The implications of catchment derived pathogens on the management of an oyster farm in Oyster Harbour, Albany

A summary of a report[1] for the Luke Pen Scholarship award by Fiona Gibson

Introduction

The impact of upper catchment land practices on the lower catchment is a major natural resource management issue in many agricultural areas across Australia. The impacts of upstream activities (agricultural, industrial and residential) can have a negative effect on downstream environments and industries.

This study aims to discover: the financial cost of potentially polluting upper catchment land practices on an oyster farm in the lower catchment; and the management options for oyster farm and upper catchment to overcome this cost.

Most oyster farms are situated in waterways at risk of contamination by agricultural, industrial or residential activities. Water borne pathogens, primarily originating from human and animal effluent are identified as the key source of shellfish contamination. Pathogens, such as the bacterium *Escherichia coli* have been linked to food poisoning incidences in shellfish. Heavy metals and excess nutrients producing toxic algae are also responsible for shellfish contamination (ASQAAC 2004).

Ocean Foods operates an oyster farm in the receiving waters of the catchment of Oyster Harbour, Western Australia. During periods of increased pollution (primarily caused by agricultural and residential runoff), the oyster farm is forced to close and harvesting ceases, in order to prevent shellfish contamination. This potentially represents a huge increase in cost to Ocean Foods, as the farm becomes unproductive. Farm closure could be avoided by moving the oyster farm to an uncontaminated site or by using depuration or purification systems, whereby purified or uncontaminated water is used to cleanse the oyster of any harmful bacteria (ASQAAC 2004).

To evaluate the potential cost of the upper catchment practices on Ocean Foods, a bioeconomic model was developed. The benefit or loss to Ocean Foods from closure was determined by comparing a recent season with periods of closure (2003–04), with a hypothetical season of no closure. Closure has several implications for the farm, including the depreciation of cash flows and a decrease in revenue through lost markets and sales. Two farm management options to reduce this cost were also explored: relocating the oyster stock to a site where there is no contamination risk; and relaying of stock during periods of closure to a no risk site for natural cleansing and depuration.

[1] F Gibson, 'The implications of water borne pathogens on the management of an oyster farm at Oyster Harbour, Albany' BSc thesis, University of Western Australia, Perth, 2004.

Study site

Oyster Harbour is approximately 400 kilometres south-east of Perth, situated between Albany and the Southern Ocean. Figure 1 shows the location of Ocean Foods lease sites in Oyster Harbour and around Mistaken Island.

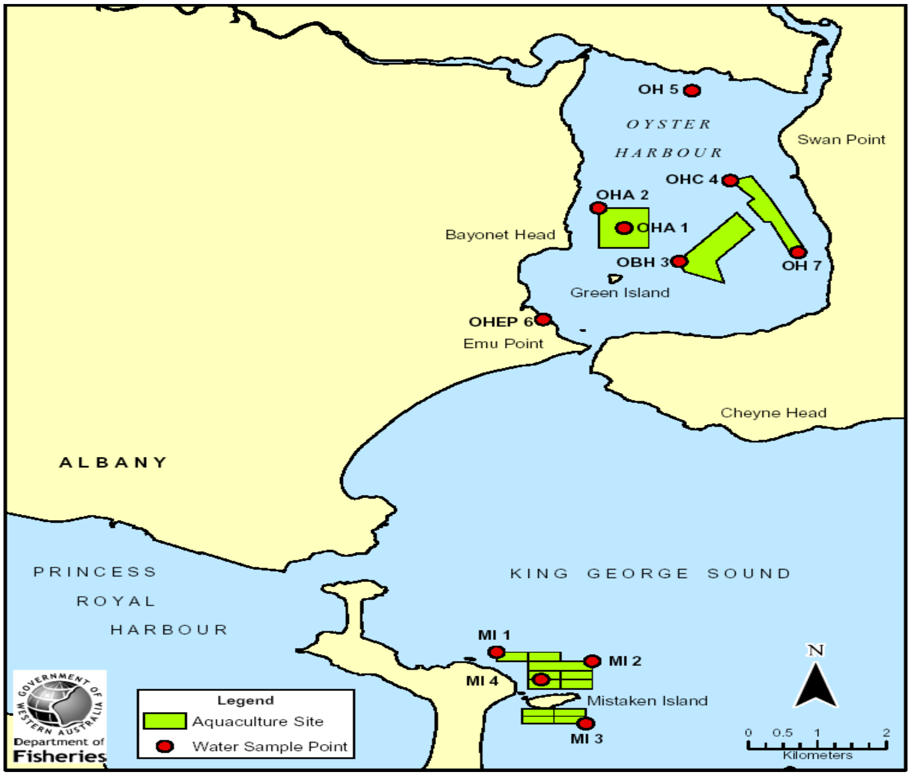

Figure 1. A detailed map of the leases held by Ocean Foods in Oyster Harbour and King George Sound for 2004. The lease currently in operation is situated between the sampling sites OHC4 and OH7 (DoF and WADoH 2004).

The oyster industry

The oysters produced by Ocean Foods are Sydney rock oysters (*Saccostrea glomeratus*). These oysters are sold all year round with peak sales between December and May. Ocean Foods sell the majority of their oysters to one wholesaler in Perth, with some sold to retailers and restaurants outside the metropolitan area and restaurants and wholesalers in Sydney. The prices are the same all year round, showing no change with the seasons or shifts in demand.

Oyster farms across Australia are required to conform to the food safety regulations set by the Australian Shellfish Quality Assurance Program (ASQAP). The Western Australian Shellfish Quality Assurance Program (WASQAP) addresses the requirements of the ASQAP and the Australian Quarantine Inspection Service so that shellfish can be exported to the European and Asian markets, as well as sold domestically. The Department of Fisheries

(DoF) and the Department of Health (DoH) oversees the WASQAP monitoring program (DoF and WADoH, 2004).

The production area currently used by Ocean Foods has been classified by AQIS as a contamination risk site and is currently managed under the WASQAP. This classification recognises that Ocean Foods must safeguarded it's operation from any potential public health risks associated with consuming shellfish from it's lease area (DoF and WADoH 2004). To continue this approval, Oceans Foods must monitor their lease area by taking frequent water and oyster flesh samples for analysis.

Under the WASQAP, the DoF and the DoH must close harvesting activities at the farm if there is a risk of the shellfish being contaminated. Farm closure is imposed during an adverse event. This includes a sporadic rainfall event, which will bring potentially contaminated water to the lease site, a pollution spill, or other events that adversely affects the bacteriological quality of water in the lease site.

During a heavy rainfall event, effluent and inorganic material from grazing and cropping upstream is carried by Albany's two major rivers, the King and Kalgan, into the Harbour. Point source pollution can also contribute to contamination, arising from a number of sources around the harbour, including wastewater discharge and spillage of petroleum based products (DoF and WADoH 2004).

The ASQAP has set up a trigger system for sporadic rainfall events, using gauge stations on the King and Kalgan Rivers. If there is any flow above the accepted threshold, the farm is notified of the approaching risk of contamination. The farm can then be closed before the pollutant water reaches the oyster lease. If the timing is right, Ocean Foods can harvest stock before the contaminated water reaches the oyster lease—unless the farm is shut down as a precaution.

Worldwide, shellfish farms situated in potentially adverse sites avoid the problem of farm closure by using depuration or purification systems. Depuration can reduce the level of certain pathogenic organisms that may be present in live shellfish by using a controlled aquatic environment. A depuration unit can be a single tank, tray or box which supplies purified water to clear the oyster of any harmful bacteria (ASQAAC 2004). Alternatively, shellfish can be transported to an approved site and the ambient environment used as a treatment process, a technique known as relaying.

Bioeconomic modelling

Bioeconomic modelling has been used in this study to evaluate and improve the efficiency of the oyster farm. The bioeconomic model incorporates a biological submodel with a production and economic sub-model. It encompasses the relationships between the biological factors that determine production and supply, and the economic factors affecting the aquacultural industry (Clarke 1985). The advantage of modelling is that it allows the modeller to include the most important features whilst disregarding those insignificant to the problem being addressed (Shang 1986).

In this study a bioeconomic model was developed to look at the possible increase in cost caused by farm closure at Ocean Foods. The model was also used to evaluate two farm management options, which could reduce the cost of closure: relocating the oyster stock to a site where there is no contamination risk; and relaying of stock during periods of closure to a no risk site, for natural cleansing and depuration.

The biological sub-model for the model incorporates the Sydney rock oyster growth function, monthly temperature and initial size. A growth function of the Sydney rock oyster, applicable for Oyster Harbour, was developed based on experimental data from Port Stephens (Figure 2). The data was kindly provided by John Nell at the Department of Fisheries (NSW). The model is based on the instantaneous growth model developed by Askew (1978) and later modified by Mason et al. (1998). A multiple regression model proposed by Hall (1983) was then used to determine the significance of the growth determinants (i.e. initial size and temperature).

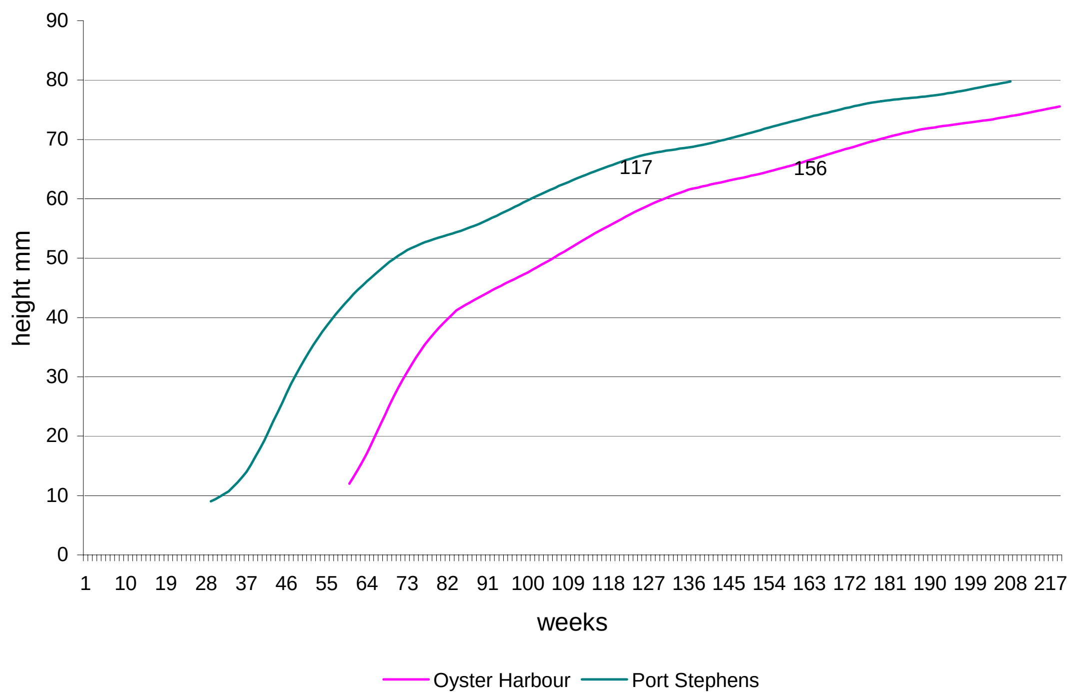

Figure 2. A comparison of the predicted growth function at Port Stephens with the modified growth function for Oyster Harbour.

The production sub-model assumes that all the oysters do not reach harvestable size in the same week, and harvest is spread over a 12-month period. A triangular distribution, which is a continuous distribution, was used to determine the proportion of oysters ready to harvest in a particular week if the average oyster reaches harvestable size (65 mm) at three years (Figure 3).

The bioeconomic model predicts the growth, survival and harvest of one batch of oysters over a four-year period, on a weekly time step. When closure is enforced on the farm, the model postpones harvesting until the farm reopens. It is assumed that the harvested amount does not change when the farm reopens, as there is no data to support this. This extends the harvest period by the total number of closure weeks, so all stock are harvested.

Although prices in the oyster industry were not subject to seasonal change, prices after farm closure were altered to reflect a decline in market confidence and reduced sales during closure. Harvest rates, closure periods and prices were then incorporated into the biological model so the gross margin could be determined.

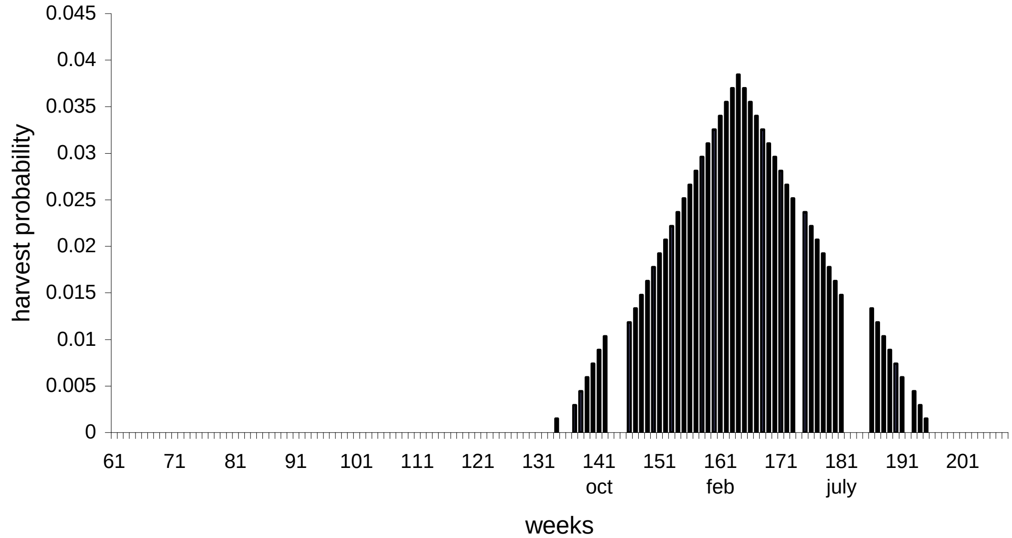

Figure 3. A triangular distribution of the harvest period, including the closure periods of Ocean Foods over 2003–04.

Simulations and results

Four simulations were run by manipulating different aspects of the model. The first reflected the original system with closure periods indicated in Figure 3, taken from actual closure of the oyster farm over 2003–04, while the second simulated no closure for the farm. Closure was found to impact on the farm's gross margin.

The other two simulations demonstrated two alternative management options:

- moving the oyster stock to Mistaken Island (King George Sound)
- using the Mistaken Island lease as a natural depuration site.

The Mistaken Island depuration option was marginally profitable and relocating the farm was unprofitable due to increased running costs associated with moving the farm outside the harbour.

Conclusions

The model found that the periods of closure decreased the farm's 2003–04 gross margin by 5.6% or $22 401. In the context of the oyster farms total income it can be considered a marginal impact, contributing only 4.5%. However, when compared to the farms yearly profit it may represent a significant loss. As long as the closure periods are short, their affect on the gross margin can be termed more of a cash flow problem rather than one threatening to disrupt farm viability.

The delays in revenue streams could be avoided by implementing natural depuration, whereby a proportion of stock is kept at a no risk site. When closure occurs these stocks could be used to fulfil any outstanding orders. This way, markets will not be lost, the price of oysters will not drop and consumer confidence in Ocean Foods will be maintained.

Whilst implementing better management practices to decrease nutrient and effluent runoff may limit the instances of closure, the impacts on profit identified in this study compared with the costs imposed on other industries within the catchment may not match the gains incurred by Ocean Foods. However there may be other benefits that accrue to changing catchment management practices other than those identified in this study. Several parameters are important for the future success of Ocean Foods:

- improving growth rates through selective breeding
- more detailed understanding of prices
- minimising the loss of markets from closure.

It is important that these are explored in more detail.

References

Allen, PG, Botsford, LW, Shuur, AM & Johnston, WE 1984, Bioeconomics of aquaculture, Elviser Science, Netherlands.

Askew, CG 1978, ‘A generalised growth and mortality model for assessing the economics of bivalve culture’, Aquaculture, vol. 14, pp. 91–104.

Australian Shellfish Quality Assurance Advisory Committee (ASQAAC) 2004, Australian Shellfish quality Assurance: Operations Manual Version 2002–03, Department of Primary Industries and Resources South Australia, viewed 6 October 2004, <http:www.pir.sa.gov.au/ASQAP_MANUAL/>.

Clarke, CW 1985, Bioeconomic modelling and fisheries management, John Wiley and Sons, Toronto.

Department of Fisheries and Western Australian Department for Health 2004, Perennial Report (January 2001–January 2004) and Update Sanitary Survey Report (January 2003–January 2004). The Western Australian Shellfish Quality Assurance Program (WASQAP); Oyster Harbour (Albany), Australian Government Publishing Services, Canberra.

Gibson, F 2004, ‘The implications of water borne pathogens on the management of an oyster farm at Oyster Harbour, Albany’ BSc thesis, University of Western Australia, Perth.

Hall, S 1983, ‘A multiple regression model of oyster growth’, Fisheries Research, vol. 2, pp. 167–175.

Mason, C, Reid, DD & Nell, JA 1998, ‘Growth characteristics of the Sydney rock oyster *Saccostrea commercialis* in relation to size and temperature’, Journal of Experimental Marine Biology, vol. 227, pp. 155–168.

National Centre for Environmental Decision-Making Research (NCEDR) 2004, Cost-benefit analysis and environmental decision-making, University of Tennessee, viewed 15 October 2004, <http://www.ncedr.org>.

Shang, YC 1986, 'Research in aquaculture economics: A review', Aquacultural Engineering, vol. 5, pp. 103–108.

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