Pearling In Perspective

An overview of the Australian Pearling Industry and its Environmental Credentials

Pearl Producers Association

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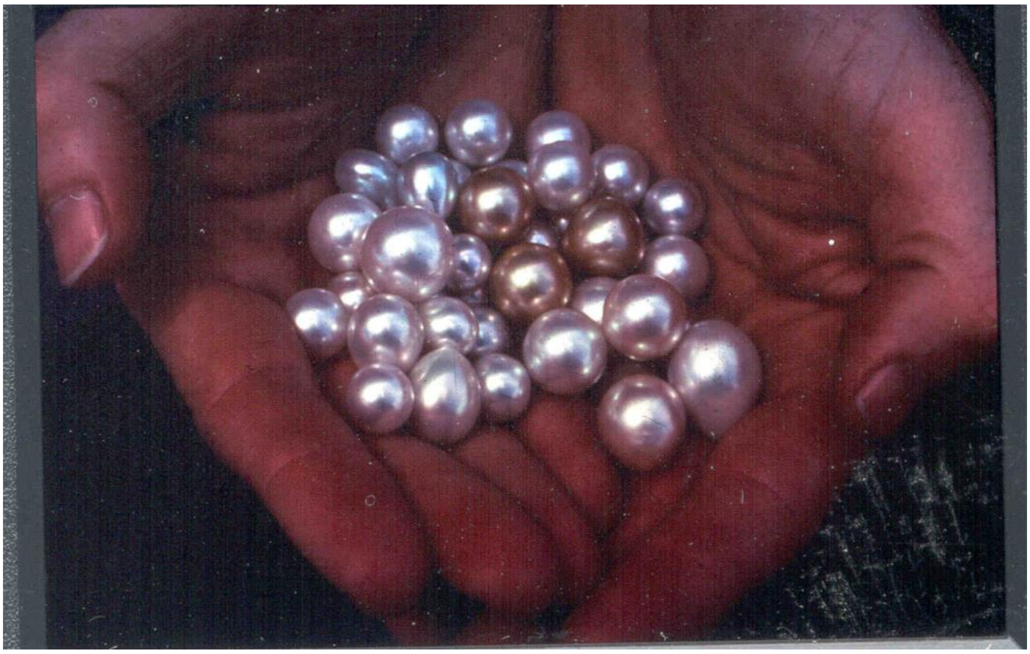
"It is our duty to preserve our wonderful Australian environment. It is also the only way to achieve superior aquaculture results."

Nicholas Paspaley AO



Pearling in Perspective

Executive Summary

The pearling industry is among Australia's oldest and most valuable fishing and aquaculture industries. The pearling industry is based on the *Pinctada maxima* pearl oyster species and stretches from NW Cape in WA to Cape York/Torres Strait.

The industry is dependent on the highest quality environment to produce the highest quality pearls as acknowledged by the world markets. The pearling industry therefore has an intrinsic self interest in maintaining a high level of environmental stewardship.

The modern pearling industry is based largely in Western Australia and is developing in the Northern Territory. The pearling industry provides valuable employment and infrastructure in remote regional Northern Australia. The pearling industry employs approximately 1500 people from regional centers, primarily from Broome and Darwin.

As many of the industry farms are located in remote areas, there is an obligation to provide a high level of duty of care not only to the pearling company employees and surrounding natural environment, but also to other users of the marine area. The pearling industry provides safe haven and/or support on many occasions to non-pearling people in distress in the remote Cobourg, Kimberley and Montebello Islands regions.

The pearling industry is well managed through a number of legislative instruments that cover ecologically sustainable development principles however the pearling industry has committed to proactively establish the environmental credentials of their industry through commissioned investigations and independent third party evaluation.

The overall conclusion in the general community is that the pearling industry is environmentally benign. Research conducted in Australia (mainly Tasmania) and internationally on other mollusc farming industries supports this premise and further demonstrates this benign impact to be the case for the Australian pearling industry. Authors of several research reports have concluded that longline shellfish farming is having little impact and went as far as to suggest <u>that extensive monitoring of longline shellfish farms of this type would appear not to be necessary.</u>

Formal risk assessment workshops into the Australian pearling industry incorporating wide stakeholder participation have been held with no significant threats identified. Projects identified from these workshops are continuing to further our understanding of the interaction between pearl farming and the environment.

The *P.maxima* pearling industry has adopted an Environmental Code of Practice, and is currently establishing an Environmental Management System template which can be utilised by individual pearling companies as part of their environmental management plan.

Several commissioned reports have been completed with results confirming the general view that pearling is environmentally benign.

The Enzer Report concluded that:

'In general the industry was found to be environmentally benign, producing a high value product with a minimum of environmental disruption'.

Another observation with regard to environmental monitoring of pearl farms was that:

'The levels of effect are so small that separating them from natural variation in background levels would be difficult, if not impossible.'

A research program commissioned by Port Stephens Pearls as a part of the environmental monitoring requirements to support a pearl farm application further reinforces the case finding that the pearl farming activities at Wanda Head have not altered the environment beyond the level of naturally occurring variation or beyond the ability of the environment to rapidly assimilate any additional nutrients. The report concludes that there was no detectable change in the chemical composition of the sediment underneath the experimental farm over time relative to five control sites sampled.

A judicial investigation on appeal in this Port Stephens pearl farm by the Land and Environment Court New South Wales found that:

- there would be no impact on water quality of Port Stephens
- the likely impact on adjacent seagrass beds would be negligible
- there will be no significant impact on the whale, turtle and dolphin populations of Port Stephens
- the material cleaned from the oysters was extracted from, or deposited out of, the surrounding water column
- the visual nature of the plume from the cleaning process was of a similar nature to that caused by wind, rainfall and boat wakes

The Court found no evidence of any real threat of irreversible environmental damage, and ordered that the development application be granted.

In comparison to the longline shellfish farms studied in Tasmania (referred above), the pearl farm at Port Stephens has operated at stocking densities of less than one third of those in Tasmania and is in deeper water with higher current flows. All factors that would significantly further reduce the potential for impact. The *P. maxima* pearling industry in WA and NT operate <u>at even lower densities and higher current flows than Port Stephens.</u>

The results from the initial pilot study of a commissioned FRDC funded benthos monitoring impact study in WA pearl farms has found no evidence of impact from the pearl farms on the benthos or sediment chemistry.

The pearl farms studied are some of the longest operating in Australia, with decades of continuous pearl cultivation. Removal of fouling is necessary to prevent the oysters being smothered and maximize feeding opportunities for strong pearl growth.

At each farm, the condition of the benthos within the pearl lease was compared to 3 reference locations located at least 1km from the pearl lease boundary, in similar water depths, current flows, and sediment particle size. The physico-chemistry parameters measured from sediment core samples were total organic matter, nitrogen, phosphorus, carbonates, and redox potential. Grabs samples of sediments were used to collect the benthic macrofauna (>1mm in size) which were identified to class/order taxonomic level.

At all three farms, there was no significant difference between the benthic faunal communities below the longlines when compared to the reference locations. There was also no difference in the number of benthic fauna individuals, number of benthic species, or the Shannon-Weiner diversity index for the benthic fauna between the longlines and nearby reference locations.

Multivariate analysis of the benthic faunal communities confirmed that the pearl farms did not influence the benthic assemblage composition under the longlines. Sediment physico-chemistry at all three farms was not typical of organically enriched locations arising from finfish and intensive mussel aquaculture reported elsewhere in the world and there was no elevation in the sediment nutrients (total organic matter, nitrogen, and phosphorus), nor a difference in the carbonate content, and redox potential (which is an indication of anoxic conditions).

In conclusion, the results from this pilot study indicate that there is no evidence for benthic disturbance at WA & NT pearl farms. The research will continue through to July 2009 to obtain additional spatial and temporal data.

The Australian Pearling Industry

The pearling industry began in the mid 1800's with the collection of pearl oyster for mother of pearl (MOP) used for buttons and furniture inlay. Initially, many people lost their lives to disease, cyclones and decompression sickness from diving, and with the advent of plastic buttons and the Second World War, the industry declined. Since the mid 1950's the industry has focused on the production of pearls and in recent decades, has built an enviable reputation as the producer of the world's finest pearls from the silver-lip pearl oyster specie, *Pinctada maxima.*

The early decades of the pearl MOP fishery went through cycles of boom and bust, with the loss of men and boats through cyclones and other storms, loss of life and permanent injuries through diving mishaps labour problems, racial tensions, fluctuating prices, and competition from other nations.

While there are still variations in the economic cycles, the industry is now highly organised and geared to maintaining sustainable production on an economical and environmentally sound basis

The Australian pearl oyster industry is now the world's premium producer of the highly prized, silver-white South Sea pearls grown in the silver-lip pearl oyster *Pinctada maxima*. Australian companies have an enviable record for producing a high quality product with an annual value of production as high as $250 million in the mid 1990's. This makes the pearling industry one of the largest and most successful fishing/aquaculture industries in Australia.

Australian technology and husbandry techniques are unique and honed to the point that each oyster can produce up to three pearls during its productive life while other countries can generally only achieve one. This provides a significant economic advantage when comparing cost/return ratios per oyster.

Other pearling products include pearl oyster meat (adductor muscle) sold within Australia and MOP is sent to the US, Japan, SE Asia, France and the Middle East for buttons and inlay work.

The majority of the industry is located in Western Australia, while the Northern Territory also has a maturing but still significant industry. Queensland is a small scale developmental stage. Neither NT nor QLD have economically viable wildstock fisheries and rely on hatchery production for pearl oyster supply.

The pearl culture industry is ‘vertically integrated’ and involves six basic activities:

Source Pearl Oysters

- **Pearl Oyster Fishing**
- **Hatchery production of Pearl Oysters**

Seeding

Farming

Harvesting

Marketing

Biology of the silver-lip pearl oyster (Pinctada maxima)

Distribution and Stock Structure

The Silver lip (sometimes called Gold lipped) pearl oyster (*Pinctada maxima*) belongs to the Family *Pteriidae*, which is a small family of bivalve molluscs, widespread in the Indo-West Pacific. Within Australia, electrophoresis study of the genetic structure of the pearl oysters has shown that the WA population is distinct from those in NT and Qld (Benzie and Smith, 2002). A more detailed mtDNA investigation of the Western Australian population revealed some minor clinal differences from the north of the fishery to the southern end of the distribution (Benzie and Smith, 2002).

Life History

The life cycle of *P.maxima* is typical of many marine bivalves. *P.maxima* is a protandrous hermaphrodite. The oysters maturing first as males around three to four years of age and at a size of 110 to 120 mm DVM, after which the oysters undergo a sex change and become female. By 170 mm in length, approximately half of the pearl oysters are males and half are females. Since the oysters can spawn every year, each individual can function as both a male and then a female for several spawning seasons. Very few pearl oysters are both male and female simultaneously (Rose et al., 1990; Rose and Baker, 1994). Observations suggest sex of individuals may be affected by environmental factors such as food resources.

The breeding season of *P.maxima* extends from the spring months of September or October through to the autumn months of April and May. Although there is variability from month to month, the primary spawning occurs from the middle of October to December. A smaller secondary spawning occurs in February and March (Rose et al., 1990; Rose and Baker, 1994). Collection of settling spat in the field has confirmed the spawning periodicity (Knuckey, 1995).

During the spawning season, the sperm and eggs are released into the water column, where fertilisation occurs. Egg production by an individual female is extremely high. Laboratory studies have shown that females can release from two to 12 million eggs (Rose and Baker, 1994).

Following fertilisation eggs develop into a tiny veliger stage. This planktonic larval stage is a distributional phase that allows the young pearl oysters to colonise new areas if suitable sea floor can be found. Since losses in the water column are extremely high, only a tiny fraction, far less than 1% of the fertilised eggs, actually survive the veliger stage.

The length of the planktonic stage in *P. maxima* suggests its distributional potential is intermediate.

Settlement usually occurs around days 28 to 35. When they are ready to metamorphose they settle to the sea floor and test for a suitable habitat. If an appropriate area is found, they settle on it and metamorphose into the juvenile stage. If no suitable settlement site is located within a short period the pearl oysters will metamorphose and die.

During the juvenile and early adult phases of the life cycle of *Pinctada maxima*, it attaches to the sea floor by tiny threads. *Pinctada maxima* live on shallow rocky pavements on the continental shelf where there are small crevices into which the young pearl oysters can settle and develop.

Like most bivalves, pearl oysters are filter feeders. They use their gills to filter small food particles out of the surrounding water. Growth rates are initially fast. Field measurements at the fishing grounds on Western Australia's Eighty Mile Beach have shown that the pearl oysters reach the minimum legal fishing size of 120 mm in their third year of life. They are available to be collected for three to four years before growing to a size where they are no longer suitable for round pearl culture as they are too slow growing to produce high quality pearls. Large wild oysters of 200 mm are 15 to 20 years old (Joll, 1996). The pearl oysters can reach a DVM pearl oyster height of at least 270 mm (Rose and Baker, 1994).

Physical Environment

The Western Australian pearl oyster fishery extends over 3 bioregions of Western Australia – the Gascoyne, Pilbara and Kimberley and as a result there is considerable variation in the environmental conditions. Pearl oysters are commonly found in areas where the seabed has crevices that allow the young pearl oysters to settle into a protected environment and a hard substratum for them to attach to. The seabed is typically a flat basement rock with very little relief. Fine sediment accumulates to a depth of a few millimeters, obscuring the underlying rock surface. A variety of organisms attach to the rock, providing vertical relief of up to 1m off the seabed.

The industry has recognised a variety of seabed types within the fishing grounds and has developed identifiers for them over the years such as 'potato', 'garden', 'collar', 'asparagus'. There can be a substantial overlap in the fauna on the various seabed types, the types being determined by the dominant species present. All share the common feature of being located on the seabed with underlying rock and are composed of a wide variety of invertebrates. None of the habitats contain ecologically sensitive areas such as seagrasses, coral reefs or mangroves. The pearl oyster seabed habitats are vulnerable to damage from natural causes such as tropical cyclones, and it is not uncommon for very large areas of this type of benthos to be stripped off the substrate or smothered under sand deposits following a cyclone event.

Of these habitats types, the potato and garden seabed support commercial quantities of pearl oysters.

The dominant species on the potato bottom is a low, round densely packed ascidian species, which live attached to the seabed. In areas of heavy potato bottom the ascidian are almost completely dominant. Sponges are the next dominant group, with a large variety of vase shaped, basket sponges (some up to 0.5m high interspersed with smaller sponges of only a few centimeters). A variety of diverse taxa are also present although total density is low. Very few corals (Turbinaria) are present. Faunal density rapidly decreases in areas where the sediment is 2-3 cm deep. Bare sand patches can be interspersed between areas of potato bottom.

Garden bottom is a very diverse assemblage dominated by hydroids. Distance between hydroids is variable, but on average they grow about one metre apart. The hydroids grow rapidly to up to one metre in height and quickly become encrusted with a variety of organisms, some very colourful, so the bottom does in fact resemble a garden.

Other than hydroids, a variety of sponges are present on the bottom. Ascidians are present, but are a larger species than that found on potato bottom. Other fauna present include soft corals, sea pens and crinoids. No hard corals are generally present.

Figure 1. Example of 'Garden Bottom'

Sources of Pearl Oysters

Pearl Oyster Wildstock

The collection of pearl oysters from the oceans off Western Australia has a long history, dating back to 1850, with the first recorded activity being in Shark Bay. In the early years, natural pearls were collected from the related species *Pinctada albina*, which were abundant in the shallows near Freshwater Camp (now Denham).

The industry moved to the north coast of WA and concentrated their efforts in Broome utilising the larger species, *Pinctada maxima*. The nacreous Mother of Pearl (MOP) lining the inside of the oysters was still the dominant reason for collecting pearl oysters. MOP was used primarily for button manufacture, but also for inlay and other decorative items. By 1910 there were nearly 400 pearl lugger boats and 3,500 people in the industry supplying up to 75% of the world output of MOP. Production reached 2000 tonnes (approx. 2 million individuals) of pearl oyster collected per year (Malone et al., 1988).

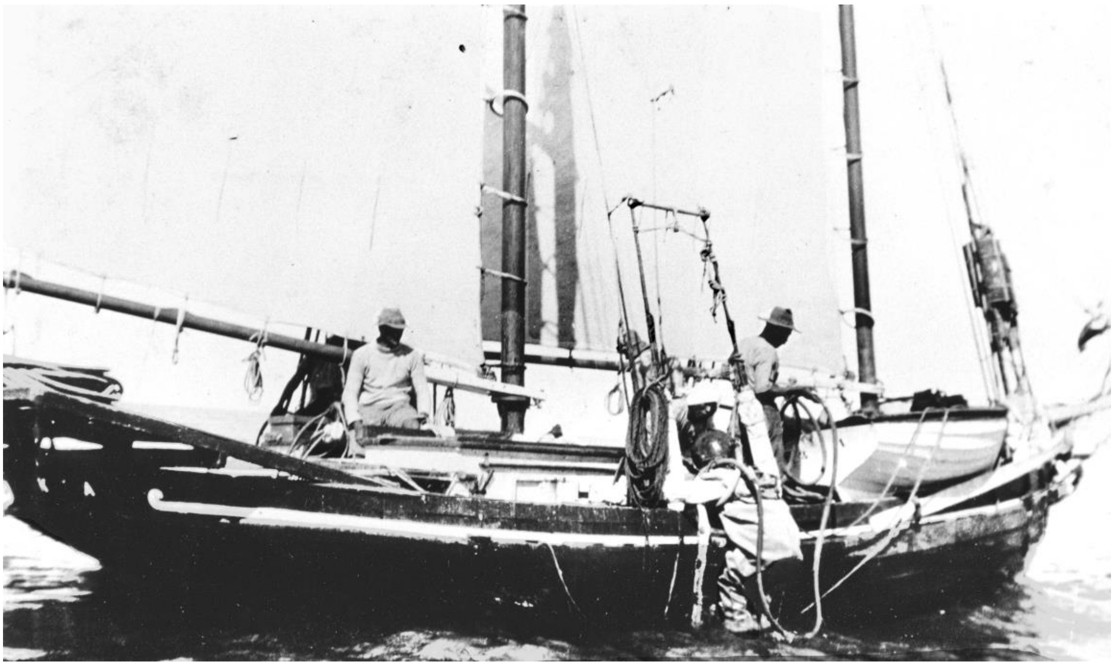


Figure 2 Pearling lugger and hardhat diver

The 1920s and 1930s were low points for the industry, first with the introduction of plastic buttons, which was then followed by the Great Depression. Similarly, during World War II pearling activity almost entirely disappeared. Pearling activity recommenced after the war finished.

The development of a pearl culture industry was made possible in 1949 with the removal of the State Government prohibition on culturing pearls. Subsequently, the settlement of Kuri Bay in the Kimberley region of Western Australia began in 1956 as the first pearl culture farm, and is still in operation over 50 years later. By the end of the 1970's most of the industry, whilst maintaining their established MOP collection activities, had started to move into cultured pearl production to the point where the catch of the larger oysters for MOP declined to less than 300 tonnes while approx 400,000 smaller oysters fished for pearl production (Malone et al., 1988).

The pearl oyster fishery was reviewed by government in the late 1980s (Malone et al, 1988) from which a series of recommendations about the ongoing management of the pearl oyster industry were developed. This included recommendations for the establishment of limits (quotas) on the number of pearl oysters to be taken from the wild pearl oyster stock based on annual stock assessments using the research data. The report also recommended the complete phasing out of MOP collection and the introduction of zones in the fishery to provide more precise management.

Further management actions included banning the take of the larger 'broodstock' oysters in the fishery south of Broome in 1985. By 1987 the take of MOP ceased, as licence owners believed that stocks of breeding size oysters should be strengthened.

During the last 10-15 years the total number of oysters fished annually from the main fishing grounds has remained extremely stable, varying by less than 10% around a mean catch of 475,000 pearl oysters. At the southern extremity of the fishery in Zone 1 (Port Hedland – Exmouth) comprising around 20% of the Pearl Oyster Fishery, the annual catch of approximately 100,000 pearl oysters (1993-2000) has fluctuated by 30%. This fluctuation is driven largely by more variable and sporadic juvenile oyster recruitment at the southern extremity of the species and cyclone-induced habitat damage in this particular region resulting in lost fishing areas. Flexibility in catch quota settings is coupled with encouragement of pearling companies in this region to substitute their take of wild pearl oysters with hatchery-reared oysters to manage this sector of industry.

Pearl oyster fishing grounds are located from the Lacepede Channel, north of Broome down to Exmouth Gulf in the south. Fishing of oysters is carried between January and July each year. Divers collect the pearl oysters by hand while being towed behind a vessel running with the tide.

Hatchery Production of Pearl Oysters

The existing capability within industry to produce pearl oysters using hatchery technology is the product of extensive discussions between industry and Government in the early 1990’s on the merits of ensuring the availability of an alternative source of pearl oysters in support of the wild pearl oyster fishery and ensure a supply of pearl oysters for utilisation in the process of producing round pearls.

The catalyst for developing this technology was a perceived threat that other nations producing South Sea pearls may utilise hatchery produced pearl oysters, in numbers which may impact negatively on the market advantage provided to WA in the past from the environmental limit on pearl oysters through using solely wildstock.

An incentive based policy was introduced which provided an annual allocation of ‘hatchery options’ for each licensee with the number selected by the application of two criteria:

- a number sufficient to justify the capital investment required for hatchery technology and;
- a number not so large that the potential increase in pearl production would distort the market demand/supply equation.

The number selected was 20,000 hatchery options per licensee. Upon demonstration of consistent seeding of 1000 hatchery produced pearl oysters over three years, a licencee was able to convert it’s ‘options’ to fully operational hatchery seeding quota.

The policy was clearly designed to achieve the strategic position of establishing the technical capacity, should it be required in the future, to respond to increases in South Sea pearl production of an equivalent quality to Australia’s production from other nations, whilst aiming to ensure the maximum economic benefit for both the pearling industry and the Western Australian community.

Pearl Oyster Industry Management

Western Australia

During the period from 13 February 1991 to 2 February 1995, the Western Australian pearling industry was administered under the Western Australian Pearling Act 1912 in two parts:

- The catching sector by a Joint Authority, established under the Offshore Constitutional Settlement and comprising the Commonwealth and Western Australian Ministers responsible for fisheries, including pearling; and
- The remaining aspects of the pearling industry, such as farm leases and hatcheries, by the Western Australian Minister for Fisheries.

Since 1995, all aspects of the industry have been managed solely by Western Australia in accordance with the Western Australian Pearling Act 1990.

The Pearling General (Regulations) 1991 support the Act and provides the framework for the management of administrative and technical matters. The unique nature of the *P. maxima* pearling industry has resulted in separate, stand alone legislation through the Pearling Act 1990.

All aspects of the management of other species of pearl oysters (e.g. Black lipped, *Pinctada margaritifera*) are managed under the provisions of the Fish Resources Management Act 1994.

The Executive Director (ED) of the Department of Fisheries may grant leases, licences and permits under Section 23 of the Pearling Act 1990 subject to a number of conditions being satisfied and the Executive Director having regard to any policy guidelines issued by the Minister for Fisheries to assist in applying the Act. These guidelines are detailed in the Pearl Oyster Fishing Ministerial Policy Guidelines No 17 (April, 1997). These guidelines deal with the elements of fishing and farming and focus on the establishment of zones in the fishery, quota allocation and transfer of pearl oyster.

Quota Management System

The wild stock pearl oyster fishery is managed on a system of individual quotas within an annual Total Allowable Catch (TAC) declared each year based on sustainability indicators. The total number of wildstock quota units in the Pearl Oyster Fishery is 572 and has been allocated between the licensed pearling companies. The annual TAC is allocated equally across the 572 quota units. The status of stocks on the fishing grounds is constantly monitored and is reviewed annually by the Department of Fisheries in liaison with the Pearling Industry Advisory Committee (PIAC) and the annual quota is adjusted accordingly. Each operator has an annual quota of live wildstock pearl oysters, which is collected according to each operator's access to the four nominated fishing zones.

Minimum and Maximum Size Limits

Pearling is managed as a 'gauntlet' fishery with pearl oysters only taken between a minimum and maximum size. The minimum size limit for collection of pearl oysters is 120 mm, when the oysters are three to four years old. The cost effective maximum size for collection is 160mm. The oysters may grow to 270 mm but are too slow growing to produce high quality pearls. This is beneficial to the fishery because oysters larger than 160 mm form the basis of the breeding stock and are in plentiful supply.

Research and Data Collection

Monitoring catch and effort data against the allocated quotas is vital to ensure the integrity of the management strategy. Every year, catch and effort data from over 60,000 individual dives made during the collecting season is provided to the Department of Fisheries. From these detailed diver logbook records, at-sea sampling of catches and information gathered during research projects, the status of the stocks is reviewed and catch quotas are set.

Northern Territory

The Northern Territory pearling industry is also quota regulated, with the majority of oysters originating from hatchery produced stocks. The industry is expanding in the Northern Territory as latent quota is utilised. There are currently 420 quota units allocated in the Northern Territory allowing companies to seed 420 000 oysters.

The Northern Territory pearling industry is administered under the Fisheries Act (1988). Subsidiary to the Act is the Pearl Oyster Culture Industry Management Plan which outlines the regulatory and operational framework used to manage the industry. The Management Plan covers regulations relating to quota rights and transfers, pearl oyster fishing, spat collection and seeding.

Production is primarily from the Cobourg Peninsula area, but there are also pearl farms operating in eastern Arnhemland.

A Memorandum of Understanding (MOU) has been signed between the Northern Territory and Western Australia which recognises the strong links between the two industries, and commits the two major pearling jurisdictions to collaborative policy development to ensure the orderly development of the pearling industry.

Process for Producing Pearls

Pearl Oyster Fishing

While there has historically been wild stock pearl oyster fisheries in the Northern Territory and Queensland, the only significant, commercial pearl oyster fishery remaining in the world is in Western Australia.

The pearl oyster fishery of Western Australia (WA) operates in shallow coastal waters along the North-West Shelf and 80 Mile Beach. In any given year, there can be between 6 to 10 vessels fishing for pearl oysters.

There is only one target species in this fishery, the silver lipped pearl oyster *Pinctada maxima*, which are individually collected by highly trained divers being towed behind vessels. These pearling vessels are up to about 35 m long, and many are custom designed for the pearling industry.

The total crew on the vessels is usually 10 to 12 people: these include the skipper, engineer, a number of deckhand(s), cook(s), and six divers.

Figure 3. Pearl oyster fishing vessel towing divers

Fishing for live pearl oysters begins early in January and continues for up to seven months. The areas where pearl oysters are collected are subject to extreme tidal ranges (up to 9 m), and consequently have very strong tidal currents. Diving is too difficult and dangerous during the strong water movements of the spring tide (largest difference between high to low tide) and is only undertaken for six to twelve days on the neap tides (smallest difference between high to low tide) when water movement is substantially reduced.

Fishing for pearl oysters generally involves the extension of long booms or arms stretching outwards from each side of the vessel with a number of weighted ropes hung vertically from each boom to a height of approximately one to two metres from the seabed. Divers use these weighted ropes to stay close to the seafloor and swim from side to side collecting pearl oysters. Most boats use three lines per boom which allow six divers to work simultaneously. (See Figure 4)

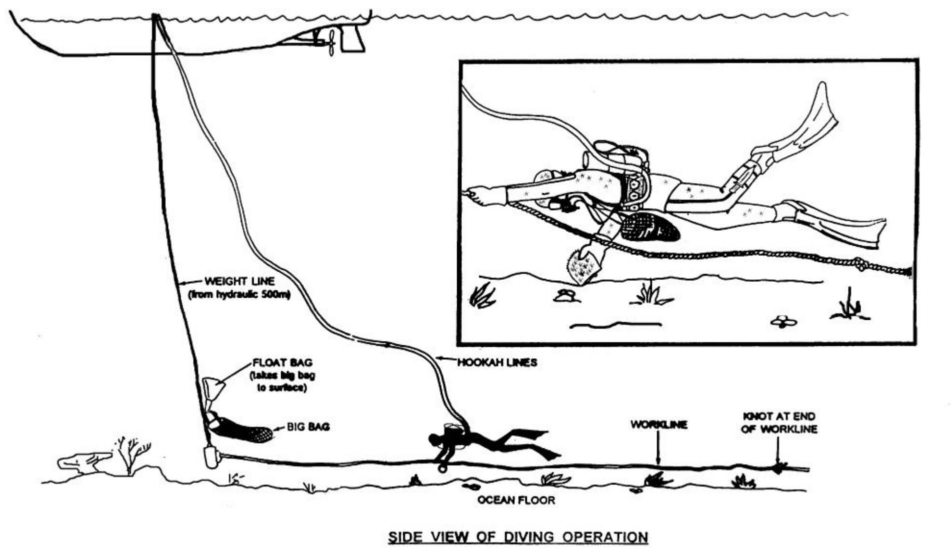


Figure 4. Pearl Oyster fishing setup

The vessel begins “drifting” with the tide at one end of an identified pearl oyster ‘patch’ and moves slowly across the patch at a rate of about one knot towing the divers. The engine remains in gear to maintain steerage of the vessel, but even at minimum speed the boat moves too fast for the divers, and so a stern drogue is deployed to act as a floating sea anchor and slow the boat. Ropes attached to the drogue can be manipulated to open the drogue fully and slow the boat or partially close it to increase speed.

A code of practice developed specifically for pearl oyster collection diving has specialised dive depth rules (profiles) which have been developed after rigorous research over several years by world experts in diving medicine. The pearling industry engages both a full time dive safety officer and a specialist consultant hyperbaric dive doctor to manage the dive code of practice and monitor industry. The industry also maintains a recompression chamber operated jointly with the Broome Hospital.

Considerable problems were encountered in the pearling industry in the early years on the pearl luggers before diving physiology was fully understood. Many divers died or were permanently injured through lack of understanding of diving medicine. With the benefit of past experience and modern medical knowledge, a standardised technique and set of diving profiles has been designed specifically for modern pearl oyster divers designed specifically for the Western Australian Kimberley tidal conditions. Dives shallower than 23m last for no more than 40 minutes, followed by a stringent ascent (recompression) process and on- surface interval while the boat is repositioned for the next drift dive. Dives in very shallow water at 8m can be longer in duration after proven research adjusts the recompression processes. Time limits are strictly adhered to as extending the diving time by even a few minutes will significantly add to the total bottom time over a 10-dive day and increase the risk of decompression sickness. Pearl oyster patches in very deep water (>30m) are not fished at all as the safety factor does not allow an economical dive time limit. This of course means these untouched pearl oysters act as a breeding stock supplying continuous recruitment to the fishery overall.

Divers operate on a hookah system, with air supplied from a surface compressor rather than carry air in tanks on their backs. Coded signals using hand held buzzers are used by the head diver to communicate with the crew on the boat to control the speed and direction of the boat (by adjusting the drogue), height of divers (by lifting/lowering the weights) to maximise pearl oyster collection. Since water clarity is paramount to divers being able to efficiently sight and collect the pearl oysters, significant effort is put in place to ensure the weight line does not strike the sea floor. The diver will signal to the vessel to raise the weight according to the sea floor height- thus preventing the weight from striking the bottom. Not only does this practice prevent damage to the seabed, but also allows the diver to see clearly and thus maximise the efficiency of fishing for pearl oysters.

The divers swim about 1.5 m off the seabed to obtain the maximum field of view. Even in murky water when the divers swim closer to the bottom they are still above the bottom substrate.

Each diver wears a neck bag during the dive. As pearl oysters are collected, placed in the neck bag until it is full. Divers are skilled at identifying pearl oysters that are deemed of ‘culture pearl oyster’ quality – the appropriate size and quality. Once the neck bag is full the diver pulls himself to the weightline and transfers the oysters to the larger bag attached.

Figure 5 Diver Collecting Pearl Oyster from Wildstock Fishery

Each diver makes an average of eight to 10 dives per day in depths of less than 23m starting at first light. A good diver aims to collect an average of 250 ‘culture quality’ pearl oysters per day.

At the end of each dive the pearl oysters that have been collected are immediately measured and graded on deck. Oysters that are too big or too small are returned immediately to the patch from which they were taken. Oysters of the target size are cleaned by scraping off encrusting organisms from the outside of the pearl oyster. A high-pressure hose is then used to wash the oyster. No chemicals are used in any part of the pearl culture process. The oysters are placed in mesh panels on the boat, each panel holding six oysters (see Figure 6). The panels have plastic coated steel frames and hold two pearl oysters across and three down. Light netting of about 2 mm diameter is used to hold the oysters into place. A 6 mm rope is used to make a handle.

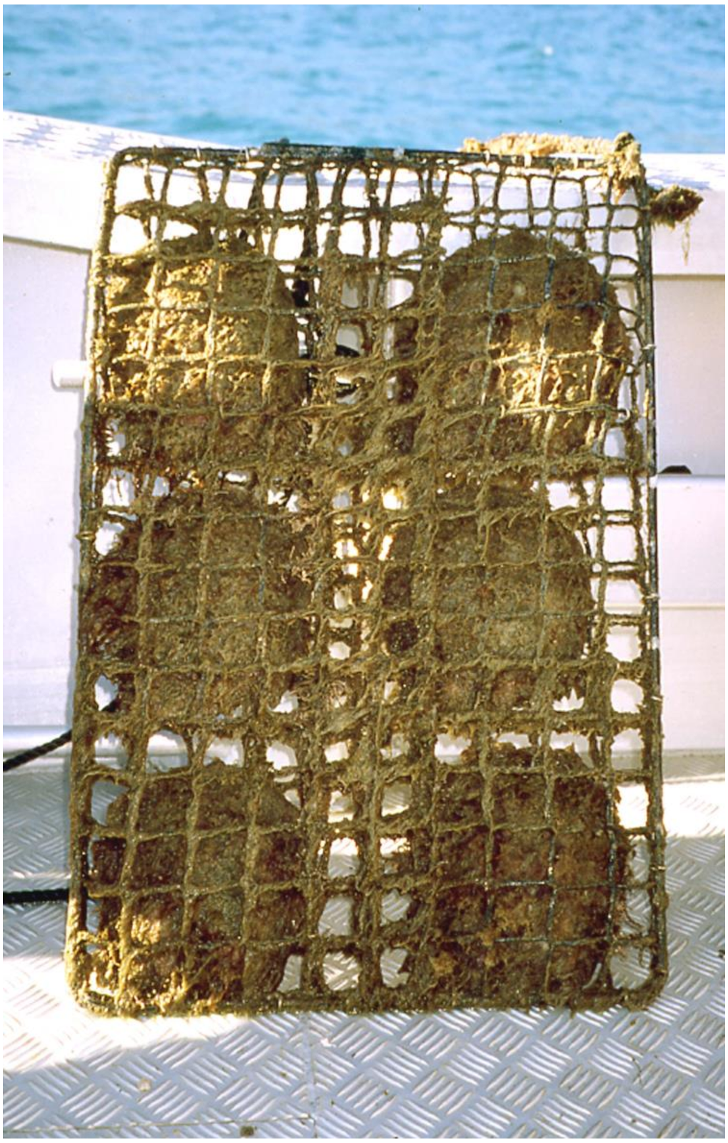


Figure 6 A panel containing pearl oyster

When in panels, the oysters are then held in tanks on board the vessel. Oysters are out of the water for less than one hour. Every panel is individually tagged for compliance purposes to indicate which company has collected the oysters. Each company is only issued sufficient tags by the Department of Fisheries, to match its total pearl oyster fishing quota and the tags are serial numbered.

Once all the pearl oysters have been placed in the panels and the panels are tagged, they are removed from the tanks and taken to a pearl oyster “fishing holding site” generally within 2nm of the fishing vessel. Transportation is in an smaller, open boat, but the pearl oysters are kept under a shade cloth and there is a padded covering on the floor of the boat to minimise jarring.

Additional fishing holding sites are used as the fishing boats work different areas along the coast to minimise transport.

The panels are placed on a continuous line on the seabed by divers in a fishing holding site area. Divers move down the line to ensure the pearl oysters are in close to normal orientation on the sea floor. A surface buoy is placed at the end to mark the line, which may be several hundred metres long. Under the Pearling Regulations, a buoy must mark the fishing holding site and the Department must be notified of its location.

The sea floor at the fishing holding sites is deliberately selected to be very similar to that found on the fishing grounds and consists mainly of sand bottom with occasional sponges, soft corals, sea fans, and other fauna present. This is known throughout the industry as 'garden' bottom.

The pearl oysters remain at the fishing holding sites for a period of up to two months which minimises the physiological effect on the oysters from having been collected allowing the pearl oysters to recover full vitality before they are seeded.

All pearling related equipment must be removed from the fishing holding site by the 31 December of the same year in which fishing has occurred.

Hatchery Production of Pearl Oysters

Hatchery techniques for *P. maxima* are a relatively recent development and were pioneered by Rose et al. (1994) and in general terms are similar to those used for other species of bivalve molluscs. Most of the pearl oyster hatchery activity occurs in Western Australia.

After carefully selected broodstock complete spawning, fertilised eggs are stocked into tanks of filtered seawater. After approximately 24 hours metamorphosis from egg to free swimming larvae is complete and cultured microalgae is added to the rearing tanks. The initial algal species utilised commonly include *Chaetoceros calcitrans*, *C. muelleri*, *Tahitian Isochrysis sp.* (T.Iso), *Tetraselmis sp.* and *Nannochloris sp.* (Rose and Baker, 1994), *Pavlova lutheri* (Minaur, 1969; Tanaka and Kumeta, 1981) and *I galbana*, *C. calcitrans*, *Chlamydomonas sp*. and *Tetraselmis sp.* (Nugranad *et al*. 1998). Gentle aeration is supplied to mix the suspension within the tank. Algal concentrations are increased during the culture period from 5 cells μL^{-1} on day 1 to 50 cells μL^{-1} on day 21 (Rose *et al*., 1990). Water changes are conducted every 2 to 4 days at which time culling and size grading of the larvae also take place.

Larvae begin to metamorphose on day 24 into spat (juvenile oysters). A settling density of 1 larva per mL in the settling tanks is recommended by Taylor *et al.* (1998) to maximise yield. Settlement occurs either on the tank walls and bottom, or on collectors hung inside the tanks. The former method allows more accurate counting when the spat are removed for re-settling, while the latter method requires less handling of newly settled spat. Spat attach to settling substrates with byssal threads as in the wild and a variety of collectors have been used such as shadecloth, nylon netting, unraveled nylon rope and plates of dark coloured glass or plastic (Rose, 1990).

In the hatchery, newly settled spat are treated in a similar manner to larvae. As they become larger the feeding rates and water circulation are increased to ensure that attached spat have sufficient access to food and oxygen. Larger spat may consume considerable amounts of algae, and this is when the algal production resources of the hatchery may be limiting. Mills (2000) determined the optimum temperature and feeding conditions for the nursery culture of *P. maxima* spat.

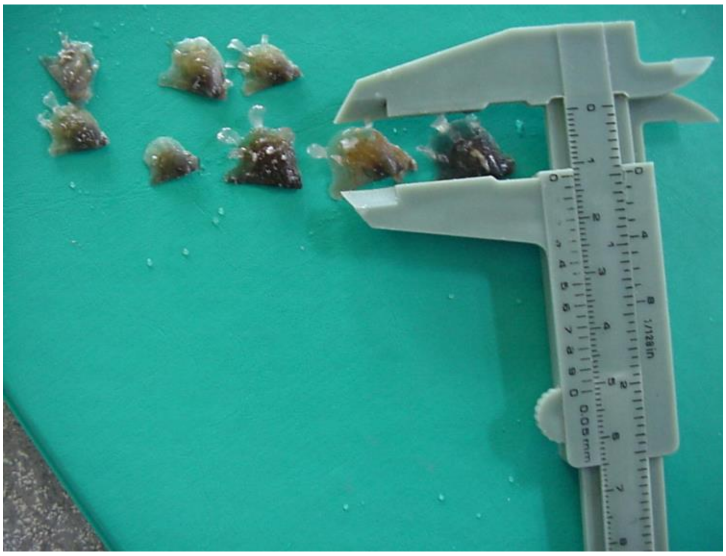


Figure 7. Pearl oyster spat

Spat are commonly held in the hatchery until they are large enough to be placed into mesh cages or other structures. Once spat attain about 20 to 50 mm in shell height, they are generally transferred to small mesh panels on surface longlines in the ocean. As the spat size increases, they are transferred to panels with progressively larger mesh size.

Both Taylor *et al*., (1997) and Mills (2004) investigated the effects of fouling organisms and cleaning periodicy on the culture success of *P. maxima*. Taylor *et al*., (1997b) showed that fouling decreased spat growth and survival, presumably due to increased competition and reduced water flow. In both studies the most efficient cleaning interval was 4 weeks. More frequent cleaning did not provide commensurate benefits in growth or survival.

Given that the nursery period before the spat growout to seedable size that can be utilised for pearl production is two to three years, the efficiency and effectiveness of the farm cleaning program must be optimised in order to reduce the considerable costs and infrastructure involved. Most farms now have personnel specialising in the culture of the spat to seeding size.

The Pearl Oyster Translocation Protocol is administered by the WA Department of Fisheries and outlines the required protocols which must be adhered to by commercial hatcheries. These protocols include annual inspection to authorise minimum standards for filtration of incoming seawater, cleaning and disinfection procedures, health testing, sterilisation of effluent seawater and record keeping.

The Northern Territory has similar protocols for the translocation and health testing of pearl oysters.

Seeding of Pearl Oysters

Seeding of pearl oysters is undertaken during the Austral winter (June/July/August) when water temperatures are lower and the variation in temperature is minimal. As pearl oysters are poikilotherms and cannot regulate their internal body temperature, cooler ambient temperatures reduce their metabolic rate and lead to reduced stress and associated mortalities of newly seeded oysters.

Oysters from the wild fishery are seeded at the fishing grounds, while those from hatchery produced stocks are seeded on farm sites. The seeding process for both is similar.
Seeding is generally undertaken on a purpose built vessel or shore based facility by skilled seeding technicians. The surgical instruments used by the technicians must be sterilised by law before use according to a strict protocol developed by the Pearl Producers Association (PPA) and endorsed by government.

Oysters are brought to the surface, removed from their holding panels and placed into large, recirculating seawater tanks on board the seeding vessel. The following day the tanks are allowed to drain, and the relaxed oysters open slightly as a natural response. A small wedge is inserted between the pearl oyster valves to keep them open and allow access for the seeding technician. (Figure 8)

Figure 8. Opened and pegged pearl oysters prior to seeding

The technology of pearl production relies on the insertion of a bead or ‘nucleus’ in the oyster gonad sitting on a transplanted piece of mantle tissue selected from a donor oyster. The donor oyster is carefully selected on the basis of size, health and nacre quality. Mantle tissue is excised from the donor and cut into small pieces of approximately 2-4mm. This small piece of mantle tissue is surgically implanted into the host pearl oyster along with the spherical bead (nucleus). (see Figure 9)

The mantle tissue is responsible for secreting the lustrous nacre found on the inside of the pearl oyster. Nacre producing cells from the transplanted piece of mantle tissue (called saibo), grow within the seeded oyster and form a pouch (pearl sac) encapsulating the nucleus. These cells in the pearl sac then secrete nacre onto the surface of the nucleus, forming the pearl.

The process complete, the wedge is removed and the oyster is returned to the water to recover.

The initial process of seeding and pearl sac formation is critical to the retention of the nucleus by the host oyster, and to the quality of the pearl produced. There has been a significant amount of research and development undertaken by the industry to optimise these processes.

Figure 9. Seeding of pearl oysters

Immediately following seeding, oysters are returned in panels to the sea floor and the oysters are integrated into a 'turning' program. Oysters are rotated 180° at strict intervals by divers, a process which is thought to result in a more even pearl sac development, and enhance round pearl shape. This process is a tradition which originates from the original Japanese pearl culture technology transfer, although its value has been questioned and some companies use alternative post-operative strategies.

Following the seeding and post-operative phase, all oysters are placed into panels ready for transportation to the 'grow out' phase on the pearl farms. Panels consist of a steel frame supporting plastic mesh which has pockets to accommodate individual oysters.

Transportation

Oysters from the wild fishery, having been seeded on the fishing grounds, are transported to farm sites in the Kimberley, while hatchery oysters seeded on pearl farm sites may be moved, depending on the preferred location on the farm for pearl production.

The Pearl Oyster Translocation Protocol outlines the regulatory requirements, health sampling procedures and certification approval required prior to movement of any pearl oysters within and between zones of the Western Australia pearling region and into and out of Western Australia. A similar policy document outlining Northern Territory procedures has been developed. The pearling industry is currently looking at the feasibility of having a joint system for both jurisdictions

Pearling vessels with large recirculating seawater tanks are used to transport the seeded oysters. The oysters are brought to the vessel, cleaned with high pressure seawater and loaded into the sea water tanks. Fresh seawater is constantly circulated through the tanks during the transportation of the oysters. Failure to provide clean and hygienic transportation conditions were identified as the cause of large scale mortalities following transport in the 1980's due to stress induced *Vibrio sp*. infection (Pass *et al*., 1987).

Monitoring by industry has found that the characteristics of the discharge water from the tanks are indistinguishable from the ambient seawater.

Pearl Farm Sites

Pearling farm sites used for the culture of *P. maxima* are located between Arnhemland in the Northern Territory and Exmouth in Western Australia. The majority of the farming activity occurs in the remote Kimberley region of northern Western Australia. Some farms, such as Kuri Bay, Cygnet Bay and Knocker Bay, have been in constant pearl production for over 50 years.

In Western Australia the process of obtaining a marine lease area for pearling is outlined in Ministerial Policy Guideline Number 8: *Assessment of applications and authorisations for Aquaculture and Pearling in coastal waters of Western Australia*

This Policy Guideline outlines the process required for lease applications, including public and interdepartmental consultation, site environmental impact assessment and the appeals process.

The amount of lease area in total that may be held by an individual company is restricted according to an agreed formula calculated in accordance with the quota holdings held by an individual company at any point in time.

The formulae used has been established using historical pearl oyster stocking rates which have delivered best results in husbandry technology and disease management.

Thus the maximum lease area held in total by the industry is restricted to the total quota allocated plus stockholding on hand and removes any opportunity for take up lease area by any pearling operator in excess of the formula attributed to their quota. The Policy Guidelines also require pearling companies to relinquish existing lease holdings commensurate in size to new areas identified/required in a different location where a company's quota holdings have not increased to allow for any increase in total marine area under the formula.

The total area held under lease by the Western Australian Pearling Industry has stabilised at around 200 sq. nm, and has been stable for several years.

Pearling leases are non-exclusive, meaning that there is no impediment to recreational or commercial vessels traversing the lease, or to traditional, commercial or recreational fishers utilising the natural resources within a lease area.

In the Northern Territory the pearl lease applications are assessed by the Environmental Protection Agency (EPA). Each proposed new lease requires the submission, and acceptance of, an assessment of the likely impact of the pearling activities on the surrounding environment. In recognition of the historical demonstration of minimal impact of pearling activities on their surrounding environment, authorities have accepted Environmental Management Plans for the specified site, rather than an Environmental Impact Statement, as is required for other developments assessed to have greater environmental impact.

The Northern Territory has adopted a similar policy requiring minimum distance between lease areas as applied in Western Australia.

Farm sites are chosen primarily according to their protection from cyclones and the sediment characteristics for quality pearl production. Severe tropical cyclones seasonally occur throughout the entire range where pearling is undertaken, and historically have severely impacted on both pearl farms and the habitat of the pearl oyster beds of the wild fishery.

Favoured pearl farm areas are remote from pollution sources and other threats to the key ingredient to success - water quality. *P.maxima* is a very sensitive oceanic organism, and vulnerable to poor water quality which leads to mortalities and reduced pearl size and quality. Fresh water is also avoided when selecting pearl farms with sites located well away from large river mouth areas prone to flood during monsoonal seasons.

Areas with mud bottoms are preferred farm sites as it provides the best holding ground for the longline anchor system. (see Figure 10). Additionally, estuarine areas and submerged reef are avoided as they act as reservoirs for problematic fouling organisms such as barnacles and oysters (from estuarine areas) and for oyster pathogens such as *Cliona*, from reef areas.

The Kimberley is a very high energy environment; tidal amplitudes may reach 10m, and generate strong tidal currents. These strong currents constantly renew the phytoplankton which nourish the pearl oysters, and reduce the potential for localised impacts from the pearl farms (see Figure 11).

Figure 10. Typical benthos sample from Kimberley pearl lease areas

Figure 11. The Horizontal waterfalls, Talbot Bay

There are three main ecologically sensitive habitats in the Pilbara and Kimberley regions: mangroves, seagrasses and coral reefs.

Seagrasses are widely distributed along the Pilbara and Kimberley coasts and offshore islands. However, in contrast to the dense meadows formed elsewhere in Australia, most of the tropical species found along the north coast form only patchy associations in which the plants have 10% or less of the biomass of southern seagrass communities.

Corals are diverse in both the Kimberley and Pilbara regions, and form extensive reefs in many areas. Coral reefs are well known to harbor a biologically diverse and ecologically productive community in areas where nutrient supplies are low. Some of the major coral reefs in the Pilbara, such as the Rowley Shoals, are protected as marine parks. While some species of corals can survive as small individual communities in turbid areas, the only extensive coral reefs are offshore where the water is clear. Studies undertaken by the Western Australian Museum in conjunction with the University of Western Australia and the Museums and Art Galleries of the Northern Territory (Wells, 1989; Morgan, 1992; Wells et al., 1995; Walker et al., 1996b; Walker, 1997) have documented the distributions of many species of marine plants and pearl oysters in the Kimberley region.

Mangroves are common all along the sheltered coastal areas of northern Australia. In the Kimberley mangroves tend to be restricted to narrow scattered bands along the rocky coastline, with more developed forests at the rear of sheltered bays and along estuaries.

In general, these sensitive habitats do not overlap with the distribution of the pearl farming areas.

Pearling leases are generally in the more open waters of sheltered bays away from the littoral and estuarine areas.

Aquatic Animal Health/Disease Management

Diseases risk management is very important to industry and government and has resulted in the development of strict rules within the pearling industry. This includes a minimum distance between pearl farms set at 5nm (measured over water), except where there is written agreement between operators of two leases to allow activity within 2nm.

Pearl Farming

On delivery to the farm sites, the panels of seeded oysters are placed onto longlines consisting of a rope backbone with attached surface floats anchored at each end in the thick mud bottom by specially designed anchors. Panels are attached to the longlines by short lengths of rope (droppers) at regular intervals.

The key to pearl quality is the health and growth of the oyster and this is maximised through access to adequate quantities of food/nutrients. To ensure maximum food access the oysters are cleaned regularly to remove biofouling organisms which compete with the pearl oyster for available food. At the same time the integrity of the associated husbandry equipment is inspected to prevent oyster losses and fouling organisms removed as well.

The average interval between cleaning cycles is four weeks.

Farm staff carryout this function aboard specially designed cleaning vessels. The longline is lifted onto large winches on the side of a cleaning vessel which pull the vessel down the length of the longline. As a panel of oysters comes along the line it is pulled to the surface and placed inside a cleaning machine which sprays the oysters with high pressure seawater as it moves along a conveyer belt. The seawater removes the bulk of the fouling (which consists of slime, mud and invertebrates) from the panels and oysters. Hard fouling such as barnacles and other oysters are then removed by cleaning staff using stainless steel chisels. The cleaned panel of oysters is then returned to the water having never been detached from the longline. The longline and floats are also cleaned.

No chemicals are used anywhere in the pearling process. Individual companies have cleaning programs tailored to the fouling characteristics of their particular farm sites.

Figure 12. A typical cleaning boat attached to a longline.

Farm staff is housed on site, either aboard a dedicated accommodation vessel or a shore based camp. Due to the remote nature of most farms, companies operate a roster system, commonly 2 to 4 weeks on, followed by 1 or 2 weeks off. Staff movement is commonly via seaplane, which also delivers fresh food and other cargo. For those operating on the Dampier Peninsula road access is available. Vessels are used to deliver heavier or more bulky cargo.

Pearl Harvest

Following the process of seeding, a pearl oyster lays down nacre within the pearl sac and covering the implanted bead/nucleus. It will take two years of this process to produce a pearl to a quality level accepted by the Australian pearling industry as 'marketable'. As Australian producers cannot compete with the low production costs of many of their competitors, high quality standards are used to differentiate and maintain the premium paid for Australian pearls.

The pearls are harvested at the farm site. Similar to seeding, harvesting is conducted on specially designed vessels or shore facilities. Panels of seeded oysters are delivered to the harvest vessel/land site where the oysters opened and presented to the technicians. The technician surgically removes the pearl from the sac.

If the quality of the pearl is adjudged to be appropriate and the pearl oyster is in good condition a new nucleus is inserted into the pearl oyster sac. As the pearl sac is already in place from the first seeding process two years ago, the insertion of a new piece of mantle tissue from a donor oyster is not required. Following the pearl removal and re-seeding with a new nucleus, the oyster is placed back into a panel and returned to the water attached to the longline. Over the next two years the pearl production process is repeated, and at harvest an assessment is made as to whether another nucleus may be inserted to produce a third pearl from an individual oyster.

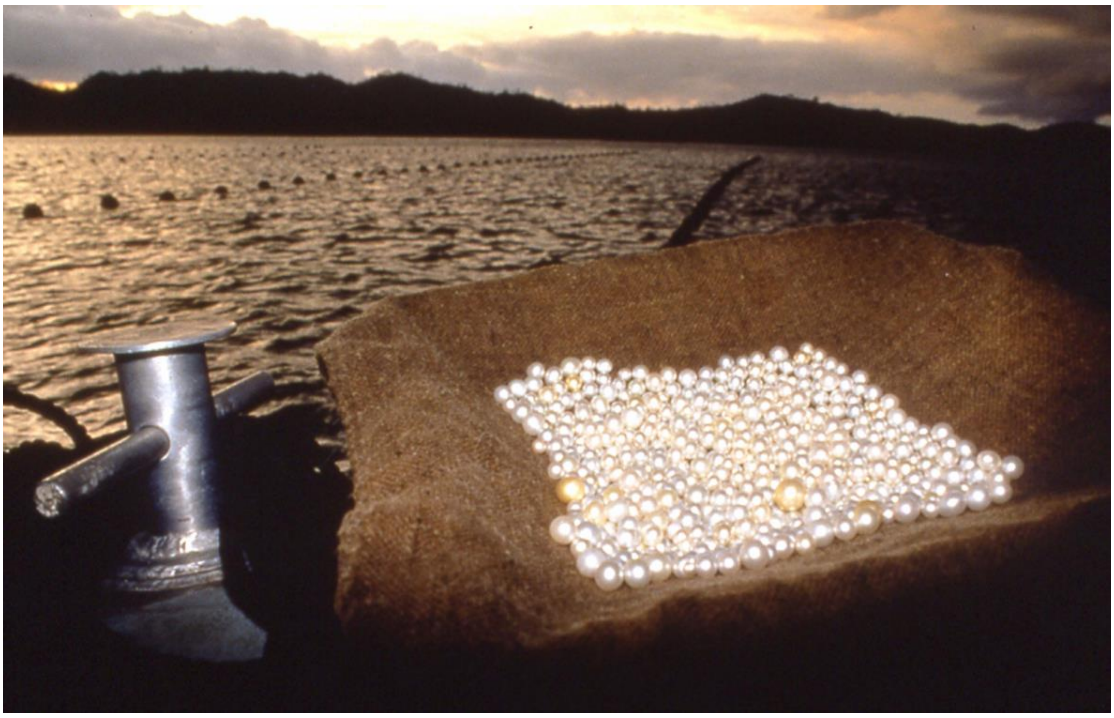


Figure 13. The result of years of work: the harvested pearls.

Oysters which have not produced a pearl of sufficient quality are not re-seeded and are processed to produce saleable end products such as pearl meat and Mother of Pearl (MOP). Only the adductor muscle is utilised for the pearl meat and is snap frozen on-board the harvest vessel. The MOP is graded according to international quality requirements and packed into storage drums. The sale of pearl meat and MOP is a significant contributor to the income of pearling companies.

Marketing

Pearling companies are increasing their investment in marketing to promote the quality of the pearls produced by the Australian pearling industry, as a significant ‘point of differentiation’ compared to other pearl suppliers around the world.

While other countries also produce pearls from *P.maxima* pearl oysters, there is recognition internationally that Australia produces the finest pearls in the world due to their size and quality. The quality of the Australian natural environment contributes enormously to this important quality advantage.

There are five main virtues which determine the quality of a pearl:

Lustre

Lustre describes the interplay of refraction and reflection of light from the surface and depths of the pearl. Lustre gives the pearl its glow and aura. The higher the lustre the more valuable the pearl.

Complexion

Pearls may be more or less blemished with spots and various marks on the surface. Although blemishes may not detract from a pearls appeal, they decrease the value.

Size

Larger pearls are more valuable due to their size and rarity. High quality pearls above 15mm in size are particularly rare.

Shape

Although round pearls are traditionally the favourites, many of the other shapes such as baroque and circle’ are gaining in popularity.

Colour

Australian pearls come in a range of colours, yellow, white, silver, pink, green, apricot, cognac and champagne. The favoured pearl colour is up to the beholder, but white with pink or rainbow overtones are the most popular.

Pearling Environmental Code of Practice

Both the Northern Territory and Western Australian pearling industries have adopted a Pearling Environmental Code of Practice which outlines environmental responsibilities of license holders (Appendix 3).

This Code is administered and revisions co-ordinated through the peak sector body, Pearl Producers Association.

A project to establish an EMS template which can be adopted by an individual pearling company has been completed (see later in document).

Waste Disposal

Vessels are used to collect non-biodegradable waste from the farm site for appropriate disposal in regional centres such as Darwin, Derby and Broome.

As the production of pearls requires a high quality environment, pearl farms have procedures for the collection and disposal of waste from shore camps and support vessels. Companies have formalised documented processes in place to minimise environmental impact. These outline company policies on the minimisation and processing of waste materials, staff responsibilities toward the environment and other ways to minimise environmental impacts.

Whale Interaction Protocol

The Pearling Environmental Code of Conduct has been enhanced with a Whale Interaction Protocol designed by the pearling industry (PPA) in conjunction with the Department of Environment and Conservation, whale management team and Seanet.

In the more than five decades of the Australian *P.maxima* pearling industry, there have been only two humpback whale interactions and on both occasions the whale was successfully released. There have been no recorded entanglements of marine turtles, dugongs or other endangered icon species.

Environmental Studies on the Australian Pearling Industry

In recognition of the widespread and growing community interest in the marine environment, the pearling industry has initiated or collaborated in projects and processes and incorporated other projects results to demonstrate its environmental credentials.

Western Australian Museum 1997

Staff of the West Australian Museum conducted a biological survey of the 'garden bottom' underneath the pearl farm longlines within Beagle Bay. This survey did not detect any measurable impact to the underlying habitat (Anon 1997).

The Enzer Report (Wells, 1998)

The environmental assessment process of the pearling industry began with the commissioning of a study by the WA peak industry representative body, the Pearl Producers Association (PPA) into the environmental effects of pearling. The study was conducted by Enzer Marine Environmental Consulting and was concluded in April 1998, headed by renowned scientist Dr Fred Wells.

The terms of reference were to produce a report which:

- Describes the general environment(s) in which pearling occurs (e.g. bottom types);
- Describes the pearling activities that have the potential to cause an impact on the environment;
- Identifies and briefly describes those elements of the environment which could be impacted by the pearling industry, and of those elements, identifies and describes in detail the most important in relation to the potential environmental impact by the pearling industry;
- Provides advice on the possible design and requirements of an environmental monitoring program for the pearling industry;
- Provides advice on the possible elements or components of an environmental code of practice for the pearling industry.
- To describe the operations of the industry, and to identify the issues and potential environmental impacts considerable field work was undertaken taking in the hatchery production, fishing activities and land and sea based pearl farms.

The executive summary of this study is attached (Appendix 1).

The report concluded that:

Environmental effects of the various components are minor. The minor is the returning to the sea of material cleaned from the pearl oyster shells. However, no chemicals are used in the cleaning process and the material returned is of marine origin and temporally and spatially widely dispersed.

In addition the report identified four potential environmental problems:

- Antifoulant paints
- Materials used in the manufacturing of panels
- Sanitation; and
- Plastic tags

Other generic issues identified were those associated with vessel and shore camp activities:

- Waste disposal
- Grey water
- Fuel and oil storage
- Oil disposal; and boat paints

The Enzer Report concluded that:

'In general the industry was found to be environmentally benign, producing a high value product with a minimum of environmental disruption'.

Another observation with regard to environmental monitoring of pearl farms was that:

'The levels of effect are so small that separating them from natural variation in background levels would be difficult, if not impossible.'

IRC Environment : Environmental Risk and Impact Assessment of the Pearling Industry (Jernakoff, 2002) (Executive summary Appendix 4).

In 2001, funded through the WA Fishing Industry Development Unit (IDU) and the Fisheries Research and Development Corporation (FRDC), the PPA commissioned the environmental risk assessment consultancy, International Risk Consultants – Environment (IRCE), to conduct an environmental audit and risk assessment of pearl culture in WA. (Jernakoff 2001 – FRDC 2001/099).

The consultants undertook an;

1. Evaluation of current Pearl Industry practices and procedures building on the Enzer Report,

2. Ecological Risk Assessment on pearl culture including a workshop,

3. Environmental information gap analysis, and

4. Environmental management gap analysis.

The executive summary of this study is attached (Attachment 2).

The consultants concluded that the key environmental issue for the industry is whether or not there are long term environmental impacts from pearl culture (Jernakoff 2001). In keeping with the conclusions of Enzer (1998) they found that the available evidence suggests the environmental impact of pearling is low; however there is scant scientific evidence to prove this point. Jernakoff recommended that a study should be undertaken to document whether this is in fact the case, and to quantify the extent to which pearling might change the natural environment. Jernakoff (2001) suggested these studies should initially focus on four components:

1. The composition of the fouling growth cleaned from cultured pearl oysters

2. The potential for modifying benthic habitat below pearl farms;

3. The disposal of grey water from vessels and shore camps; and

4. Monitoring interactions with protected fauna.

Both Enzer and Jernakoff highlighted the general lack of information about the environment and ecosystems on which the pearl industry depends.

The pearling industry won the Environment Award at the 2003 WA Fishing Industry Council awards presentations for their efforts in implementing the process of assessing the environmental credentials for the pearling industry.

ESD Assessment 2002

Following the Enzer Report the *P.maxima* pearling industry was one of the first to prepare an application to Environment Australia outlining the industry's compatibility with the Commonwealth EPBC legislation requirements for ecologically sustainable development (ESD).

A significant part of this assessment process was the report by consultants IRC Environment investigating ESD and other environmental issues within the pearling industry.

As a part of this process an environmental risk assessment workshop in relation to the wild capture fishery and the grow out phase of the industry. The workshop participants included representatives from the pearling industry, Dept of Fisheries managers, recreational fishers, conservation groups, Environmental Protection Authority, Environment Australia and Conservation and Land Management. The workshop did not identify any serious environmental risk associated with the pearling industry and the results are contained in the IRC (Jernakoff 2001) report.

Overall the workshop report confirms the status of the pearling industry as environmentally benign.

Several minor studies were recommended to confirm anecdotal observations there is no impact. Research projects to address these have been included in the industry Strategic Research and Development plan developed by the peak industry body (PPA) for further development and funding.

Environmental Risk Assessment Workshop (PPA, 2004)

Continuing the pearling industry's process of environmental assessment, a follow up risk assessment workshop was held in September 2004. Industry responses and progress relating to the issues highlighted in the 2002 risk assessment workshop were presented.

As with the similar Environmental Risk Assessment Workshop conducted in 2001, the 2004 workshop found the majority of environmental risks associated with the pearling industry are low with only four risks considered moderate. This indicated that the risk profile of pearling between 2002 and 2004 had changed very little.

Three new issues arose from this workshop and included:

- Fuel and chemical management
- Water quality loss (from a theoretical spill of diesel 50 000 L at a land base)
- Water quality loss (from a theoretical spill of aviation fuel 35 000 L)
- Water quality loss (chemical treatment of sewage)
- Waste management on vessels

Port Stephens Report – Update on monitoring for impacts from biodeposition from pearl cultivation in Port Stephens (Gifford, 2004)

This research program was commissioned by Port Stephens Pearls Pty. Ltd. as a part of the environmental monitoring requirements to support a development application to farm Akoya pearl oysters in Port Stephens.

The study began in 2000 and involved the comparison of the benthos under a pearl farm lease site at Port Stephens and 5 control sites. Total organic carbon (TOC), nitrogen (N) and phosphorous (P) levels in the sediment were analysed. These factors, particularly Total Organic Carbon have been shown to be the most appropriate indicator of organic matter accumulation and subsequent changes in the benthic community structure.

Quantities of sediment TOC, P and N were compared statistically at nine sites on 12 occasions. The additional ability of these analyses to detect change further reinforces earlier findings that the pearl farming activities have not altered the environment beyond the level of naturally occurring variation or beyond the ability of the environment to rapidly assimilate any additional nutrients.

The report concludes that there was no detectable change in the chemical composition of the sediment underneath the experimental farm over time relative to five control sites sampled.

These findings are consistent with those of similar shellfish farming activities in other areas of Australia. In a study of the impacts of subtidal shellfish farming in Tasmania, Crawford *et al*. (2003) looked at the impacts of three longline shellfish farms which were considered the most likely to exhibit impacts if they were to occur. On the basis of these studies, these authors concluded that longline shellfish farming is having little impact and went as far as to suggest that extensive monitoring of longline shellfish farms of this type would appear not to be necessary.

In comparison to the farms studied in Tasmania, the pearl farm at Wanda Head in Port Stephens has operated at stocking densities of less than one third of those in Tasmania and is in deeper water with higher current flows. All factors that would significantly further reduce the potential for impact.

The *P. maxima* pearling industry in WA and NT operate at even lower densities and higher current flows than that in Port Stephens.

Hartstein and Stevens (2005) also found no detectable organic enrichment of sediments underlying shellfish farms with moderate tidal stream flow.

Despite the research showing conclusively that the Port Stephens pearl farm was having no detectable impact on the underlying benthos or seagrass beds, the development application was refused by the New South Wales Minister for Infrastructure and Planning and was recently the subject of a judicial investigation by the Land and Environment Court New South Wales.

In summing up, Justice Talbot found that:

- there would be no impact on water quality of Port Stephens
- the likely impact on adjacent seagrass beds would be negligible
- there will be no significant impact on the whale, turtle and dolphin populations of Port Stephens
- the material cleaned from the oysters was extracted from, or deposited out of, the surrounding water column
- the visual nature of the plume from the cleaning process was of a similar nature to that caused by wind, rainfall and boat wakes

The Court found no evidence of any real threat of irreversible environmental damage, and ordered that the development application be granted.

Seafood Services Australia: Environmental Management System Pilot Program (SSA, 2005)

The PPA joined as a partner with a Seafood Services Ltd (SSA) pilot program developing Environmental Management Systems (EMS) for Australia's seafood and aquaculture industries.

The PPA aim was to develop an industry wide EMS '*template'* which can be implemented within each individual pearling company in the form of an Environmental Management Plan (EMP).

This template has now been completed and circulated throughout industry. An EMS workshop to assist pearling companies to implement the process was held in April 2008 and companies commenced introduction of EMS processes into their operations.

Development of the scientific requirements of an Environmental Management System (EMS) for the pearling (Pinctada maxima) industry (PPA, 2006)

In 2005/06, the PPA commenced a project (funded through the WA Fishing Industry Development Unit (IDU) and the Fisheries Research and Development Corporation (FRDC)), aimed at addressing the primary environmental concern raised in the risk assessment processes relating to the pearling industry: *Is there any impact of the material cleaned from the pearl oyster on the underlying benthos?*

The specific aims were to:

1. determine the relevant scientific requirements for a pearl industry EMS
2. determine if the benthic physical/chemical or ecological variables beneath established pearl farms differ from the surrounding environment
3. develop the PPA's capacity to initiate and co-ordinate strategic research;

The objectives of this project were to:

- Quantify the extent that the cultivation of pearl oysters is found to modify the benthos,
- Inform industry on the extent to which culture modifies the environment.
- Input any findings into the PPA's development of industry wide Environmental Management Systems
- Improve the publicly available knowledge about the actual level, if any, of environmental modification associated with pearl culture and the industry's management strategies around this issue.

The Research objectives were to:

1. Determine whether there is any difference in the benthic faunal communities at pearl farms compared with suitable reference locations
2. Determine whether there is a difference in the physical and chemical profile of the benthos below farm sites compared to suitable reference locations
3. Develop a low cost, rapid and robust early warning monitoring protocol to be incorporated into environmental management decision trees for future incorporation into EMP's
4. Compare sedimentation under lease sites (during cleaning operations) with reference areas

Literature reports indicate that generally the primary environmental concern for mollusc aquaculture is disturbance of the benthos below lease sites. Therefore, the methodology was formulated to allow detection of any putative benthic ecological (benthic fauna), physical (particle size analysis) or chemical (redox, Total Organic Carbon (TOC) and nitrogen) change at differing spatial and temporal scales.

Three pearling leases were studied in detail spread throughout the Kimberley region:

- Seaflower Bay
- Kuri Bay
- Cygnet Bay

These locations were chosen to reflect maximum potential for benthic disturbance below pearl leases. Each site had been in operation for a significant period of time. Literature reports indicate that the main factor governing whether a shellfish farm will impact on the benthos below the lease area is stocking density. As such, for this study farms with a relatively long and consistent history of farming activity were chosen. These three locations were studied in detail, involving comparisons of benthic fauna below lease locations and comparing them to the benthic fauna of three nearby reference locations.

The project will be conducted over 3 years. Initial planning/pilot studies have been carried out in the first 6 months to determine spatial variability at each location, followed by the experimental sampling period of 2 years. Analysis/write-up will take place in the final 6 months. Sediment sampling will be conducted every 2 months for 2 years at farms and references, according to the protocols of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000). Sediment Redox, Total Organic Carbon (TOC), Nitrogen (N) and grain size analysis will be measured. This type of intensive sampling regime allows the derivation of site specific environmental trigger values, which subsequently allow the monitoring of the impacted site only, rather than ongoing extensive reference site monitoring.

The sampling design and analysis carried out will be similar to the protocols of Gifford et. al. (2004). Reference locations would be located at least 500m from lease location and would be matched on depth, sediment composition and tidal regime.

Furthermore, an initial pilot study has been conducted to determine the need for nested "sites" within each location, depending on the degree of spatial variation (Morrissey et al, 1992). If highlighted in the pilot study, 3 sites nested within each location (10-20m apart) will be sampled. Should variability among sites within locations be consistent, the sampling will be reduced to the location level only. As such, the experimental design incorporates a hierarchical structure to allow determination of spatial variability. 4 replicate samples will be taken at each site 4 times per year for 2 years for benthic fauna.

Two general predictions will be tested:

1. The diversity and composition of benthic fauna below lease sites will be different from reference sites;

2. Abundances of various faunal groups will be different between lease and reference sites. Diversity and composition of faunal assemblages will be analysed using multivariate statistical methods. Non-parametrical multidimensional scaling (nMDS) will be used to identify patterns of similarity among faunal assemblages at lease and reference sites. Significance of any present patterns will be tested by analyses of similarities (ANOSIM) using PRIMER 5).

To analyse patterns of differences in abundances of taxa, a post-impact asymmetrical analyses of variance will be carried out within each waterway or "place", consisting of 1 farm and 3 reference "locations" with 4 replicates per nested site. As stated earlier, sampling will occur every 2 months for physico-chemical analysis and 4 times a year for benthic community analysis.

Simultaneously, 5 replicate sediment cores will be taken every 2 months for 2 years at reference and lease area locations for the analysis of the sediment physico-chemical parameters TOC, N, redox and particle size analysis. From this research, it may be possible to choose (if appropriate) a physico-chemical factor that can be employed to define site specific trigger values (ANZECC 2000) of sediment chemistry as an early, simple and cost-effective measurement of physico-chemical disturbance and potential future benthic disturbance.

Five (5) sedimentation traps will also be deployed for a 24 hour period at each of the reference and impacted location at various times over the 2 year monitoring time frame.

The information gained from the study will reveal the degree of impact, if any, on the marine environment, and provide the pearling industry with benchmark standards from which to evaluate the health of the underlying benthos.

The results from the initial pilot study found no evidence of impact from the pearl farms on the benthos or sediment chemistry.

The Executive Summary of the pilot study states:

The pearl farms surveyed in this pilot study were Kuri Bay, Cygnet Bay, and Vansittart Bay (Seaflower Bay). At each farm, the condition of the benthos within the pearl lease was compared to 3 reference locations located at least 1km from the pearl lease boundary, in similar water depths, current flows, and sediment particle size. The physico-chemistry parameters measured from sediment core samples were total organic matter, nitrogen, phosphorus, carbonates, and redox potential. Grabs samples of sediments were used to collect the benthic macrofauna (>1mm in size) which were identified to class/order taxonomic level.

At all three farms, there was no significant difference between the benthic faunal communities below the longlines when compared to the reference locations. There was also no difference in the number of benthic fauna individuals, number of benthic species, or the Shannon-Weiner diversity index for the benthic fauna between the longlines and nearby reference locations.

Multivariate analysis of the benthic faunal communities (MDS, ANOSIM) confirmed that the pearl farms did not influence the benthic assemblage composition under the longlines. In other studies of this nature, a change in community composition can be a consistently sensitive indicator of environmental disturbance (Grant et al. 1995, Macleod et al. 2004). The benthic fauna assemblages under other aquaculture enterprises (e.g. finfish aquaculture) have been shown to change as a consequence of increased nutrient levels, anoxic sediments and other changes to the benthos (Hargrave et al. 1997, Mirto et al. 2000).

Sediment physico-chemistry at all three farms was not typical of organically enriched locations arising from finfish and intensive mussel aquaculture reported elsewhere in the world (Hargrave et al. 1997, Mirto et al. 2000, La Rosa et al. 2001). There was no elevation in the sediment nutrients (total organic matter, nitrogen, and phosphorus), nor a difference in the carbonate content, and redox potential (which is an indication of anoxic conditions).

In conclusion, the results from this pilot study indicate that there is no evidence for benthic disturbance at Kuri, Cygnet, and Vansittart Bays pearl farms. This is of particular note as these farms are some of the longest operating in Australia, with decades of continuous pearl cultivation. Nonetheless, definitive conclusions regarding the presence/absence of environmental disturbance can only be drawn following the addition of temporal replication.

The research will continue through to July 2009 to obtain additional spatial and temporal data.

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Appendix 1.

Executive Summary: The Environmental Impact of Pearling (Pinctada maxima) in Western Australia. (Enzer Report)

The pearling (*Pinctada maxima*) industry in Western Australia was investigated in detail to provide a basis of understanding the operations of the industry and the actual and potential impacts caused. Operational methods used by pearling companies and the regulatory framework for their environmental activities are described. Environmental impacts are divided into those which occur throughout the operations of the industry, which are largely related to the use of boats, and those which occur in particular operations.

Universal features of the use of boats and operation of shore camps include:

- waste disposal;
- grey water;
- fuel and oil storage;
- oil disposal; and
- boat paints.

In these features the pearling industry faces the same environmental problems as other operators of boats and small camps on shore in isolated areas. One major difference is the siting of boats at a single station for prolonged periods, with possible accumulation of sanitary wastes. This is not considered to be a problem given the strong water movements in areas used for farms. However, a simple study might demonstrate the lack of a significant effect.

The use of boat paints containing tributyltin (TBT) was banned in Western Australia for boats smaller than 25 m in 1991 and maximum leaching rates were imposed for larger vessels. Use of TBT is still permitted in the Northern Territory. Given the known deleterious ecological effects of TBT in the marine environment, and in particular the effects on shell deposition mechanisms in bivalves, the pearling industry should ensure there are no companies using TBT-based paints. Similarly, the effects of copper-based paints on bivalves should be examined.

Industry operations were divided into five categories and the environmental effects of each assessed:

- wild harvesting of pearl oysters;
- effects of holding dumps;
- transportation of pearl oysters;
- growing of pearl oysters on farms; and
- hatchery production of juvenile pearl oysters.

Environmental effects of the various components are minor. The major effect is the returning to the sea of material cleaned from pearl oyster shells. However, no chemicals are used in the cleaning process and the material returned is of marine origin and temporally and spatially widely dispersed.

A series of comments is made on potential areas for further investigation or monitoring. These include sanitation and boat paints described above, use of degradable tags, buildup of petroleum residues, and determination of the chemical composition of plastics used in panels holding pearl oysters.

A number of suggestions are made of possible items for inclusion in an environmental code of conduct for the industry.

In general the industry was found to be environmentally benign, producing a high value product with a minimum of environmental disruption.

Appendix 2.

Executive Summary: IRC Environment (2002): Environmental Risk and Impact Assessment of the Pearling Industry (Jernakoff Report)

OBJECTIVES:

The overall project objectives include:

1. Identify key environmental issues and risks facing the Pearling Industry.
2. Identify gaps that would need to be addressed in current Pearling Industry procedures in order to develop a PPA Environmental Code of Practice in line with the requirements of an Environmental Management System such as ISO 14001.
3. Source and obtain ecological information to assist the industry in identifying what environmental characteristics are key elements of successful pearl farming.
4. Recommend what environmental parameters should be used in monitoring program to ensure that any potential environmental impact of pearl farming on the marine environment is detected.
5. Recommend research priorities on pearl oyster fishing / farming environmental issues.
6. Provide information that is transferable to similar types of aquaculture eg black lipped pearl fishery, abalone hatchery operations.
7. Position the Pearling Industry to satisfy the Environment Australia/SCFA ESD assessment processes.

NON TECHNICAL SUMMARY

OUTCOMES ACHIEVED

The following outcomes align with the project objectives:

- Integration with the SCFA Ecological Sustainable Development (ESD) process.
- Demonstration of environmental due diligence and environmental stewardship of the Pearl fishery.
- A strategy with which the Pearling Industry can enhance its position in the light of current government policy.
- The development of a PPA Environmental Code of Practice along the lines of an Environmental Management System (EMS) (eg, ISO14001).
- Provision of knowledge that could be transferred to similar fisheries such as black lipped pearls and abalone hatcheries.
- A report outlining gaps in key environmental information required to address government policy issues on sustainability.
- A report outlining gaps in the current management system in the Pearling Industry and an ISO 14001 fishery.
- A report of the ecological risk assessment workshop.

To achieve the objectives and outcomes that the PPA set, essentially four tasks were required.

- Task 1: Evaluation of current Pearl Industry practices and procedures;
- Task 2: Environmental risk assessment workshop;
- Task 3: Gap analysis of key environmental information; and
- Task 4: EMS gap analysis.

Task 1: Evaluation of current Pearl Industry practices and procedures

A site visit was planned to evaluate current Pearl Industry practices and procedures. The objectives of the site visit were to:

- visit at least 3 pearl farms, fishing vessels and interview staff to assess first hand how the fishery operates and how closely its procedures and practices are in line with those required of an internationally recognised environmental management system.
- assess the degree to which existing practices and procedures are implemented.
- report on the site visit and evaluate physical conditions, existing practices and procedures of a pearl industry in operation in the Broome, Darwin and Kimberley region.

The locations visited were Bynoe Harbour, Kuri Bay and Talbot Bay. During the visit the observed farming activities included growout, seeding and harvesting. The physical conditions were observed in which the activities operated and the extent to which management systems were implemented.

Task 2: Environmental Risk Assessment Workshop

The PPA required a comprehensive and scientifically defensible assessment of the fishery and farming operations to the ecosystem (environmental and ecological risk assessment). A risk assessment was carried out based on existing knowledge, considering all aspects of the fishery, identifying and prioritising gaps in knowledge and producing a set of prioritised risks. The broad intent of the Environmental Risk Assessment Workshop was to provide a register of the main potential environmental and ecological risks that arise from the various activities carried out by the *Pinctada maxima* fishery. This risk register is used to identify the underlying issues so that these may be addressed through the development of an appropriate management strategy. This enables the fishing activities to focus on reducing the risk of deleteriously affecting the ecosystem in which the fishery occurs.

The aim was also to integrate the workshop with the broader Ecological Sustainable Development (ESD) research program by providing a session of the workshop for the Department of Fisheries Western Australia (DFWA) to address environmental and ecological risks for the Wild Harvest component of the *Pinctada maxima* fishery. The risk assessment workshop was held during September 2001 at the Fremantle Sailing Club, Western Australia. The risk assessment results were incorporated into the development of an industry code and can also be used to assist the industry if it chooses to seek MSC accreditation.

Task 3: Gap analysis of key environmental information

The identification of key environmental issues as identified from Task 1 assisted in determining if adequate information on those issues exists or if information is required following a review of national and international literature.

A significant feature of this review was to ensure that all recommendations are outcome based and applicable to the needs of the Pearling Industry as opposed to those that are of theoretical or of academic interest. The review, built on the report by Enzer (1998) identified appropriate information or key gaps that are required to be answered to meet the PPA's outcomes. Relevant research strategies were recommended to address those gaps.

Task 4: EMS Gap analysis

The PPA is required to ensure that environmental issues are integrated into aquaculture business activities. An outcome of this effort is to position the PPA as industry leaders in the area of environmental stewardship of fisheries resources from both a national and international perspective. One of PPA 's goals is to have its environmental achievements and activities recognised by an objective, transparent and internationally accepted method. PPA sees achieving and demonstrating compliance to an internationally recognised standard such as ISO 14001 as a solution to this requirement. The gaps were significant enough to prevent pearling companies from achieving the requirements of the Standard at the present time (and therefore certification to ISO 14001).

The gap analysis used information collected during Task 1 and compared the current procedures and systems used by companies within the PPA with those required by an ISO 14001 EMS. The gap analysis also identified areas where a Pearling Industry environmental code of practice could be developed.

Environmental Code of Practice

The PPA members have prepared an environmental code of practice to provide minimum standards for environmental performance. The PPA will encourage all pearlers to adopt this Code as a statement of the industry’s commitment to ecologically sustainable development.

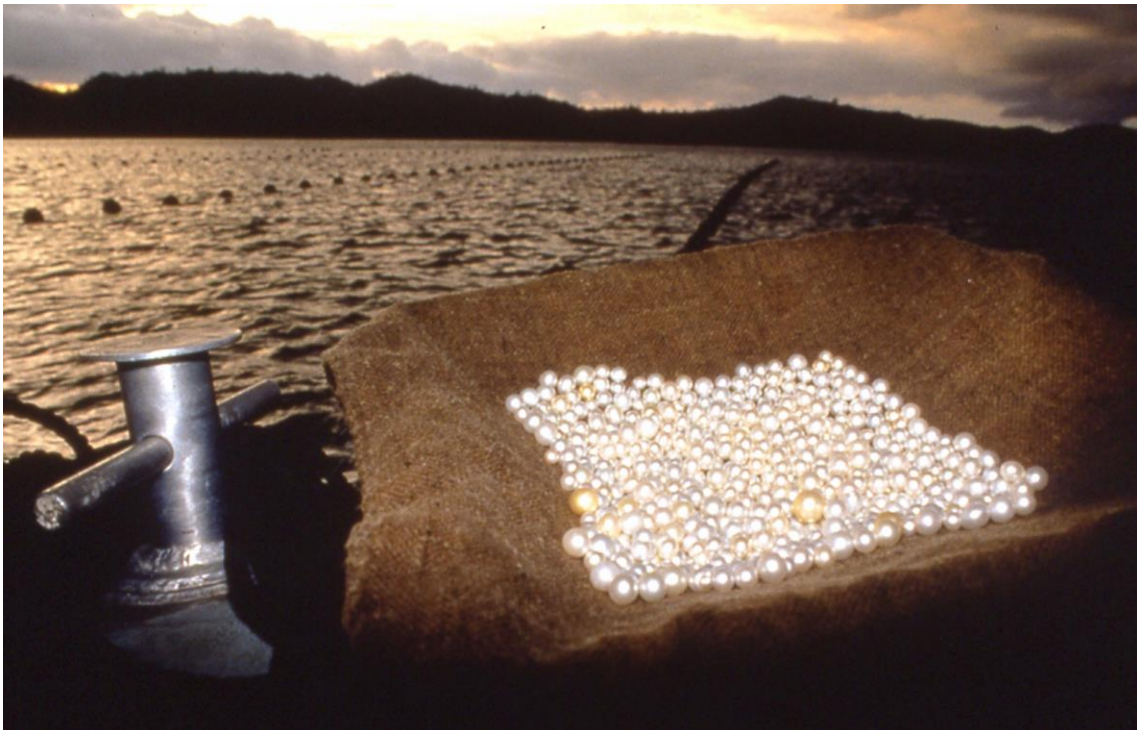
The outcome for pearlers should be to continue to:

- *operate in an environmentally responsible manner; and*
- *be known as an industry that is environmentally benign, producing a high quality product with minimal adverse effect on the environment.*

Appendix 3.

PEARLING INDUSTRY

ENVIRONMENTAL CODE OF CONDUCT



PEARL PRODUCERS ASSOCIATION

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Introduction

Australian South Sea pearls are the most highly regarded in the jewellery industry worldwide. The Western Australian pearling industry is one of the largest and most successful fishing and aquaculture industries in Australia. The industry is based on the pearl oyster *Pinctada maxima*, a bivalve mollusc species.

Production is based on a mix of the collection by diving for pearl oysters from the wild and oysters produced in land based hatcheries. Oysters are seeded with a nucleus to start the pearl culture process and then placed in net panels attached to a long line system on sea based grow -out farms to produce the pearls to commercial sizes.

This success of the Australian pearling industry was not achieved by adopting overseas technology, rather it was the result of decades of hard work and innovation to develop the technology according to local conditions. Australian pearl farmers are the world leaders in pearling development and technology

The total numbers of pearl oysters from both wild and hatchery sources that can be seeded is limited through a annual quota system applied within the industry. Industry participates in this process to protect and ensure the sustainibility of the wild stocks of pearl oysters. Department of Fisheries Western Australia is the primary regulatory agency for the pearling industry and maintains individual quotas on each licensed operator.

The Need for an Environmental Code of Conduct

Australian South Sea pearls are synonymous with an image of *'rare, natural and from a pristine environment'* – resulting in the ability to command premium prices. With a well managed fishery, clean environment and freedom from many of the major diseases experienced in the northern hemisphere, Western Australian pearlers have a strong competitive marketing advantage.

Clean water and a healthy environment means strong growing oysters which will produce high quality pearls. Hence, environmental protection has always been a major priority for the industry, as it relies on the provision of a healthy environment for its continued viability.

It has been recognised by the Western Australian pearling industry that the only sound approach to the ongoing sustainability is through maintaining the integrity of the environment that supports it.

The peak industry body, the Pearl Producers Association (PPA), is playing a major role in ensuring the sustainability of the industry through its commitment to the continuing implementation of industry best practice based on ecologically sustainable development principles. Recognition by the pearling industry of the need for pearling to play a major role in the ongoing protection of the waters of Western Australia has led to the development of this Environmental Code of Conduct.

What is a Code of Conduct?

A Code of Conduct provides a voluntary set of guidelines for the carrying out of a specific activity.

For the pearling industry the document specifically aims to:

- Provide realistic objectives;
- Be flexible and relevant to the Western Australian pearling industry;
- Provide a mechanism for environmental self regulation;
- Be practical and focus on outcomes;
- Provide options for environmental management;
- Recognise that only the financial success of a pearling operation can ensure the provision of adequate resources to manage environmental issues

The Environmental Code of Conduct evolved out of a continuing consultation process involving representatives from industry, government, environmental interest groups, recreational fishers, Aboriginal groups and other stakeholders with a commitment to the sustainable management of Western Australia's aquatic environment.

The preparation and distribution of this Code is one of the many steps in a strategy promoting responsible environmental practices within the pearling industry. The initial step involved a comprehensive study of the environmental impact of the pearling industry (Enzer 1998). This study concluded that the pearling industry was environmentally benign.

Subsequent to the Enzer report, a risk assesment workshop involving many different stakeholders was held as part of the process required to fullfill the Ecological Sustainable Development requirements of Environment Australia. This workshop identified no significant threats to the environment from pearling activities.

The guiding principles outlined in the Code will provide specific sectors of the industry with a framework in which they can develop their own individual company Environmental Code of Conduct and Management Systems, with a focus on ecological and economic sustainability for their particular site or operation.

The Code does not remove the legal requirements that pearling companies have under their respective environmental authorities and associated conditions.

The PPA members have prepared and endorsed this Code to provide a minimum generic standard for environmental performance. The PPA will encourage all pearlers to adopt this Code as a statement of the industry's commitment to ecologically sustainable development. The outcome for pearlers should be to:

- *continue to operate in an environmentally responsible manner; and*
- *be known as an industry that is environmentally benign, producing a high quality product with little adverse effect on the environment.*

This Code is designed to interface with two key industry Codes of Conduct:

- Code of Conduct for Responsible Fisheries developed by the Food and Agriculture Organisation; and
- Australian Aquaculture Code of Conduct developed by the Primary Industries and Resources South Australia.

Ecologically Sustainable Development

The concept of Ecologically Sustainable Development has evolved from the World Commission on Environment and Development's report, *Our Common Future* (1987). It can be generally defined as ***conserving and enhancing the community's resources such that, our total quality of life, both now and in the future, is secured.***

The Environmental Code of Conduct for the Pearling industry supports the principles of Ecologically Sustainable Development and the Precautionary Principle.

Consistent with the three operational interpretations of the Precautionary Principle (Young 1993), it is suggested that as confidence with an activity increases, a transition should be made to require the use of best available technology only when this does not entail excessive cost.

The management practices set out in this Code of Conduct provide a responsible approach to environmental management while ensuring that pearling industry activities will continue to be economically viable.

Underlying philosophy for the Code of Conduct

Management of the Pearling Industry recognises that protection of the environment is a requirement of all businesses to ensure long-term benefit to all stakeholders. The pearling industry is committed to the development and operation of an environmentally sustainable pearling industry.

The following principles are adopted to maintain ecological and economic sustainability for the pearling industry:

- Ecologically sustainable development (ESD);
- Economic viability;
- Long term protection of the environment to ensure availability of suitable sites for pearling operations;
- Compliance with, and implementation of, necessary systems to support legislative requirements and the industry Code of Conduct;
- Resource sharing and consideration of the other users of the environment; and
- Research and development to support the achievement of the above five priorities.

These principles provide the industry with the mechanism to implement the Code of Conduct.

The Code

Industry will work in conjunction with government and other stakeholders to ensure that the pearling industry is managed sustainably (ecologically and economically) and that the pearling industry's considerable social, economic and environmental benefits are maintained.

This will be accomplished through three guiding principles for environmental best practice.

1. Protect the environment.
2. Comply with regulations.
3. Treat aquatic animals responsibly

1. Protect the environment:

- Encourage the development and operations of pearling at a rate in accordance with ecologically sustainable principles.
- Encourage the development and operations of pearling in accordance with legislative responsibilities and environmental standards.
- Support natural resources management that provides improved outcomes for sustainable resource use through effective co-operation between government agencies, the pearling industry and the wider community.
- Promote industry training and education opportunities in environmental awareness, aquatic and bird species identification, clean production methods and best pearling practices.
- Recognise the importance of good farm site selection, system design and infrastructure to minimise ecosystem impacts.
- Monitor and review farm management practices to minimise ecological impact on:
    - sensitive benthic habitats such as coral, seagrass and mangroves
    - marine wildlife, mammals and migratory bird species and their breeding, feeding and resting areas
    - estate islands through introduction of feral plants and animals
- Minimise and, where practicable, eliminate the use of chemicals.
- Provide for disposal and/or processing of wastes to minimise the risk of ecological damage.
- *Work in close association with governments to maintain and continuously review protocols regarding the translocation of live pearl products within and between states.*
- Support the maintenance of precise records regarding the transfer or translocation of stock between pearling operational areas.

2. Comply with the regulations:

- Promote responsible environmental performance in line with this code and any legislative responsibilities.
- Promote effective consultative mechanisms with governments, the community and other users.
- Expand self management and co-regulation to include industry-based codes of conduct that specifically address environmental issues.

3. Treat aquatic animals and birds responsibly:

- Monitor and review farm management practices to minimise ecological impact on:
    - marine wildlife, mammals and migratory bird species
    - estate islands through introduction of feral plants and animals
- Fauna interaction management techniques should be planned and implemented to minimise impacts to native fauna species while protecting the economic viability of the pearl farm.
- Introduce interaction mitigation arrangements where required
- Establish contingency plans, in conjunction with responsible authorities, for recovery of aquatic animals and birds which have interacted with pearling equipment
- Seek to develop expertise in aquatic animal health management and ecological sustainability within the pearling industry.
- Promote the maintenance of efficient and sustainable stocking densities on pearl farms.
- Address the physical and biological requirements of *Pinctada maxima*.
- Continue to develop methods to transfer and harvest pearl oysters which reduce stress.
- Support the development of appropriate emergency contingency plans to deal with the spread of diseases, parasites and other pathogens.
- Encourage the immediate reporting of any mass mortalities of oyster stocks or other environmental problems to the relevant agencies and the containment of diseased or infected stock.
- Identify responsibilities for environmental monitoring proportionate to possible environmental risk and benefits.
- Promote the correct disposal of dead stock in a manner that will not render the likelihood of any disease or pathogen being released into natural waterways.
- Support research and development programs to expand knowledge and understanding of pearling operations and their environmental interactions.

Appropriate Management Practices

Appropriate Management Practices have been determined using Best Practice Environmental Management.

The Best Practice Environmental Management is *the management of the activity to achieve an ongoing minimisation of the activity's environmental harm through cost-effective measures assessed against the measures currently used nationally and internationally for the activity (EPA 1994).*

In deciding the Best Practice Environmental Management of a pearling activity, regard should be had to the following measures:

- Strategic planning by the person carrying out, or proposing to carry out, the pearling activity;
- Administrative systems put into effect by the person;
- Public consultation carried out by the person and authorities;
- Systems and process design;
- Waste prevention, treatment and disposal.

Pearl Farm Design and Planning

The planning stage of any pearl farm (new or expanding), is crucial not only for financial success, but also as an opportunity to design the development in a way which will not cause undue influences on the environment.

New pearl farms and any expansion of existing farms, should be designed and planned in accordance with the checklist below to minimise the risk of harm to the environment.

The planning and design of proposed pearl farms should incorporate the following:

- Identification of features of the farm and its environment which have aspects of ecological value;
- Farm size must be limited according to legislative requirements;
- Farm design and associated land and sea bases should minimise disturbance to mangrove communities or other tidally influenced zones;
- The final design should ensure that the proposed pearl farm will operate in an environmentally sustainable manner and in accordance with other sections of this Code of Conduct.

Disease Management

Disease and health management requires an holistic management approach inclusive of, water quality management, hygiene and post seeding/harvest health.

The pearling industry, in conjunction with authorities, has developed plans to ensure that, in the event of a disease outbreak, the threat of disease spread within a farm and spread from a farm is minimised.

Disease management must be in accordance with any Pearl Health Management Guidelines adopted by the pearling industry and the Department of Fisheries WA.

Environmental Complaints

Complaints in regard to environmental issues on pearl farms may take two forms:

1. Receipt of a formal complaint from an administering authority;
2. Receipt of a written complaint from a third party.

Complaints will be recognised by the pearling industry under this Code of Conduct on the basis that the complaint:

- is in a formal or written manner;
- notes the specific incident;
- notes the specific concern or potential impact of the alleged incident;
- notes the date, time and place of the alleged incident;

On receipt of a complaint made in the appropriate form, the pearling company will implement an investigation. Such an investigation will include:

- a review of the relevant environmental records,
- communications with the responsible employee(s) and;
- any other actions the pearling management deems as necessary.

In the event that any single incident is substantiated by the investigation, the pearling company should undertake a review of operating procedures to ensure where possible that the incident is not repeated.

Environmental Records and Auditing

Under this Code of Conduct, pearling companies should undertake to keep all records required to provide a substantial base of information for the collation of environmental data relevant to the farming operation. Such records should include:

- Time and date of monitoring activities;
- Laboratory water quality results;

    - original analysis report;

    - collated data;

- In situ water quality measurement results;
- Rainfall records and records of major rain events and visual observations of surrounding waterways;
- Correspondence with relevant authorities, interest groups and community organisations;
- Written complaints received by the company and reports on outcomes from any investigations;
- A copy of relevant licenses and approvals;

Under this Code of Conduct, pearlers should conduct an *annual review* of their environmental records and management systems. The review shall comprise an internal review to confirm that the proposed actions are appropriate.

Site Rehabilitation

This Code of Conduct provides for the rehabilitation of pearl farm sites on termination of pearl farming activities.

Where a pearl farmer chooses to terminate the operation of a pearl farm and not continue with a similar use, the pearl farm site must be rehabilitated in accordance with any requirements set by the Department of Fisheries WA as the pearl farm lease administering authority.

Code of Conduct Review

This Code of Conduct will remain a dynamic document and shall be reviewed by the PPA on a three (3) yearly basis. New technology should be incorporated immediately where appropriate, based on its efficiency and effectiveness to minimise the environmental impacts of pearl farming.

Contact

To find out more about the Code of Conduct or learn about sustainable pearling practices contact:

Executive Officer
Pearl Producers Association
PO Box 55
Mt Hawthorn 6915
Phone (08) 9244 2933
Fax (08) 9244 2934.
Email pearler@wafic.org.au

Appendix 4.

Executive Report: P.maxima Pearl Oyster Industry Risk Assessment Workshop (PPA, 2004)

Pearl Producers Association

Workshop Report:

2004 Environmental Risk Assessment of the Pearling Industry

DATE: NOVEMBER 2004

PROJECT: J03-013

DOC NO.: J03-013-001 REV B

SEAFOOD SERVICES AUSTRALIA

EXECUTIVE SUMMARY

An environmental risk assessment was conducted by the Pearl Producers Association Inc (PPA). This report is based on the risk assessment workshop undertaken in September 2004 at the Royal Freshwater Bay Yacht Club, Western Australia.

The broad intent of the workshop was to provide a register of the main potential environmental (including ecological) risks that arise from the various grow out activities associated with the *Pinctada maxima* Pearling Industry in Western Australia. The workshop reviewed and updated the environmental and ecological aspects of the Farming component of the *P.maxima* industry that were identified during the baseline environmental (including ecological) risk assessment in September 2001. In addition to the review of previously identified items, workshop participants were asked to:

- review and reassign the risk (if required) of previously identified items to reflect current knowledge;
- identify new risks; and
- remove obsolete risks from the initial assessment.

The Workshop Agenda is provided in Attachment 2. The workshop had 23 participants from an invitation list of 41, including representatives from the Department of Fisheries Western Australia (DFWA), PPA, Conservation Council of Western Australia, WA Museum, NT Department Fisheries, Seafood Services Australia, University of NSW, University of Tasmania, Marine and Coastal Community Network, Western Australian Fishing Industry Council and the Aboriginal Lands Trust as well as industry and company representatives (see Attachment 1 for the Workshop Participants). The risk ranking process, using a working group of experts, delivers the ability to prioritise risks and therefore focus on the relevant management actions required for the *P. maxima* industry. A group of experts also avoids the need for time consuming sourcing and review of data during the workshop. Data known to exist was referenced prior to and during the workshop to support the allocation of risk levels. The risks were described using the factors consequence (where 1 represented negligible to 6 representing catastrophic) and likelihood (where 1 represented remote to 6 being likely).

In total, 17 environmental and ecological issues were identified across the *P. maxima* grow out industry. Sixteen of these items were within the scope of the risk assessment. (The other item referred to external influences beyond the control of the pearling industry. The issue was recorded however in the workshop notes, Attachment 3, but does not appear in the overall results of the environmental risk assessment). No high risks were identified during the workshop. Risks associated with the issues identified were ranked as either moderate (25% in total) or low (75%). The risks were similarly ranked during the risk assessment in September 2001 moderate (23%) and low (77%). The items raised during 2001 risk assessment were also similar nature however three new items were assessed

during the 2004 workshop. The following figures 1 and 2 shows the Impact and Numerical Risk Distribution for all risks identified during the 2001 environmental risk assessment. Figures 3 and 4 also show the Impact and Numerical Risk Distribution for all risks identified, this time for the 2004 environmental risk assessment.

Figure 1: Risk Ranking of Pearl Farm Activities - 2001 Environmental Risk Assessment

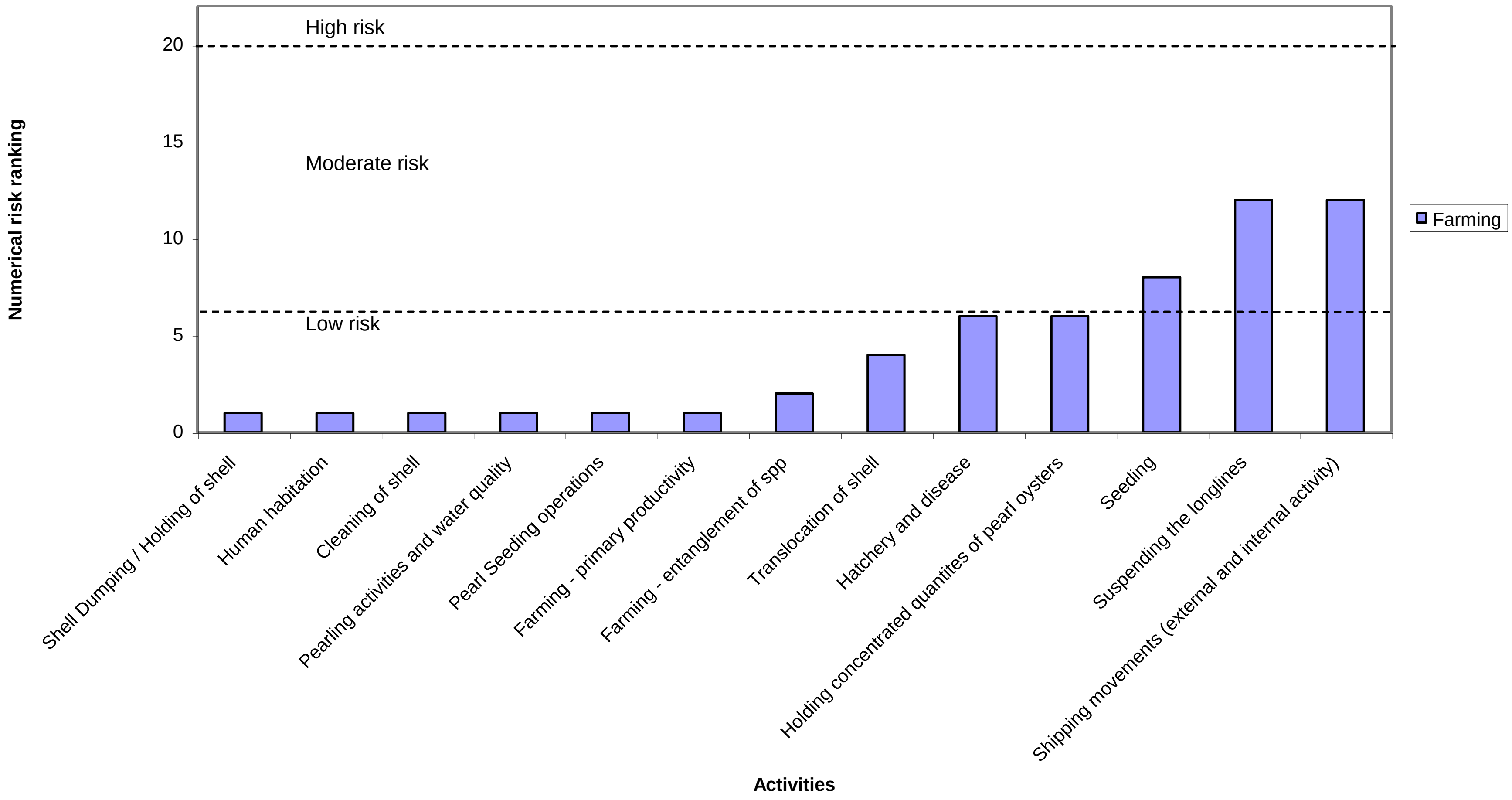


Figure 2 shows the impacts associated with the various activities outlined in Figure 1.

Figure 2: Risk Ranking of Impacts from Pearl Farm Activities- 2001 Environmental Risk Assessment

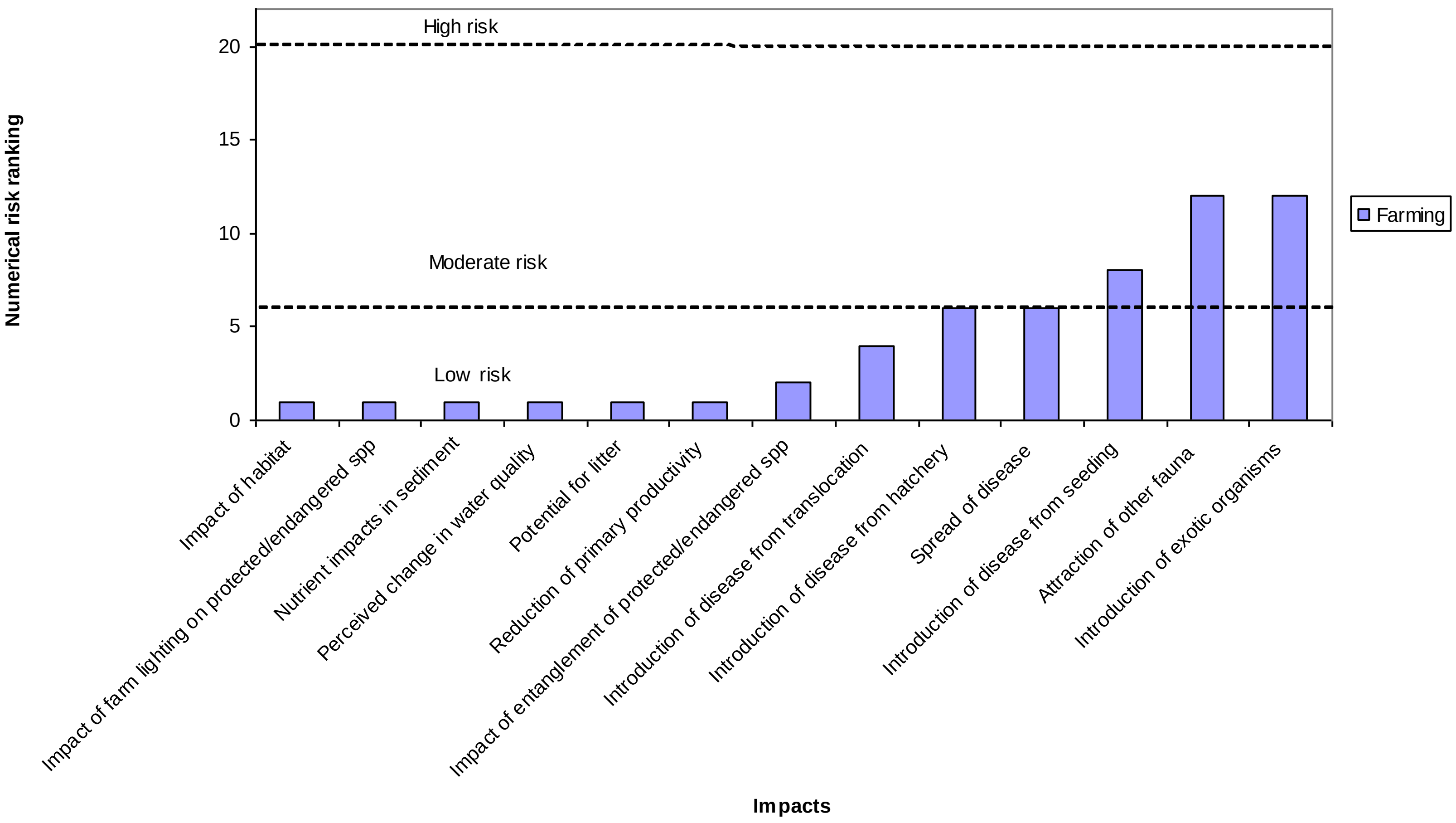


Figure 3: Risk Ranking of Pearl Farm Activities - 2004 Environmental Risk Assessment

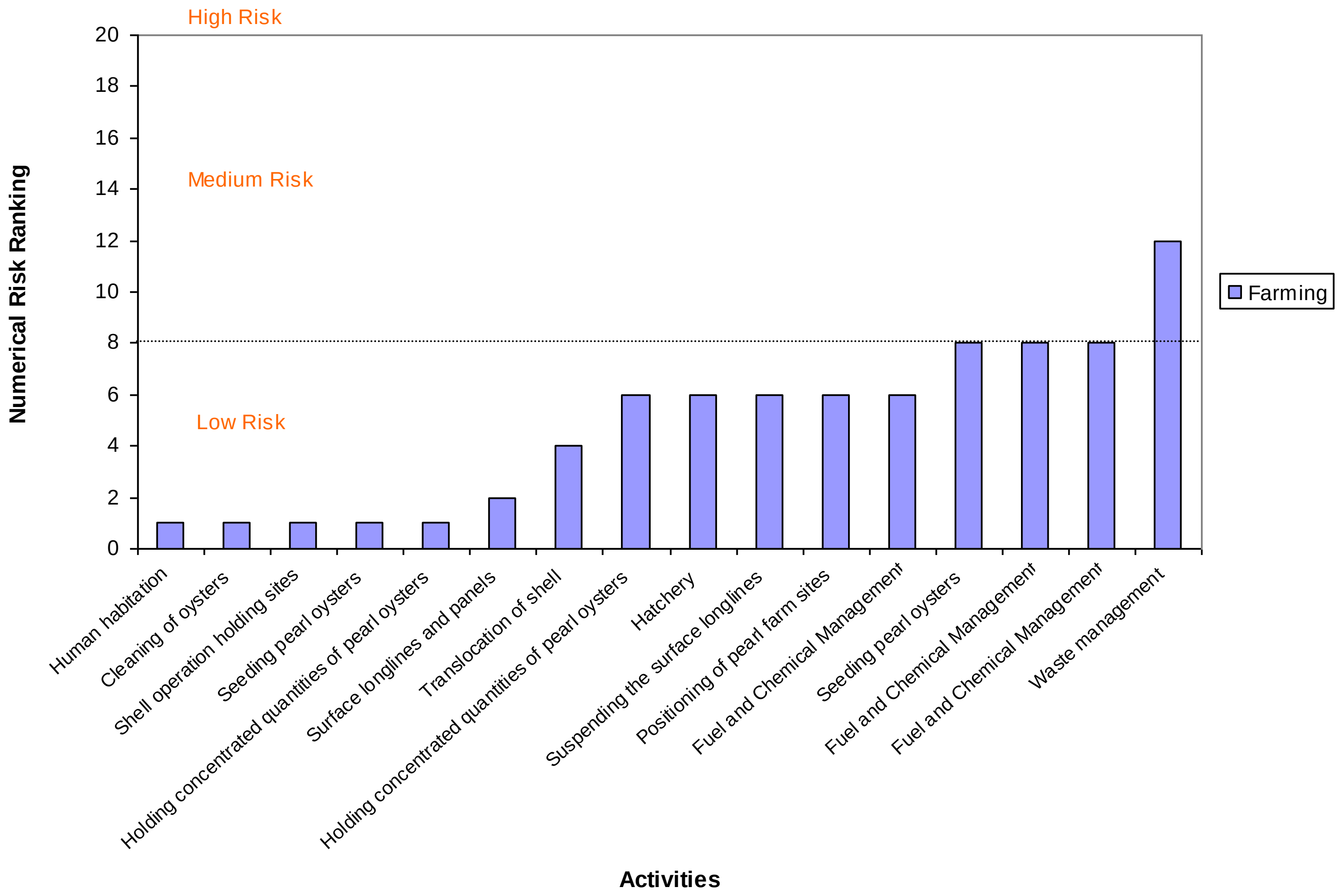
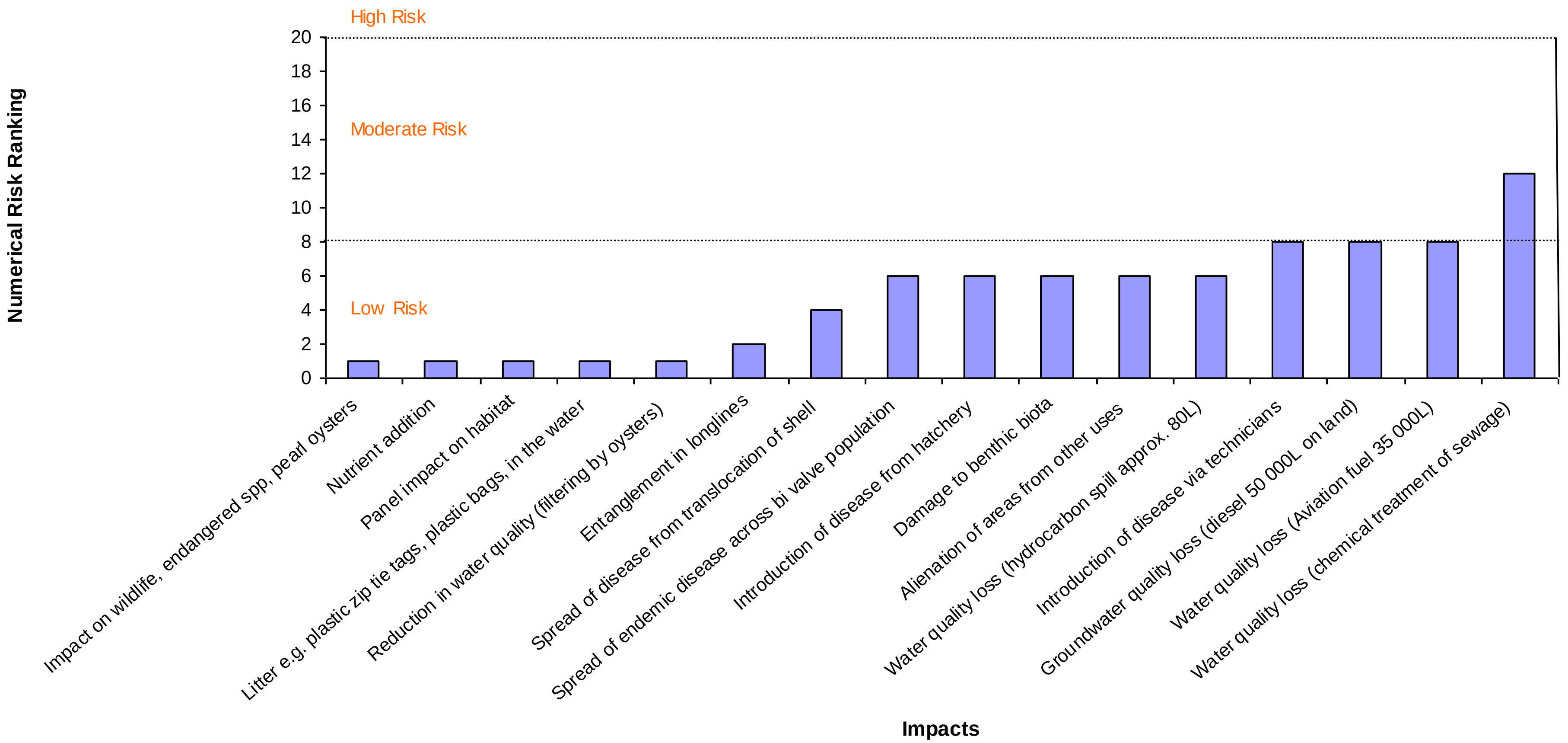


Figure 4 shows the impacts associated with the various activities outlined in Figure 3.

Figure 4: Risk Ranking of Impacts from Pearl Farm Activities- 2004 Environmental Risk Assessment



When sorted according to the risk level, the 2004 register of risks has identified the following issues for the *P. maxima* grow out industry. Within the moderate risk category, the associated potential issues include:

- Water quality loss from the chemical treatment of vessel sewage (Consequence 2, Likelihood 6) (Activity = waste management on vessels);
- Water quality loss from hydrocarbon spills (Consequence 4, Likelihood 2) (Activity = fuel and chemical management); and
- Introduction of disease from seeding (Consequence 4, Likelihood 2) (Activity = seeding).

When sorted according to the risk level, the 2001 register of risks has identified the following main issues for the *P. maxima industry*. Within the moderate risk category, the associated potential issues include:

- Introduction of exotic organisms (Consequence 3 Likelihood 4) (Activity = Shipping Movements);
- Attraction of other fauna (Consequence 2 Likelihood 6) (Activity = Suspending of longlines); and
- Introduction of disease from seeding (Consequence 4 Likelihood 2) (Activity = seeding).

The risk profile for the pearling industry has changed very little between 2001 and 2004.

For identified issues with moderate risk, these risks are acceptable, as long as risk reduction is applied to reduce risks to as low as reasonably practicable (ALARP). In these instances a management strategy needs to be implemented. The focus of this report is in line with risk assessment methodology (section 4 of this report) which involves the review of the risk rankings to determining if the risk is acceptably low, or if management actions are required to reduce the risk to ALARP for the main risks identified during the workshop. As no high risks were identified, moderate risks become the focus of risk management. Low risks are included in this report, but are not dealt with in detail.

The environmental risk and impact assessment workshop participants provided 10 recommendations to address the identified risks to the *P. maxima* fishery. These recommendations are included in Attachment 3 in context with the respective issues, impacts and risks that the recommendations are designed to address.

These recommendations (not in any order of priority) are:

1. Replicate *P. maxima* disease management policies across all hatcheries using pearl oyster species and exclude east coast hatcheries selling into Western Australia or the Northern Territory without license and protocols and having used Western Australian broodstock. (Activity = Hatchery; Impact = Introduction of disease)

2. Minimise lighting on farm bases and accommodation ships. (Activity = Human habitation; Impact = Impact on conservation areas [e.g. wildlife, endangered species and pearl oysters] from lighting).
3. Need knowledge of FAD effect to understand fisheries management impacts (Activity = Suspending the surface longlines; Impact = Attraction of other fauna).
4. Consider video as a method to demonstrate benthic condition in this region. (Activity = Cleaning of oysters; Impact = Nutrient impacts in sediment).
5. PPA develop description of holding site activities (Activity = Pearl oyster operation holding sites; Impact = Panel impact on habitat).
6. Shoe cleaning protocol similar to AQIS requirements, establish links with Akoya Industry in the Eastern States to monitor activities, maintain protocols and requirements to sterilise technicians' instruments within criteria for technicians license under new Pearling Act. (Activity = Seeding pearl oysters; Impact = Introduction of disease).
7. Review entanglement incidents, industry take action to demonstrate vigilance due to public perception, positive method to record - VES (Activity = Surface longlines and panels: Impact = Entanglement in longlines).
8. Demonstrate that all fuel tanks are compliant to AS 1940 (Activity = Fuel, Chemical and Waste Management: Impact = Loss of water quality).
9. Obtain available research on stocking densities (Activity = Holding concentrated quantities of pearl oysters; Impact = Reduction in primary productivity/water quality).
10. High level of communication between PPA and other user groups (Activity = Positioning of pearl farm sites: Impact = Perceived alienation of areas from other uses, perceived loss of visual amenity).

Because managing risk for the *P. maxima* industry is an ongoing process, it is recommended that a risk management culture continue to be developed. This culture requires participants in the industry to be a part of the ALARP process by actively inputting into the development of an impact and risk register, and assist in defining the fisheries' environmental and ecological risk profile.