# 3.3 The Australian experience: pearl oyster mortalities and disease problems

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## ABSTRACT

Australian aboriginals were trading pearls long before Europeans "discovered" pearls in Australian waters in 1812. By the end of the nineteenth century, fishing for "mother of pearl" shell and the incidental pearls was well established. The industry was heavily affected by the decline in value of mother of pearl after World War II (WWII). Artificial seeding of pearls (*Pinctada maxima*) began in Australia in 1956, under agreement with the Japanese and production grew until major mortalities in the 1970s affected industry growth. The mortalities were traced to inadequate management practices resulting in *Vibrio harveyi* infections and, following improvements to shell handling techniques, mortalities were eliminated. The *Pinctada maxima* industry in Western Australia and Northern Territory is the most valuable in Australia and is heavily regulated. Smaller industries exist in Australia farming non-maxima pearl oysters. Though a range of parasites have been identified in pearl oysters, none have caused serious problems for the industry, however, mortalities in Exmouth Gulf in 2006 with an unknown aetiology have forced changes to industry protocols.

## HISTORY OF THE INDUSTRY

A well-established trade in pearls and mother-of-pearl (MOP) shells existed among the aboriginal people of Australia long before pearls were "discovered" by Europeans in Queensland waters in 1812. Though initial shell harvests were in the Torres Strait - Thursday Island area of Queensland, an industry soon developed in Western Australia, first at Shark Bay in the 1850s for pearls from *Pinctada albina albina* and soon after, in Nicol Bay, for pearls from *P. maxima*. Initially aboriginal and Malay "free" divers were used but, with the increasing demand for MOP shells and with the arrival of hard-hat compressed air diving suits in the 1880s, pearling moved north to the town of Cossack (now abandoned) and later to the port of Broome. By 1910, Broome was producing 75 percent of the world's output of pearl shell which involved more than 400 luggers

and 3 500 people. However, the collapse in market price for MOP after World War I (WW1) was equally dramatic. By 1939, the number of luggers had reduced to 73 and after WWII, only 15 boats resumed pearling (Malone, Hancock and Jeffries, 1988; O'Sullivan, 1995).

In 1956, Pearls Proprietary Ltd. introduced pearl culture at Kuri Bay (see Plate 1) in association with Japanese and other overseas investors and under agreement with the Japanese Government. By 1973, Kuri Bay was said to produce around 60 percent of the world's finest round pearls and by 1987 there were 11 companies farming pearls in the Broome region (Malone, Hancock and Jeffries, 1988). In 2001, there were five pearl hatcheries and 16 companies operating farms in Western Australia from North East Cape to the Northern Territory border though recent rationalization in the industry saw the number of hatcheries reduced to three by 2006. The annual quota that can be seeded in Western Australia consists of 572 000 wild stock shell and 350 000 hatchery produced pearl oysters. At present, leases in Western Australia cover 150 square nautical miles and that area is predicted to increase to 280 square nautical miles by 2010. Availability of suitable sites has been identified as a critical constraint to industry expansion. Annual production is now in excess of AUS$190 million with production of pearls from *P. maxima* being supplemented with "black" pearls farmed in *Pinctada margaritifera* in the Shark Bay area.

The Northern Territory has a history of over exploitation of natural pearl oyster beds, which began in Darwin Harbour, when beds were depleted early last century. The western grounds, near Bathurst Island, were discovered around 1929-1930 and were fished out by 1939. The eastern grounds, off Boucat Bay, were discovered in 1936 and by the 1950s were no longer commercially viable. Presently, pearl culture operations in the Northern Territory are centered on Bynoe Harbour, Coburg Peninsula, and the English Company Islands. Pearl cultivation also occurs in Darwin and Bynoe Harbours. An annual quota of 420 000 *P. maxima* oysters can be seeded that is split up between 7 pearl licensees. There are currently two hatcheries (J. Humphrey, Darwin DPIE, pers. comm.)

In Queensland, the pearling beds collapsed from overfishing in the 1930s. In 1999-2000, there were approximately 20 licensed areas for pearl cultivation in Queensland, but not all were in use and about 16 000 shells were seeded in that reporting period. In 2003-2004, the value of the pearling industry was reported as AU$338 000 and there has been little growth since then. There is some minor production from mollusc hatcheries. The main species farmed is *P. maxima*, with some production from *P. margaritifera*, *P. radiata* and *Pteria penguin* (T. Hawkesford, Queensland DPIE, pers. comm.; Lobegeiger, 2001).

In New South Wales, a small *P. imbricata* farm has met with considerable public and political opposition, however, the experience gained has been used to develop other *P. imbricata* farms in Queensland and Western Australia.

## DISEASE ISSUES

Unexplained mortalities of oysters on lease sites in the Kuri Bay region commenced in the 1970s and occurred subsequently in leases in the Broome area and at Darwin. Deaths of more than 50 percent of the oysters following transfer from the "80 Mile Beach" fishing ground to the farms were recorded, but not among wild stocks or oysters harvested then "dumped" near the grounds. The stock situation became so serious in the early 1980s that the Western Australian Government was forced to impose a moratorium, until December 1987, on the number of companies licensed to fish for and farm shell. Results published by Dybdahl and Pass (1985) and Pass, Dybdahl and Mannion (1987) attributed the losses of the oysters to the conditions during transport that allowed build up of the pathogenic bacterium *Vibrio harveyi*. Their report made recommendations to modify management practices. These

modifications were successful in reducing the mortalities but the problem also made the companies acutely aware of disease issues and the potential for transfer of disease between areas. Pass, Perkins and Dybdahl (1988) described a virus from the digestive gland of *P. maxima*. The inclusion bodies were visible in apparently healthy oysters and no pathological significance could be ascribed to them (see Plate 2). In 1993, a papovavirus-like infection and a *Perkinsus*-like infection (Norton, Shepherd and Prior, 1993) were described from *P. maxima* collected from the Torres Strait region. In 1994, industry approved funding by the Fisheries Research Development Corporation (FRDC)of a survey to determine the disease status of the oyster industry across all three affected states. The survey was undertaken from 1995 to 1998 (Humphrey *et al.*, 1998) (Table 1). Shell disease was independently described from *P. maxima* in 1996 (Perkins, 1996) and a haplosporidian, found in 1993 from the same oyster species was finally described in 1998 (Hine and Thorne, 1998). The emergence of an intracellular ciliate in the digestive gland of oysters in the Exmouth Gulf region was reported by Jones and Creeper (2006). A severe mortality with an infectious aetiology occurred in *Pinctada maxima*, but not other *Pinctada* species growing in Exmouth

Gulf in 2006. The cause is still under investigation. The pathogens and diseases of *Pinctada maxima* in Australia are listed in Table 3.3.1.

TABLE 3.3.1
**Parasites and diseases previously recorded in pearl oysters Pinctada maxima in northern Australia. QLD = Queensland, NT= Northern Territory, WA= Western Australia**

| Aetiological agent | Disease/Pathology | Geographic location | Reference |
|---|---|---|---|
| **Viruses** | | | |
| Papova-like virus | Epithelial hypertrophy of palp | QLD | Norton *et al.,* 1993b; Humphrey *et al.,* 1998 |
| Intranuclear viral inclusions | None | WA, NT, QLD | Pass *et al.,* 1988; Humphrey *et al.,* 1998 |
| **Bacteria** | | | |
| Rickettsiales : Large form | None | WA, NT, QLD | Humphrey *et al.,* 1998 |
| Rickettsiales : Small form | None | WA | Humphrey *et al.,* 1998 |
| *V. alginolyticus* | | WA | Humphrey *et al.,* 1998 |
| *V. anguillarum* | | WA | Humphrey *et al.,* 1998 |
| *V. harveyi* | Mortalities | WA | Dybdahl and Pass, 1985; Pass *et al.,* 1987 |
| *V. mediterranei* | | WA | Humphrey *et al.,* 1998 |
| *V. parahaemolyticus* | | WA | Humphrey *et al.,* 1998 |
| *V. pelagius* | | WA | Humphrey *et al.,* 1998 |
| *Vibrio* sp. | Mortalities | WA | Dybdahl and Pass, 1985 |
| *V. splendidus* II | | WA | Humphrey *et al.,* 1998 |
| *Corynebacterium* sp. | | WA | Humphrey *et al.,* 1998 |
| *Erwinia hebicola* | | WA | Humphrey *et al.,* 1998 |
| *Photobacterium* sp. | | WA | Humphrey *et al.,* 1998 |
| *Pseudomonas putrefaciens* | | WA | Humphrey *et al.,* 1998 |
| **Protozoa** | | | |
| Intracellular cilliate | None | WA | Jones and Creeper, 2006 |
| Gregarines | None | | |
| *Haplosporidium* sp. | None | WA | Hine and Thorne, 1998 |
| *Perkinsus* sp. | Mortalities | QLD | Norton *et al.,* 1993a |
| Apicomplexan | | | Hine and Thorne, 2000 |
| *Cryptosporidia*-like | | NT | Humphrey *et al.,* 1998 |
| **Metazoa; Crustacea** | | | |
| *Conchodytes maculatus* | None | | Bruce, 1989; Chace and Bruce, 1993 |
| *Pinnotheres villosus* | | | Dix, 1973 |
| *Anthessius pinctadae* | | NT, WA | Humphrey *et al.,* 1998 |
| **Metazoa: Platyhelminthes** | | | |
| Larval lecanicephalid cestodes | | WA, NT, QLD | Humphrey *et al.,* 1998 |

## WESTERN AUSTRALIAN PEARL OYSTER MANAGEMENT

The most highly regulated pearling industry in Australia is that in Western Australia. The regulatory regime was heavily influenced by the disease problems encountered in the 1980s. Management of the translocation of pearl oysters in Western Australia is based on the concept of creating a closed population of known disease status that can then be tested with a high degree of confidence. The coastline has been divided into zones for stock management purposes so the movement of oysters between zones is subject to their being tested for disease. Hatcheries are licenced and are subject to annual inspection and disease testing of production batches. Imports of live shell from out-of-State are generally prohibited. A decision was taken by the industry in 1998 to increase the test sample size from 150 to 300 oysters to further improve the probability of detecting pathogens.

For a disease problem to develop, the causative agent must already be present around the area or must be introduced, most likely by human agency. Management regimes and freedom from disease certification minimize the risk of introduction by human agency, but pathogens cannot be detected and excluded with absolute certainty. Therefore, in a disease or mortality event on a pearl farm in Western Australia, the farm would be quarantined. This is one reason why, in addition to the zones, there is currently a five nautical mile buffer zone around each farm. It is generally not possible to site another farm within this zone without agreement between the farm owners but, in any event, adjacent farms cannot be closer than 2 nautical miles.

In a disease emergency, there would be a buffer zone created around the quarantined farm of at least 1–2 miles (depending on the organism and its likely rate of spread). Farms within the buffer zone would also be quarantined. Thus, the closer the farms, the greater the chance of disease spread and the more expensive (in terms of impacts and losses) would be the problem of containing a disease should it occur. Pearl farms, unlike marine fish cages, cannot be "towed away" if trouble strikes.

Disinfection protocols existed for vessels involved in shell movement between farms and for equipment used by visiting seeding technicians prior to the 2006 mortality event. Epidemiological investigations following the mortalities suggested that the involvement of divers and their gear in the spread of the pathogen had been overlooked. These are also now subject to disinfection protocols when moving between farms.

The following are some of the major requirements for *P. maxima* pearl hatcheries in Western Australia, or for producing spat for Western Australia: (a) high level

**PLATE 3.3.1**
**Pearl oyster locations in Australia**

Scenic shot of Kuri Bay, the original lease site for Paspaley pearls and occupied continuously by them since they pioneered pearl seeding in the 1950s.

Pearling lugger waiting for high tide while at the Broome jetty in the 1990s.

of filtration of incoming water to remove other larvae and most bacteria; (b) use of axenic algal cultures where possible to reduce the build-up of bacteria in the larval tanks; (c) testing of all outgoing spat batches and (d) filtration of all effluent water from the hatchery to prevent disease spread from a hatchery to the environment.

Filtration of hatchery inflow water and bacterial control through hygiene is not unique to the pearling industry. Anyone who has seen the results of a barnacle settlement or a sabellid tubeworm settlement in the pipes will appreciate the economic value of filtration. The problem, however, is not confined to bacteria free in the water column. Bacteria on biofilms can produce exotoxins, including proteinases and ciliostatic toxins that are pathogenic to larvae (Tubiash, 1975; Nottage and Birkbeck, 1987; Nottage, Sinclair and Birkbeck, 1989; Riquelme *et al.*, 1996).

The control of bacterial growth in mollusc hatcheries is often associated with the routine use of antibiotics (Jeffries, 1982; Prieur, 1990; Moore *et al.*, 1993; Riquelme *et al.*, 1996). This practice is discouraged in Western Australia, in part because no drugs are registered for such use and also because of the disease resistance problems which can occur (Kerry *et al.*, 1994; Riquelme *et al.*, 1996; pers. obs.).

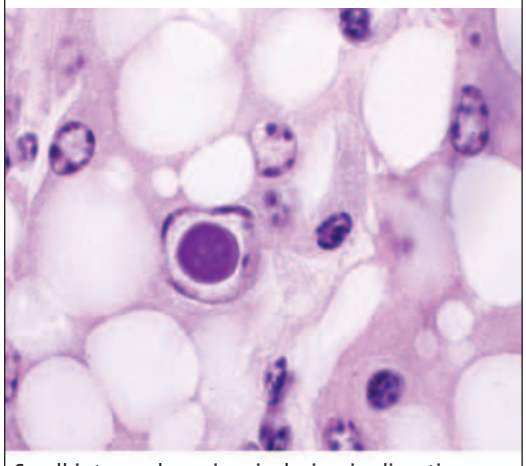
Sorgeloos (1995), in discussing hatcheries generally, commented that the reduction of bacterial loads, particularly in the feed and culture water, should be considered to be important and that strict hygiene measures should be taken including regular disinfection and dry-out of the complete culture circuit (including piping) between production cycles. This is common practice in pearl hatcheries.

The principle behind the requirement that effluent be filtered is recognition that hatcheries can be a source of infection for the surrounding wild fishery. In particular, it would be possible to breed a virulent strain of pathogen, possibly drug resistant, which would be released in large numbers into the environment (McVicar, 1997). Studies in British Columbia (Canada) have associated an increased risk of *Aeromonas salmonicida* in sea cages which are within 10 km of infected cages and, even where release of pathogens can not be clearly demonstrated, public perception of a "disease risk" from a hatchery may be enough to force closure.

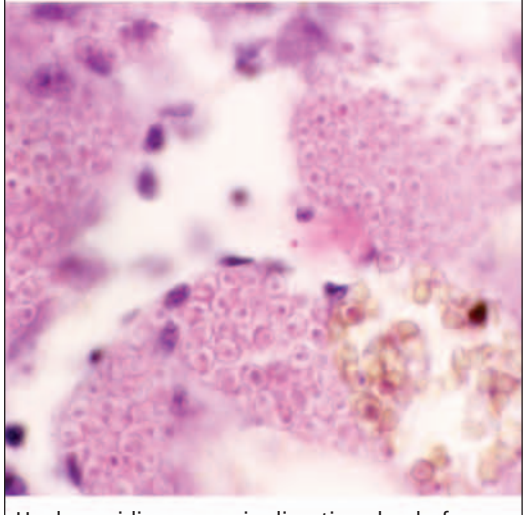
## CONCLUSION

A number of disease issues have arisen in the industry during the last 5 years, including vibriosis, *Haplosporidium* sp., a rickettsia in the digestive

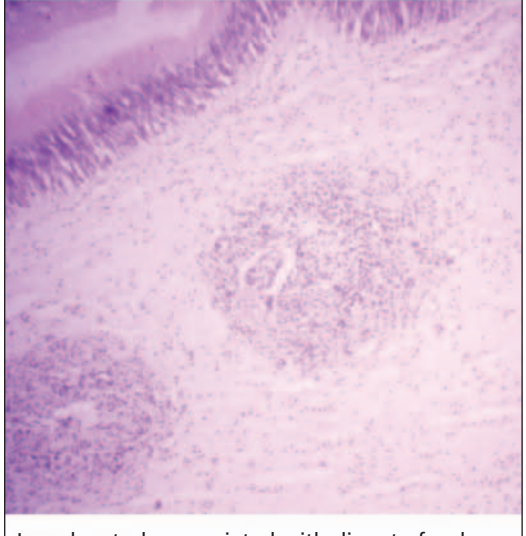
**PLATE 3.3.2**
**Diseases of pearl oysters in Australia**



Small intranuclear virus-inclusion in digestive gland of *Pinctada maxima* (H & E, x1000).



Haplosporidian spores in digestive gland of *Pinctada maxima* (H & E, x1000).



Larval cestodes associated with discrete focal granuloma in interstitial tissues of *Pinctada maxima* (H & E, x 200).

gland and an intracellular ciliate. These incidents have demonstrated the value of the management regimes in place and the close links that have developed between the industry and the government fish health laboratories. These links proved to be of great value in generating early reporting of mortalities and in cooperation between companies and government to contain and mitigate the impact of the mortality event in 2006.

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## REFERENCES

**Bruce, A.J**. 1989. Notes on some Indo-Pacific Pontoniinae. 45 *Conchodytes maculatus* sp. nov., a new bivalve associate from the Australian northwest shelf. *Crustaceana* 56: 182-192.

**Chace, F.A. & Bruce, A.J**. 1993. The Caridean shrimps (Crustacea: Decapoda) of the Albatross Philippine Expedition, 1907-1910, Part 6: Superfamily Palaemonoidea. *Smithsonian Contributions to Zoology* 39: 337-339.

**Dix, T.G.** 1973. Mantle changes in the pearl oyster *Pinctada maxima* induced by the pea crab *Pinnotheres villosus*. *Veliger* 15: 330-331.

**Dybdahl, R. & Pass, D.A.**. 1985. An investigation of mortality of the pearl oyster *Pinctada maxima*, in Western Australia. *Western Australia Department of Fishery. Report*. 71: 1-78.

**Hine, P.M. & Thorne, T.** 1998. *Haplosporidium* sp. (Haplosporidia) in hatchery reared pearl oysters *Pinctada maxima* (Jameson, 1901) in Western Australia. *Journal of Invertebrate Pathology* 71: 48-52.

**Humphrey, J.D., Norton, J.H., Jones, J.B., Barton, M.A., Connell, M.T., Shelley, C.C. & Creeper, J.H.** 1998. Pearl oyster (*Pinctada maxima*) aquaculture: health survey of Northern Territory, Western Australia and Queensland pearl oyster beds and farms. *Fisheries Research and Development Corporation Final Report* 94/079: 108 pp.

**Jeffries, V**. 1982. Three *Vibrio* strains pathogenic to larvae of *Crassostrea gigas* and *Ostrea edulis*. *Aquaculture* 29: 201-226.

**Jones, J. B. & Creeper, J**. 2006. Diseases of pearl oysters and other molluscs: A Western Australian perspective. *Journal of Shellfish Research* 25: 233-238.

**Kerry, J., Hidney, M., Coyne, R., Cazabon, D., NicGbhainn, S. & Smith, P.** 1994. Frequency and distribution of resistance to oxytetracycline in microorganisms isolated from marine fish farm sediments following therapeutic use of oxytetracycline. *Aquaculture* 123: 43-54.

**Lobegeiger, R**. 2001. Report to farmers: Queensland Aquaculture Production Survey 1999-2000. Department of Primary Industries, Queensland, 24 pp.

**Malone, F.J., Hancock, D.A. & Jeffries, B.** 1988. Final report of the Pearling Industry Review Committee. Western Australian Fisheries Management Paper 17: 1-216.

**McVicar, A.H.** 1997. Interaction of pathogens in aquaculture with wild fish populations. *Bull. Eur. Assn. Fish Pathol*. 17: 197-200.

**Moore, W., Anderson, G. & Manzi, J.J.** 1993. Effects of the antibiotic oxytetracycline hydrochloride on *Vibrio* spp bacteria in the larval and early post-test culture of the hard clam *Mercenaria mercenaria. World Aquaculture* 24: 75-78.

**Norton, J.H., Shepherd, M.A., Perkins F.O. & Prior, H.C**. 1993. *Perkinsus*-like infection in farmed golden-lipped Pearl oyster, *Pinctada maxima*, from the Torres Strait, Australia. *Journal of Invertebrate Pathology* 62 :105-106.

**Norton, J.H., Shepherd, M.A. & Prior, H.C.** 1993. Papovavirus-like infection of the golden-lipped Pearl oyster, *Pinctada maxima*, from the Torres Strait, Australia. *Journal of Invertebrate Pathology* 62 :198-200.

**Nottage, A.S. & Birkbeck, T.H.** 1987. The role of toxins in *Vibrio* infections of bivalve molluscs. *Aquaculture* 67: 244-246.

**Nottage, A.S., Sinclair, P.D. & Birkbeck, T.H.** 1989. Role of low molecular weight ciliostatic toxins in vibriosis of bivalve molluscs. *Journal of Aquatic Animal Health* 1: 180-186.

**O'Sullivan, D**. 1995. Pearls of Australia: an overview of pearl production techniques in Australia. *Australian Gemmologist* 19: 155-161.

**Pass, D.A., Dybdahl, R. & Mannion, M.M.**. 1987. Investigations into the causes of mortality of the Pearl oyster, *Pinctada maxima* (Jamson) in Western Australia. *Aquaculture* 65: 149-169.

**Pass, D.A., Perkins, F. O. & Dybdahl, R**. 1988. Virus-like particles in the digestive gland of the pearl oyster (*Pinctada maxima*). *Journal of Invertebrate Pathology* 51:166-167.

**Perkins, F.O.** 1996. Shell disease in the gold lip pearl oyster, *Pinctada maxima* and the eastern oyster, *Crassostrea virginica*. *Aquatic Living Resources* 9 :159-168.

**Prieur, D., Mervel, G., Nicolas, J.L., Plusquellec, A. & Vigneulle, M.** 1990. Interactions between larval molluscs and bacteria in the marine environment. *Oceanographic and Marine Biological Annual Review* 28: 277-352.

**Riquelme, C., Toranzo, A.E., Barja J.L., Vergara, N. & Araya, R.** 1996. Association of *Aeromonas hydrophila* and *Vibrio alginolyticus* with larval mortalities of scallop (*Argopecten purpuratus*). *Journal of Invertebrate Pathology* 67: 213-218.

**Sorgeloos, P**. 1995. Bioengineering of hatcheries for marine fish and shellfish. *Journal of Marine Biotechnology* 3: 42-45.

**Tubiash, H.S.** 1975. Bacterial pathogens associated with cultured bivalve mollusc larvae, pp. 61-71. *In* Smith W.L. & Chanley M.H. (eds). Culture of marine invertebrate animals. New York, Plenum Press. 388 pp.