Proc. Assoc. Advmt. Anim. Breed. Genet. ***17***: *115-118*

ECONOMIC WEIGHTS FOR DISEASE RESISTANCE IN SYDNEY ROCK OYSTERS

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SUMMARY

Sydney rock oyster farmers and wholesalers surveyed in 2006 provided production and economic data, which were used to construct a profit function for the industry. Economic values, assuming a range of initial mortality levels, were estimated using the partial first derivative of the profit function. Economic values were differentiated for Winter Mortality (WM) and QX disease taking into account the growth phase at which mortality occurred and reported mortality levels for these diseases.

Increased mortality leads to higher costs associated with replacing dead oysters, which is done by attaining additional spat (young oysters). Plus there are additional grading costs, particularly at the later stages of growth, which increased the economic value for mortality occurring in later growth phases. There was little difference in the corresponding economic values between nursery and initial grow out growth phases, but mortality during the final grow out growth phase had large economic values.

For QX disease, the high level of mortality typically occurring in the final growth phase (90%) resulted in an economic value of -\$0.146/% per dozen oysters. No successful management practices are available to manage QX disease. Winter Mortality commonly causes approximately 46% mortality, resulting in an economic value of -\$0.061/%. When management strategies were used to reduce initial mortality levels (between 10% and 30%), economic values were between -\$0.047/% and -\$0.052/% respectively. The difference between the economic values for WM and QX disease resistance show that selecting against mortality from QX disease is more economically important to a breeding program than selecting against WM, assuming similar genetic variation for both diseases.

INTRODUCTION

The Sydney Rock Oyster (SRO: *Saccostrea glomerata*) has historically been the most important edible oyster in Australia (Brown, 1997). Two biological constraints to SRO production include Winter Mortality (WM) and QX disease (‘QLD Unknown’), which are associated with infections by *Bonamia roughleyi* and *Marteilia sydneyi*, respectively.

Winter Mortality generally occurs along the NSW coast from Port Stephens (24°S) down to the Victorian border (37°S). Infection occurs in the third winter of an oyster's life, causing mortality rates as high as 80% (Smith, 2000), which is just before many farmed SROs reach market size (Nell 2001). QX disease mostly affects farmers from the Georges River (34°S) to Hervey Bay in Southern QLD (24°S) (Nell 2001). Infection occurs in summer, with up to 90% mortality (Nell, 2001). In 1994, QX disease effectively ruined SRO production in the Georges River. The NSW Department of Primary Industries and Fisheries SRO breeding program, aimed at increasing growth rates, was subsequently expanded to include selection against mortality from QX and WM. Recent results show that cumulative mortality was reduced in the lines selected against mortality from QX and WM by 33% and 28% respectively, when compared to control oysters (Nell and Perkins 2006).

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[*] AGBU is a joint venture of NSW Department of Primary Industries and the University of New England

Future objectives of the SRO breeding program will include an increasing number of commercially important traits. However, currently no estimates of economic weights exist for any traits important for oyster production. This paper will investigate economic weights for generic SRO mortality, and then apply these to specific disease scenarios. Selection against mortality from disease is particularly important to oysters given that the production environment is relatively uncontrolled, thus disease management options are few. In addition, the long production cycle where risk of loss from disease is highest at later growth stages means that farmers are unable to compensate for losses.

MATERIALS AND METHODS

Production and economic data were obtained from a survey of SRO farmers (n=35) and wholesalers (n=5) conducted in 2006. Average returns were estimated from representative prices received and the proportions sold for each grade class. Variable costs included spat purchase, grading, and selling costs. Consultation with industry representatives and available literature was used to cross-check the survey estimates. All costs and returns were estimated on a dollars per dozen ($/doz) basis, as used in industry. Thus, economic values are also expressed on a $/doz basis.

Estimates for costs and returns were used as input variables for a simple profit function that describes profitability for oyster production. The function was:

$$\text{Net Returns (NR)} = [\,\bar{R} \times (1-m) \times n_s] - [c_s/(1\text{-}m) \times n_s] - [c_g\text{NUR} \times (1-m) \times n_s + c_g\text{IGO} \times (1-m) \times n_s + c_g\text{FGO} \times (1-m) \times n_s] \qquad [1]$$

Where: n_s=no. spat; m=mortality; $\bar{R}$ =average returns=$\Sigma_i p_i R_i$ for i=1-5 grade classes; p=proportion sold; R=returns; c_s=spat cost; c_g=grading costs for nursery (NUR), initial (IGO) or final (FGO) growth phases. For simplicity, this paper examines mortality as confined to a single growth phase (e.g. NUR, IGO or FGO), so only one growth phase will have a non-zero mortality. The term $c_s/(1\text{-}m)$ shows that producers generally purchase additional spat to accommodate losses. After expanding with respect to m and removing the scale effect (n_s) the equation becomes:

$$\text{NR} = [\,\bar{R} - \bar{R}\,m] - [c_s/(1\text{-}m)] - [(c_{g\text{NUR}} - m_{\text{NUR}}\,c_{g\text{NUR}}) - (c_{g\text{IGO}} - m_{\text{IGO}}\,c_{g\text{IGO}}) - (c_{g\text{FGO}} - m_{\text{FGO}}\,c_{g\text{FGO}})]$$

The economic weight calculated using the partial first derivative with respect to nursery mortality is:

$$\frac{\delta\,\text{NR}}{\delta\,m_{\text{NUR}}} = -\bar{R} - [c_s/(1\text{-}m)^2] + [c_{g\text{NUR}} + c_{g\text{IGO}} + c_{g\text{FGO}}]$$

Similarly, partial derivatives can also be derived for mortality occurring in the other growth phases.

RESULTS AND DISCUSSION

The weighted average return ($6.52/doz) was calculated based on an average sale weight of 50g and sales occurring in all grade classes. Acceptable meat condition was assumed. Spat cost was based on purchase costs for hatchery spat ($0.08/doz). Total grading costs were calculated as the sum of the cost per grading and the number of gradings performed in the NUR ($0.007/doz), IGO ($0.87/doz) and FGO ($0.78/doz) growth phases.

The economic value for a 1% change in mortality increases as higher levels of initial mortality are assumed. This is because changes in spat cost per 1% increased in an exponential manner as the assumed initial mortality increased. At higher levels of mortality the contribution of grading costs are low compared to the contributions from spat costs. The economic value expressed per dozen oysters for a change in mortality increased in magnitude from -$0.050/% to -$0.052/% and -$0.138/% for initial mortality levels (NUR and IGO) of 10%, 50% and 90% respectively.

To illustrate differences between the effects of mortality in different growth phases, economic values were also calculated from equation [1] as the difference in net returns per percent change in mortality for initial mortality levels ranging from 0% to 90% (Table 1). Changes in mortality have been shown to be approximately 10% per generation under selection (Nell & Perkins, 2006). As with mortality in the nursery phase, economic values increased in magnitude with increasing mortality level for the IGO and FGO growth phases (Table 1). However, at any given mortality level, economic values for mortality in NUR and IGO were similar but were lower in magnitude than the comparable economic value for the same mortality level in the FGO growth phase. While absolute values were larger in magnitude for the FGO growth phase, the difference between growth phases on a percentage basis diminishes with increasing initial mortality.

The economic value for mortality occurring in later growth phases is higher in magnitude due to the increasing contribution of grading costs from earlier growth phases. In reality, above a certain level of mortality (unknown) it is not economically viable to pick out the live oysters from the dead oysters for grading or sale. This threshold effectively increases mortality to 100%.

Table 1. Economic values ($/doz) per 1% increase in mortality at different initial levels for the three growth phases

Change in mortality (%)	0-1	10-11	20-21	30-31	40-41	50-51	60-61	70-71	80-81	90-91
Nursery	-0.049	-0.050	-0.050	-0.050	-0.051	-0.052	-0.054	-0.058	-0.070	-0.138
Initial grow out	-0.050	-0.050	-0.050	-0.050	-0.051	-0.052	-0.054	-0.058	-0.070	-0.138
Final grow out	-0.058	-0.058	-0.059	-0.059	-0.060	-0.061	-0.063	-0.067	-0.078	-0.146

These results show that the appropriate economic value to place on mortality depends on both the level of mortality and the growth phase in which mortality occurs. This has implications for establishing the economic values relevant to the diseases of QX and WM.

Winter Mortality. Economic values for the FGO growth phase are the most relevant to WM, but the values will vary depending on how farmers manage WM, as different levels of mortality will determine the most appropriate values to be used in any one enterprise. Assuming a WM average of 46% (Nell & Perkins, 2006), this equates to an economic value for mortality of around -$0.061/% (Table 1). However, there are a few alternative strategies that SRO farmers can employ to reduce infection from WM, which may impact on the applicable economic values.

The most common strategy to manage the risk of losses resulting from WM is to sell oysters prior to their third winter. This means that oysters are sold at lighter weight (i.e. receive a lower average return) but also incur lower grading costs. After accounting for both the reduction in returns and the change in grading costs the economic values for WM are decreased in magnitude. For example if the average sale weight is reduced to 45g and there are two fewer FGO gradings, the economic values for a 1% change in FGO mortality are approximately -$0.047/%, for expected initial mortality levels of between 10% to 30%. A second management practice to reduce the impact of WM is to raise the growing height or move oysters upstream prior to their third winter. Smith et al. (2000) stated that it was relatively inexpensive to change growing height for controlling WM. From survey data, costs to pick up oysters and put them out was calculated to be $0.14/doz, and can be used as a preliminary cost of moving SROs upstream. If this was cost effective, the economic value for mortality would then depend on the level of protection this strategy conferred (i.e. reduction in mortality). The study by Smith et al. (2000) found that SROs grown above the normal growing height by 150mm and 300mm had significantly lower mortality than those grown at a normal height. Cumulative mortality was reduced from 35% to 17% and 9% for these heights, respectively. After accounting for cost changes economic values would reduce in magnitude to -\$0.049/%, -\$0.050/% and -\$0.052/% at 10%, 20% and 30% initial mortality levels. In summary, the economic values applicable to WM were influenced by both the cost and returns along with the assumed base level for mortality, which was influenced by management strategies to control the disease.

QX disease. Economic values for the FGO phases are relevant for this disease. A 1% increase from an initial value of 80% mortality resulted in an economic weight of -\$0.078/% (Table 1). Net returns were negative when initial mortality reached 80% for the FGO phase, or 90% in any growth phase. At an initial mortality level of 90%, an economic value of -\$0.146 per 1% change in mortality was estimated. With a rapid reduction in mortality levels caused by successful selection for resistance to QX disease, the economic value would also decrease in magnitude exponentially. Farmers in QX affected estuaries can purchase older SROs to on-grow to market weight and sell before the QX high-risk season in autumn (Nell 2001). However, as few farmers implement this strategy, costs and returns for this production system could not be quantified.

CONCLUSIONS

Economic values for mortality depend on both base mortality levels that are assumed for the farm and the growth phase in which mortality occurs. Economic values increased in magnitude with increasing mortality due to increases in both spat and grading costs. These values were relatively stable for a wide range of mortality (0% to 70%), but increased dramatically after this. In addition, the economic values increased in magnitude with increasing growth phase as costs accumulated.

The economic value of -\$0.146/doz per dozen oysters for a 1% change in mortality caused by QX disease is worth more than the corresponding percentage change in mortality caused by WM (-\$0.061/doz). This is due to the very high levels of mortality associated with QX and the lack of an effective management strategy for alleviating the effects of the disease. In contrast, WM causes relatively lower levels of mortality and there are management alternatives available to control this disease. If these management strategies are used to control the effects of WM, the estimate of the economic value reduces in magnitude from -\$0.061/% to between -\$0.047/% and -\$0.052/%. The frequency and success of management interventions for WM has implications for the relative importance of selection against mortality from these specific diseases in the SRO breeding program.

ACKNOWLEDGMENTS

This study was funded by the Fisheries Research and Development Corporation and run in collaboration with the Port Stephens Fisheries Centre and the Select Oyster Company. We thank SRO industry representatives, particularly farmers and wholesalers, for their assistance with this project.

REFERENCES

Nell, J.A. (2001). Marine Fisheries Review **63**:14.
Nell, J.A. and Perkins, B. (2006). Aquaculture Research **37**: 693.
Smith, I.R., Nell, J.A. and Adlard, R. (2000). Aquaculture **185:** (3/4).