-4920, Fax:(091) 92-4920	Bruce Brown	North of Broome	Cygnets Bay	27	<i>Pinctada maxima</i>	All
Gemini Ocean Farms	P.O. Box 242, Wickham 6720, Tel: (091) 87-1426, Fax:NDA	Ray Blackney	Pt Samson	NDA	1	<i>Pteria penguin</i>	MOP, half, meat
Arrow Pearl Co P/L	P.O. Box 1236, Broome 6725, Tel: (091) 92 2272, Fax:(091) 92-1562	Stephen Arrow	80M Beach	Beagle Bay	8	<i>Pinctada maxima</i>	All
Bynoe Harboure Pearl Co P/L	P.O. Box 1069, Darwin 0801, Tel: NDA, Fax:(089) 81-5628	Stephen Arrow	NT waters	Bynoe Harbour	1	<i>Pinctada maxima</i>	All
Hamaguchi Pearl P/L	P.O. Box 119, Broome 6725, Tel: (091) 92-1044, Fax:(091) 92-1044	Hiroshi & Pearl Hamaguchi	80M Beach	Gourden Bay, WA	5	<i>Pinctada maxima</i>	Cultured
Cossack Pearl P/L	P.O. Box 127, Onslow 6710, Tel: (091) 84-6190, Fax:(091) 84-6158	Bruce Barker	Onslow	Dampier, WA	6	<i>Pinctada maxima</i>	All
Blue Seas Developments	P.O. Box 57, Broome 6725, Tel: (091) 92-1252, Fax:(091) 92-2443	Beverley Kinney	NDA	Deepwater Point, WA	5	<i>Pinctada maxima</i>	MOP, cultured, meat
Roebuck Pearl Producers P/L	P.O. Box 321, Broome 6725, Tel: (091) 92-1332, Fax:(091) 92-2153	Patricia Grey	WA	Broome, WA	13	<i>Pinctada maxima</i>	MOP, half, meat
Clipper Pearls	P.O. Box 1416, Broome 6725, Tel: (091) 92-1981, Fax:(091) 92-2153	Larry House & Mark Walsh	North WA	Broome WA	2	<i>Pinctada maxima</i>	Cultured, half
Morgan & Co P/L	79 Louis St, Nedlands 6009, Tel: (09) 389-1220, Fax:(09) 389 8232	Mrs Dinah Morgan	Montebello	Montebello	30	<i>Pinctada maxima</i>	All

Key: MOP = mother of pearl; cultured = cultured pearls; seedless = seedless pearls; half = half pearls; meat = oyster meat; NDA = no data available

This bottom farming technique requires divers to carry out routine work. Additionally, many companies now operate on the pearl oysters at the collecting grounds before transporting them to the leases. In the last year or so more companies have favoured holding the operated oysters in net bags suspended on longlines.

While the best known pearl is spherical in shape, the majority of cultured pearls are not round. The basic classes of shapes produced are round, semi round, baroque, and semi baroque, and these are often subdivided into more precise shape classes. The value of

the pearl is determined by its size, shape, colour, lustre and skin quality, with the highest valued pearls being large, round, white and smooth skinned. Half pearls are marketed independently of the round pearls and may fetch between A\$5.00 and A\$50.00 per piece. Mother-of pearl shell which has not produced half pearls is sold on a weight basis. It is a highly sought after commodity, particularly by Asian and European countries, fetching up to A\$10,000 per tonne in 1988. The meat of the adductor muscle is considered a delicacy and was sold for up to A\$300.00 per kilogram (dry weight) in 1988. However the main

market in Hong Kong has dropped somewhat and 1989 prices are around A\$150/kg.

The industry is undergoing a number of difficulties including widely varying spatfalls, resulting in a quota system for shell collection, problems with deaths of pearl oysters during transport to the culture farms, outdated technology and lack of co-operation between growers. The establishment of the Licenced Pearl Producers Association (LPPA) is expected to overcome some of these difficulties.

The industry is regulated jointly through the Federal Department of Primary Industries and Energy and the Western Australian Fisheries Department. A Pearling

Industry Review Committee has also been established and has made a number of recommendations for future development. Research work has been undertaken by the Western Fisheries Department into hatchery production of pearl oyster spat. While there has been limited success, problems have occurred with the collection and conditioning of broodstock, especially with nutrition. A number of research projects are underway to find solutions to these problems.

Despite the problems, the outlook for the industry is bright. Implementation of the Review Committee's recommendations, the LPPA and the co-operative research projects all will enable the industry to further develop, and continue to provide an extremely valuable export product.

Winged Pearl Shell newly found in Tonga

A number of grown winged pearl shell were found attached to the deployed ropes of FADs (fish aggregation devices) during the recent FAD replacement project undertaken in Vava'u, Tonga. Winged pearl shell were previously unknown in Vava'u and it is believed that the ones found may have originated from the pearl culture trials carried out by Tasaki Pearl Company in 1975, 1976, 1977 and 1979 which introduced winged, gold-lip, black-lip and Japanese pearl shell at the request of the King of Tonga.

It is unlikely that the winged pearl shell will produce round pearls as the gonad, into which the pearl nucleus is inserted, is too small and too complicated in structure to allow successful implantation. At the present time winged pearl shell produce only a half-round pearl which, well appreciated for its colour and large size, demands a considerably higher market price compared to half-pearls from other pearl shells. This has led to remarkable increases in production in recent years. Successful artificial seeding has only been carried out by the Tasaki Pearl Company hatchery in Amani, Japan which was possibly where the seed introduced to Vava'u came from. However, there is no

firm evidence to prove that the winged pearl shell found in Vava'u is originated in Japanese stocks. This would require an amino-acid analysis by electrophoresis or a comparative study of genes.

The Fisheries Division of Tonga, in association with the the FAO South Pacific Aquaculture Development Project, carried out a survey of the newly discovered winged pearl shell resource in Vava'u in November 1989 to assess the feasibility of winged pearl shell culture and half-pearl production. As a result of the survey a spat collection programme was initiated in December 1989, deploying three sets of spat collectors in different locations in Vava'u to increase settlement of winged pearl shell in the area. The collectors will be examined and re-installed periodically over a period of one year. This programme is expected to show results on depth and sites for spat collection, collector materials, the spawning season, and the growth rate of shells.

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FAO South Pacific Aquaculture Development Project

Tokelau Islands Survey

Dr Rick Braley (ACIAR Giant Clam Project, James Cook University, Townsville) conducted a preliminary investigation of pearl oysters in the three lagoons of Tokelau, this past June-July. This was as an adjunct to the giant clam survey of Tokelau, funded by the FAO South Pacific Aquaculture Development Project.

Spot checks were made down the slopes of patch reefs in the deeper parts of the lagoons. SCUBA gear was used down to 120 ft (36 m), but no black-lip pearl oysters (*Pinctada margaritifera*) were found. Pearl oysters are still occasionally found by local divers, who use them for pearl shell lures for tuna fishing. Bob Gillet (1985) had earlier suggested that the post-WWII introduction of diving goggles to

Fakaofu had led to the demise of the then scarce stocks of *P. margaritifera*. A questionnaire survey at Atafu indicated that perhaps only seven pearl oysters had been found in the lagoon there from 1954-1989. Rick considered that the prevalent thorny oysters (spondylids) in Fakaofu lagoon (as high as 56 per square metre at one site) might exclude pearl oysters by competing for settlement sites and food. It was suggested that this could seriously hinder any attempt at re-introducing pearl oysters there.

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BIBLIOGRAPHIC REFERENCES ON PEARL SHELL

All the documents in the list below are catalogued in the Fisheries Information Projects pearl shell bibliographic database and are held in the SPC library. Some are publications, but many are internal documents, mimeo reports and other forms of ephemera. In some cases we can provide single photocopies of references free of charge to SIG members or bona fide fisheries officers in Pacific Island countries. In other cases, where confidentiality requirements or copyright restrictions apply, we may be limited to advising enquirers of contact

addresses through which they may be able to obtain the document in question.

If there are documents that you feel should be added to the database, please send us a copy, or, if this is not possible, a photocopy of the cover page. Documents do not need to be formal publications - many of those in the list are not and we are keen to archive as much 'grey literature' - meaning internal reports, correspondence, unpublished data, etc as possible.

Jean-Paul Gaudechoux

- Alagarswami K. 1987. **Pearl culture**. Central Marine Fisheries Research Institute, Bulletin 39, 136pp, (SPC library).
- Alfred R.V. and Kilma N. 1989. **Survey of Pearl Oyster Resources in Namdrik**. Summary report - 16 pp. (SPC library)
- Anonymous. 1960. **Note on the pearl shell market in the South Pacific**. South Pacific Commission, 14pp, (SPC library).
- Anonymous. 1984. **Preliminary survey report for mother in the Republic of the Marshall Islands (26/5/84 - 8/6/84)**. 26 pp.(SPC library)
- Anonymous. 1987. **Study for the development of Pearl Culturing Technics (III)**. Korea Ocean Reseach & Development Institute, pp15-27, (SPC library).
- Anonymous. 1988. **Pearl Oyster Fisheries Management Plan**. 6pp.(SPC library)
- Anonymous. **Equipment of culture farm**.pp499-570, (SPC library).In Japanese.
- Coeroli M. and Mizuno K. 1985. **Study of different factors having an influence upon the pearl production of the black lip pearl oyster**. Proceedings of the Fifth International Coral Reef Congress, Tahiti, vol 5; pp 551-556, (SPC library).
- George C.D. 1969. **Techniques of Pearl Cultivation**. South Pacific Bulletin, pp 13-19, (SPC library)
- George C.D. 1978. **The Pearl**. Report to the Government of Papua New Guinea, FAO & Asian Development Bank, 168pp, (SPC library).
- Hauti A. and al. 1988. **L'aquaculture nacrrière et perlière à Ahe et à Manihi en 1987**. Ministère de la Mer, Service de la Mer et de L'Aquaculture, 64pp, (SPC library).In French
- Hauti A., Tehoiri G.A., Tchoung M. and Matitai G. 1987. **L'aquaculture nacrrière et perlière à Takapoto en 1986**. Ministère de la Mer, Service de la Mer et de L'Aquaculture, 64pp, (SPC library).
- Intes A. 1982. **La nacre en Polynésie Française (*Pinctada margaritifera* Linne) - Evolution des stocks naturels et de leur exploitation**. Océanographie Notes et documents n°16, ORSTOM Polynésie Française, 46pp, (SPC library).In French
- Intes A. 1988. **Méthodes d'évaluation des stocks d'huîtres nacrrières et perlières en Polynésie Française**. CPS/Inshore Fish.Res./BP 66, 9pp, (SPC library). In French
- Intes A. and Coeroli M. 1985. **Evolution and condition of natural stocks of Pearl Oysters (*Pinctada Margaritifera* Linne) in French Polynesia**. Proceedings of the Fifth International Coral Reef Congress, Tahiti, vol 5; pp 545-550, (SPC library).
- Intes A. and Coeroli M. 1985. **L'huître perlière de Polynésie Française - Bibliographie**. Océanographie Notes et documents n°23, ORSTOM Polynésie Française, 46pp, (SPC library).In French.
- Kakazu K., Sesoko M. and Nakano H. 1971. **Studies on Mass Production of Juveniles of Black lip Pearl Oyster, *Pinctada margaritifera* (Linne)**. Biol.Mag.Okinawa 8, pp30-36, (SPC library). In Japanese.
- Kuwatani Y. 1963. **Effect of photo-illumination of rhythmical shell movement of Pearl Oyster, *Pinctada martensii* (Dunker)**. Japanese Society of Scientific Fisheries, Vol 29, N° 12, pp 1064-1070, (SPC library).In Japanese.

- Kuwatani Y. 1965. **Studies on the breeding of the Japanese pearl oyster *Pinctada martensii* (Dunker)**. Bulletin of the National Pearl Research Laboratory, Vol 10, pp1228-1243, (SPC library). In Japanese.
- Kuwatani Y. and Nishii T. 1969. **Effect of the number of animals and the exchange of water on the growth of Japanese pearl oyster in tank culture.** Bulletin of the National Pearl Research Laboratory, Vol 14, pp1748-1764, (SPC library). In Japanese.
- Malone F.J., Hancock D.A. and Jeffriess B. 1988. **Final report of the Pearling Industry Review Committee.** Fisheries Management Paper 17, Fisheries Dept. of Western Australia, 216pp, (SPC library).
- Nishii T. 1965. **Examination of the underwater weight used for measuring the growth of the Japanese pearl oyster *Pinctada martensii* (Dunker)**. Bulletin of the National Pearl Research Laboratory, Vol 10, pp 1264-1282, (SPC library). In Japanese.
- Passfield K. 1989. **Basic requirements to set up a small pearl farm.** 2pp.(SPC library)
- Passfield K. undated. **Aquaculture of the Pearl Shell Oyster** Aquaculture Project, 18pp, (SPC library)
- Rahma I.H. and Newkirk G.F. 1987. **Economics of Tray Culture of the Mother-of-Pearl Shell *Pinctada margaritifera* in the Red Sea, Sudan.** Journal of the World Aquaculture Society, Vol 18, N°3, pp156-161, (SPC library).
- Sims N.A. 1988. **Pearls and Pearl Oysters (Poe e Parau)**. Cook Islands Fisheries Resource Profile N° 2, 155pp, (SPC library).
- Tanaka Y. and Kumeta Y. 1981. **Successful Artificial Breeding of the Silver-lip Pearl Oyster, *Pinctada maxima* (Jameson).** Bull.Natl.Res.Inst.Aquaculture n°2, pp 21-28, (SPC library).In Japanese.
- Tanaka Y., Inoha S. and Kakazu K. 1970. **Studies on Seed Production of Black-lip Pearl-oyster, *Pinctada margaritifera*, in Okinawa I - Spawning introduction by thermal stimulation.** Bull.Tokai Reg.Fish.Res.Lab 63, pp75-107, (SPC library). In Japanese.
- Tanaka Y., Inoha S. and Kakazu K. 1970. **Studies on Seed Production of Black-lip Pearl-oyster, *Pinctada margaritifera*, in Okinawa II.- Food Micro-organisms available for the larvae.** Bull.Tokai Reg.Fish.Res.Lab 63, pp79-85, (SPC library). In Japanese.
- Tanaka Y., Inoha S. and Kakazu K. 1970. **Studies on Seed Production of Black-lip Pearl-oyster, *Pinctada margaritifera*, in Okinawa V - Rearing of the larvae.** Bull.Tokai Reg.Fish.Res.Lab 63, pp97-106, (SPC library). In Japanese.
- Tanaka Y., Inoha S. and Shokida S. 1970. **Studies on Seed Production of Black-lip Pearl-oyster, *Pinctada margaritifera*, in Okinawa III- Culture experiment of *Monochrysis lutheri* at High water temperature levels.**Bull.Tokai Reg.Fish.Res.Lab 63, pp87-90, (SPC library). In Japanese.
- Tanaka Y., Inoha S. 1970. **Studies on Seed Production of Black-lip Pearl-oyster, *Pinctada margaritifera*, in Okinawa IV.- Resistibility of the larvae to centrifugally separated water from *Monochrysis* culture and to hypotonic sea water.** Bull.Tokai Reg.Fish.Res.Lab 63, pp91-95, (SPC library). In Japanese.