A review of mass mortalities in pearl oysters

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Introduction

Pearl cultivation is a form of aquaculture. The cooperative effort between humans and aquatic bivalve molluscs, results in precious gems, pearls. There is always the possibility of mass mortality of pearl oysters and these can be a serious problem, bringing the industry to the brink of collapse.

Myanmar's pearl cultivation had also been affected by abnormal mortalities of pearl oysters since about 1983. As a result of study, a bacterium, *Vibrio*, was identified as a causative agent of the mass mortality.

The purpose of this paper is to present information on mass mortalities of pearl oysters, and causes and symptoms are compiled and described. Based on the available literature and my experience, I also present some suggestions.

Mass mortalities

From 1969–1970 a mass mortality of pearl oysters occurred in pearl farms from Port Moresby (Papua New Guinea) to Kuri Bay and Smith's Harbour (Australia). It was observed that death rate on many occasions reached 100 per cent and many times, out of one cage containing ten oysters, only one had survived (George 1992).

Mortality of pearl oyster, *Pinctada maxima* was about 80 per cent, although 30 to 60 per cent was more common in the Australian pearl culture industry since 1974. It continued for more than one decade, and a three-year investigation (1980–1983) into the causes of mortality was conducted. The investigation found that mortality was related to transporting oysters from fishing grounds to lease sites, which took a ship about 37 hours. During the longer fishing periods, collected oysters were held on board for a maximum of four or five days. The oysters were kept and transported in high densities on fishing vessels with inadequate water circulation, which caused a build-up of bacteria in oyster carrier tanks. A bacterium, *Vibrio harveyi*, was found to be responsible for high mortality rates in the tanks (Dybdahl and Pass 1985).

High pearl oyster mortality rates, ranging from 30 per cent to as much as 85 per cent (depending upon the farm and its location), occurred in most, but not all, areas throughout Indonesia in 1992–94. It was likely the result of erratic weather pattern that influenced the flow of air and water currents and affected elements such as temperature and plankton (Anonymous I 1994).

In 1985–86, abnormally high mortality rates of both cultured and natural pearl oysters were observed in the Takapoto pearl farms in French Polynesia. Farms raising spat and grafted oysters suffered losses of 50 to 80 per cent of stocks during the worst disease outbreak (Intes 1995b).

The Chinese Akoya pearl industry also experienced a problem of mass mortality, with very high mortality rates. Many farmers discovered that even after four or five months of cultivation, their nuclei were still not coated at all. The major reason for this incredible turn of events was that coloured or bleached Chinese or Vietnamese made nuclei were either totally rejected or received no nacre coating at all. Furthermore, in most cases the oysters themselves eventually died (Anonymous II 1994).

In Japan, a decade-long chain of mortality problems became acute in 1996 and 1997, resulting in the death of 150 million Akoya pearl oysters in Japan (Canedy 1998). Average mortality rates, depending on locality, ranged from 25 to 60 per cent (Anonymous 1998).

Causes

Table 1 lists twelve causes (in alphabetical order) of mass mortalities of pearl oysters described in the literature.

Symptoms

The decline in physiological condition of infected or moribund pearl oysters is indicated by many symptoms. One or more of the 16 symptoms described in the following table indicate an oyster in bad condition.

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Table 1: Causes of mass mortalities of pearl oysters.

	Causes
1	Bacteria
2	Climate change
3	Farm management
4	Fouling organisms
5	Natural disasters ("tsunami" (huge wave), earthquake, etc.)
6	Nucleus
7	Parasites
8	Pollution
9	Predators
10	Red tide
11	Rough handling
12	Viruses

Table 2: Symptoms indicating a decline in the physiological condition of pearl oysters.

	Symptoms
1	Colour of adductor muscle turning red or brown
2	Slow response of adductor muscle when mantle edge is touched
3	Visceral mass becoming soft, glassy and watery
4	Abundant mucous secretions
5	Malformed mantle lobe
6	Necrosis of outer mantle
7	Heavy amorphous organic matter secreted mainly in the nacreous periphery of the valves
8	Deposition of brownish material on the inside of the shell valves
9	Twisted or irregular growth process
10	Growth processes disappear or discontinue
11	Ventricule is swollen and filled with blood
12	Rectum is swollen
13	Oyster ceases to grow altogether and finally dies in most cases
14	Reproductive function is discontinued or greatly reduced
15	Crystalline-style feeding mechanism and amount of feces are reduced
16	The function of the pearl formation mechanism is changed and effect deposition of calcium carbonate in the form of calcite instead of aragonite

Occasionally, after the disease outbreaks, a recovery follows. A strong demarcation zone on the valves indicates the oyster was infected but has recovered from illness.

Discussions

Infectious diseases have been recognised as one of the factors limiting the development of marine invertebrate farming. Normally, oysters can handle natural stress and moderate handling, but they are particularly vulnerable to diseases. However, the etiology of pearl oyster diseases and available literature are still limited. The good news for researchers is that gross and histopathological studies could provide baseline data on the occurrence and prevalence of potential pathogens and provide a basis for the diagnosis of infectious and non-infectious diseases of *Pinctada maxima* (Humphrey et al. 1999).

Besides biological factors, physical and chemical conditions can also cause serious problems for pearl cultivation. Among these factors are: decreased salinity, high water temperature, cold tides, red tides, hydrogen sulphide and pollution by domestic and industrial effluents (Mizumoto 1979; Anonymous I 1994).

Natural disasters such as hurricanes, earthquakes and tidal waves (“tsunamis”) must also be taken into account (McCormick 1966). During late 1982 and early 1983, six hurricanes struck the Tuamotu Archipelago, destroying most of the shallower bottoms and pearl farms (Intes 1995a). Indonesian pearl farms were severely affected by earthquakes and “tsunamis” in 1992, and oysters became ill and too weak to stand seeding operation (Anonymous I 1994). Nowadays, in order to improve the survival rate of pearl oysters after nucleus insertion, antibiotic coated nuclei are being produced in Japan and USA and positive results have been observed (Akiyama et al. 1998; Anonymous 1999).

George (1992) pointed out the pattern of spreading mortalities. He said that pearl shell mortalities were permanent in the Japanese home industry since 1960 and in all the pearl farms of the South Seas established with their cooperation. According to George (*ibid*), Japanese technicians moving around various culture farms may have been the carrier of causative agent(s). Increased attention is now being given to risks posed by the frequent movement of technicians and their instruments between and within countries (Aquilina 1999).

Cleaning and sterilising every instrument used in seeding has become an essential precaution and should be done before and after a technician

moves from one place to another. While there is no substantive evidence to support George's claims, it is still a good practice to sterilise the instruments used in delicate surgery on oysters of various levels of health.

Heavy mortalities due to confinement during transshipment could be controlled through improved handling and holding practices: better water circulation, decreased densities and improved hygiene on farms and during transshipment, and avoiding transshipments during colder months (Pass et al. 1987).

Transportation of pearls oysters to areas where they did not occur naturally in abundance may have resulted in the spread of diseases, parasites and predators associated with these shells. It would be unwise to introduce oysters from known infected areas to other areas and even from an area that was struck by a kind of natural disaster such as cyclone because pearl oysters may be weak.

Braley et al. (1993) warn that oysters contracting an unknown "disease" could look healthy but within two or three days only a gaping shell with dead soft tissue remains. It is therefore rather hard to say that individual stocks are "disease-free".

Except for obvious causes (e.g. "tsunami"), causative agents are usually not identifiable. Mr Koichi Takahashi, senior vice president of the Mikimo (America) company, commented on a mass mortality of pearl oysters that occurred in 1996–97 in Japan. He said, "Everybody is blaming everything, and it is really hard to determine what is the main cause"(Canedy 1998).

A better understanding of pearl culture area's ecosystem is essential for noting any abnormal changes. Managing oyster numbers on farms, spacing, maintenance operations, restrictions on stock transfers, and monitoring the hydrological environment can enhance the health of a culture farm. Closed and semi-closed lagoons, opens lagoons, bays and estuaries, sheltered coasts and open coasts progressively experience more water exchange and, thus, the risk of detrimental impact to water quality resulting from any perturbation is lessened (Anderson 1998).

Suggestions

Based on my experience, and literature studies, I offer some suggestions in Table 3 (see next page).

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Table 3: Suggestions for managing pearl oyster farms.

	Suggestions	Purposes
Pearl Oyster		
1	Attention should be paid to any abnormal mortalities of oysters	To know the first occurence of mass mortality as early as possible
2	Detect any abnormal condition of shells and visceral mass	To know the occurence of potential problems leading to mass mortality
3	Infected oysters should not be moved from one station to another	To prevent spreading of disease
Culture area		
1	Oyster lines laid on the sea bed should be in the same direction of water current	To enhance flowing of water current among oyster lines on the sea-bed and between the two valves (shells) of every individual
2	Wide space between culture lines	To provide good hygiene and food availability
3	Discarded fouling organisms should not be shelved close to the oyster-lines area	To prevent accumulation of fouling organisms, and unnecessary dead matter heaped up on culture grounds
4	Detect any abnormal quantity of predators (e.g. gasteropods)	To know the probable predation on cultured pearl oysters
Seeding operations		
1	Intruments (including gloves) used in seeding operation should be sterilised regularly	To prevent infection by instruments
2	Instruments used by a technician who moves to another station must be sterilised before and after he / she moves from one place to another	To prevent spreading of causative agents by technicians
3	Infected oyster meat should not be thrown in the sea. It should be buried on land	To prevent infection to other oysters
Other		
1	Partitions in an oyster cage should be reduced to five, to house ten oysters in a cage	To reduce substrates for fouling organisms and, as a consequence, to reduce their competition
2	Rough handling should be avoided	To reduce stress on pearl oysters, especially infected oysters
3	Record the hydrological condition of culture area regularly	To detect any environmental changes
4	Study and analyse past experiences	To identify significant facts that can help early detection

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