Declines in bivalve populations in Pumicestone Passage

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Summary

Observations of the distribution of Sydney rock oysters (*Saccostrea glomerata*) and other bivalves such as hairy mussels (*Trichomya hirsuta*) and mud cockles (*Anadara* spp.) in the Pumicestone Passage are presented. Historically, all three species of bivalves were abundant in specific locations throughout the intertidal and/or subtidal zones in this region. However, since the 1970's and particularly over the past 2 years since rainfall has returned to the catchment, increased mortalities and changes in the distribution of rock oysters, mussels and cockles have been observed. Mortalities of oysters are associated with the pathogen *Martelia sydneyi*, which is a disease process facilitated by immunosuppression of the host due to changes in water quality. The cause of mortalities of hairy mussels and mud cockles remain uninvestigated and are hence unknown. Mushroom shaped oyster clumps demonstrate that significant upwards compression of the zone suitable for oyster habitation has occurred, especially when compared to historic baselines when oyster reefs existed up to 12 feet below the low tide mark. The most recent bivalve mortalities have correlated with the decline in water quality in Pumicestone Passage since 2008, as documented in the Healthy Waterways monitoring programme. Further investigation of these mortalities and their effects on the Pumicestone Passage ecosystem appears warranted. It is likely that water quality will need to improve significantly before populations of these key ecosystem engineers can be restored.

Methods

Historical distributions of Sydney rock oysters in the Pumicestone Passage/Sandstone Point area were determined from photographs from the John Oxley Library and published historical accounts of the oyster industry in the area (Lergessner 2006). A 70 year record of the local distribution of oysters, mussels and cockles also was obtained from a long term resident of Bribie Island (Ted Clayton, personal communication 12 August 2010) who has lived on the island since the 1940's. Observations of recent distribution and zoning of Sydney rock oysters, cockles and mussels have been done visually on field trips by the author since 2004. Prevalence of *Marteilia sydneyi* infections in both wild (n = 29) and aquacultured (n = 30) Sydney rock oysters from Sandstone Point and Ningi Creek was determined on 28th January 2011 by collecting live oysters followed by microscopic analysis of air dried, stained digestive gland imprints. Intensity of *M. sydneyi* infections was classified using the following semi-quantitative scale: 0 = no parasites observed, 0.5 = parasite present, 1 = light infection, 2 = moderate infection, 3 = heavy/terminal infection. A total of 68 mussels were also sampled from 3 mussel clumps collected at Sandstone Point on 28th January 2011. There has been no investigation of the cause of mortalities of mussels or cockles, though formalin fixed material sampled 28 Jan 2011 is available for the mussels.

Results

Sydney rock oysters (*Saccostrea glomerata*)

Investigations of the cause of mortalities in Sydney rock oysters in lower Pumicestone Passage in late January 2011 (Table 1) found a high prevalence (93.3%) of infection with the pathogen *Marteilia sydneyi* (QX disease) in cultured oysters, with prevalence of infection in wild oysters being much lower (27.6%). Intensity of *M. sydneyi* in the 28 cultured oysters that were infected was much higher (2.35) than the intensity of infection (1.06) found in the 8 wild oysters that were infected (Table 1). In other words, the pathogen was over three times more prevalent in cultured oysters than in wild oysters, the latter also tending to have very light infections, except for one wild oyster which had a heavy infection typical of that found in the majority of cultured oysters. The height of the oysters in relation to tide datum appeared to influence the intensity of infection, with the cultured oysters being reared at a lower height in the water column than wild oysters in an attempt to maximise growth rates within the constraints of other disease agents such as mudworm. Mudworm was not observed in any of the 59 oysters examined. The higher rate of QX disease in the oysters reared lower in the water column is consistent with observations of local oyster farmers, who have to place their stock higher and higher in the water column in recent years in order to get any significant survival of cultured stock.

Table 1. Results of Sydney rock oyster disease survey, lower Pumicestone Passage 28 Jan 2011.

	Wild upper Ningi Creek	Wild Ningi Creek mouth	Wild Sandstone point	Cultured Ningi Creek	Cultured Sandstone Point
no. sampled.	9	10	10	20	10
Mean shell length (mm)	64.9	43.3	56.7	51.1	51.8
Range (mm)	55-76	25-52	40-72	40-62	40-65
QX Prevalence	22.2%	40%	20%	90%	100%
QX Mean intensity	0.5	1.4	1	2.2	2.6
QX intensity range	0.5 - 0.5	0.5 - 3	1 - 1	1 - 3	1 - 3
Overall prevalence	Wild oysters 27.6%			Cultured oysters 93.3%	
Overall mean intensity	Wild oysters 1.06			Cultured oysters 2.35	

Examination of clumps of wild oysters, many decades old, from the intertidal area at the mouth of Ningi Creek (Fig 1) found them to be dying from the bottom up, forming a mushroom shape where previously the clumps were monolithic. Also of interest is the comparison of the quality of the shells of oysters cultured today, compared to historic oyster shells (perhaps 80 to 100 years old) that can be found buried in sediments (under 18 inches of anoxic silt) adjacent to the remaining clumps of wild oysters at the mouth of Ningi Creek (Figure 2). The oysters cultured today have markedly thinner shells.

Hairy Mussels (*Trichomya hirsuta*) and mud cockles (*Anadara* spp.)

A total of 48 of the 68 mussels collected were dead (70%) (Figure 3). Of the dead mussels, 11 were old mortalities and 37 were fresh mortalities, as evidenced by the lack of fouling of the nacre of the inner shell valves and the presence of some with meat still inside. A significant amount of sediment and silt was observed trapped in the hairs on the outside of the shell valves (Figure 3).

The cause of these the mortalities, and those of large numbers of dead mud cockles at the mouth of Ningi Creek (Figure 4), remains to be determined. Surface water salinity at Toorbul Point in Pumicestone Passage during the recent floods decreased to 9 ppt for around a week between 12 and 20 January 2011, before increasing to 13 ppt by the 24th and 22 ppt by 30th Jan (B. Diggles personal observations). *Trichomya hirstula* is relatively tolerant of low dissolved oxygen (McIntyre 1959) but susceptible to mortality at salinities below 15 ppt (Wallis 1976). While low salinity is a potential cause for the mortalities observed in mussels and cockles, disease (e.g. *Perkinsus olseni*) or toxicity are both plausible differential diagnoses, meaning the deaths of mussels and cockles requires a proper pathological and epidemiological investigation. Samples of mussels have been fixed in formalin awaiting further processing as funding permits.

Discussion

Examination of 150 years of historical records of the distribution of Sydney rock oysters in the lower Pumicestone Passage region found that oysters used to occur in massive numbers at all levels of the intertidal zone, and even in biogenic reefs up to 12 feet below the low tide mark (Lergessner 2006), from which they were collected by dredging. The oyster industry began to experience problems from mudworm in the late 1800's (Ogburn et al. 2007), correlating with the time when European land use practices had begun to adversely affect coastal environments, mainly through increased sedimentation (McCulloch et al. 2003). Oyster production in the region peaked around 1910, and has declined since (Lergessner 2006). These historical accounts have been supported by observations of long time residents of Bribie Island who have lived here since the 1940's, who have confirmed that only remnants of the former abundance of oysters remain (T. Clayton, personal communication 12 August 2010).

While it is very likely the ultimate cause of death for the wild oysters in recent times is QX disease caused by the haplosporidian parasite *Marteilia sydneyi*, disease due to *M. sydneyi* is known to be caused by immunosuppression (Peters and Raftos 2003, Butt and Raftos 2007), due to reduced salinity (Green and Barnes 2010) and as yet unidentified water born contaminants carried in runoff (Butt and Raftos 2007). A hypothesis for the mechanism involved in formation of the mushroom shaped oyster clumps observed at Ningi Creek is that oysters lower in the intertidal zone are exposed to contaminated water for longer, and thus are more stressed and succumb to QX first via immunosuppression. The dead oysters are then not being replaced due to spatfall failure resulting either from landbased chemicals that either kill spat directly, and/or increased eutrophication and silt/sedimentation that prevents spat settlement (settlement requires relatively clean substrates). Together, these processes would account for the observed upwards compression of the zone suitable for oyster habitation, signalling a significant reduction in both the area and quality of habitat for not only oysters, but all other fisheries resources that rely on biogenic reef.

The oysters cultured today also have markedly thinner shells compared to those of perhaps 80 to 100 years ago. Study of oyster shells can provide a significant amount of information on pollution, eutrophication (Kirby and Miller 2005) and historic oyster growth rates (Harding et al. 2008) that can inform us about previous water quality baselines. More research into historic oyster shells in Pumicestone Passage is required, including aging and analysing them for pollutants and trace elements, to provide important information that will assist in elucidating the extent of changes in water quality that have occurred in the region over the last 100 years (and its effects on biogenic processes such as oyster shell calcification).

Densely packed beds of hairy mussels (*T. hirstula*) were common features of deeper sections of many estuarine ecosystems on Australias east coast in the middle of last century (McIntyre 1959). Reports from long term residents at Bribie confirm that large numbers of these mussels occurred in densely packed beds along virtually all hard bottom and sandstone ledges of Pumicestone Passage until around 15 years ago, after which time the mussels began to vanish from their usual locations (T. Clayton, personal communication 12 August 2010). Today, small clumps of these mussels are encountered only occasionally in the area (B. Diggles, personal observations), and in recent times a high proportion of these mussels are dead.

These observations for bivalves appear consistent with those of other researchers who have recorded a widespread and sustained collapse of macrobenthic infauna in Moreton Bay (97.5 % reduction in abundance since 1970's, see Quinnell et al. 2004), as well as significant dieback of key habitats such as seagrasses (Kirkman 1976, Lee Long et al. 2000), mangroves (Duke and Haller 2009), and oyster reefs (Ogburn et al. 2007, Beck et al. 2011). These environmental problems are likely to have significantly reduced food and habitat availability for fish and crab species that underpin key ecological processes in Pumicestone Passage, as well as its socio-economically important recreational fishery.

In summary, the changes to decades-old oyster clumps, together with declines in populations of other bivalves, provide a biological record of long term declines in water quality and fisheries productivity in Pumicestone Passage. These events, together with seagrass losses and mangrove dieback , are alerting us to the slow march of this ecosystem towards a system dominated by the algal/microbial loop. Oysters and other filter feeding bivalves are important ecosystem engineers that provide significant ecological services in the form of benthopelagic coupling . In other words, they help transfer the energy from the sun and nutrients fixed by microalgae in the water into animal material (oysters, gametes) and habitat (oyster shells) that are essential for a healthy ecosystem. The historic natural subtidal oyster reefs that used to occur in the area are functionally extinct (Beck et al. 2011), and those that remain in intertidal areas are being compressed upwards as water quality declines. The recent floods have simply exaggerated an ongoing decline and the issue is a serious one for Pumicestone Passage and Moreton Bay as a whole, and the situation is not likely to get better unless the underlying water quality issues begin to be addressed.

While halting the decline is by no means an easy task, there are some good examples of community based restoration programs from Chesapeake Bay, east coast of USA, where they are combating virtually identical problems to those occurring in Moreton Bay. The way that groups such as the Virginia Institute of Marine Science, the Chesapeake Foundation and other non-government and government institutions have gone about the business of restoration of the Chesapeake Bay – establishing long term restoration goals that all stakeholders set and work towards with community involvement - should be closely examined to provide a template for restoration of Pumicestone Passage and Moreton Bay. See Schulte et al (2009), and http://www.chesapeakebay.net/restrtn.htm for more information on what can be done.

Figure 1. Decades old oyster clumps at the mouth of Ningi Creek, Jan 2011. The formerly monolithic structures are now mushroom shaped, as they decay from the bottom up due to oyster death and spatfall failure due to declining water quality. Oysters that remain in the water for longest die first. A rare visible indicator of larval recruitment failure in the marine environment. The ellipse indicates the location where historic oyster shells (see Figure 2) were sampled.

Figure 2. Comparison between shells deposited by oysters today (right) compared to the two shells to its left, which are from oysters historically farmed at the mouth of Ningi Creek, Pumicestone Passage. The shells of the historic oysters are much thicker and stronger. The historic shells were recovered by the author from under 18 inches of anoxic silt and mud adjacent to where the remaining mushroom shaped oyster clumps occur (see ellipse in Figure 1).

Figure 3. In 3 mussel clumps from Toorbul Point 28 Jan 2011, 48 of 68 mussels were dead (70%). Of the dead mussels, 11 were old morts and 37 were fresh morts, some with meat still inside. Note the large amount of sediment and silt trapped on the hairs of the shell. Fishermen have reported a significant reduction in the area of historically abundant mussel beds in the lower Pumicestone Passage region over the past 15 years.

Figure 4. Large numbers of dead mud cockles are apparent in sparse stunted seagrass adjacent to the decaying oyster beds at the mouth of Ningi Creek, Pumicestone Passage 28 Jan 2011. Cause of death remains uninvestigated and is therefore unknown. In recent years, fishermen have reported significant reductions in the numbers of cockles in formerly productive cockle beds around Sandstone Point.

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