Product Differentiation of Pacific oyster (Crassostrea gigas) Cultured in British Columbia

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Nanaimo, BC
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ABSTRACT

Products that are highly differentiated are able to establish brand names that create customer loyalty and lead to higher potential revenue. Product differentiation among Pacific oyster depends on both the aesthetic quality of the shell and the taste of the meat. When Pacific oysters are sold out of shell for meat, they lose a vital component of product differentiation. The purpose of this report is to determine the difference in revenue per hectare between those licenced aquaculture tenures growing Pacific oyster for sale as shucked meat and Pacific oysters grown for sale in the shell. Furthermore, since it is the stated policy that government should seek to maximize the economic potential of tenured Crown Land, policies should be adopted that encourage the production of Pacific oysters for the high value market. Therefore, a methodology will be developed that will predict the probability that a grower will produce oysters for the shucked market based on information provided on the aquaculture licence application. Amendments to the licence application could be made to increase the probability Pacific oysters under culture will be sold into the in-shell market at harvest.

RÉSUMÉ

Les produits qui sont fortement différenciés sont en mesure d'établir les noms de marque qui créent la fidélité des clients et conduisent à des revenus potentiels plus élevés. La différenciation des produits entre l'huître du Pacifique dépend à la fois de la qualité esthétique de la coque et le goût de la viande. Lorsque les huîtres du Pacifique sont vendus hors de la coquille pour la viande, ils perdent un élément essentiel de la différenciation des produits. Le but de ce rapport est de déterminer la différence de revenu par hectare entre ces concessions aquacoles licence croissance huître du Pacifique à vendre la viande écaillés et les huîtres du Pacifique cultivées pour la vente dans la coque. En outre, puisque c'est la politique officielle que le gouvernement devrait chercher à maximiser le potentiel économique des terres de la Couronne permanent, les politiques devraient être adoptées qui favorisent la production d'huîtres du Pacifique pour le marché de grande valeur. Par conséquent, une méthode sera élaborée qui permettront de prédire la probabilité qu'un producteur va produire des huîtres écaillées pour le marché sur la base de renseignements fournis sur la demande de permis d'aquaculture. Modifications de la demande de licence pourraient être faits pour augmenter la probabilité d'huîtres du Pacifique au titre de la culture seront vendus sur le marché en coquille à la récolte.

INTRODUCTION

Pacific Oyster (Crassostrea gigas) comprised over 75% of all shellfish cultured and harvested in British Columbia in 2012 and generated over $4.4 million in revenue for producers (BC Ministry of Agriculture, 2012). After harvest, Pacific oysters are sent to licenced processing plants where they are washed, inspected and sorted for sale into the wholesale market. Generally, Pacific oysters are sold as shucked, a process that removes the meat from the shell or whole in the shell or more usually in the half shell. Oyster Bars, Raw-Bars and chefs in upscale restaurants as well as producers of processed products such as Oysters Rockerfeller sold into the retail food market are the primary consumers of Pacific oyster in the half shell (Eaton, 2012). The quality standards demanded by these high end markets include an oyster with a shell that is even rounded and deep cupped and within specific range of size, a shell with a smooth and pearly white interior and a shell with a clean banded exterior without necessary frills or thinness (Handley and Jeffs, 2003).

Efforts are being made to increase product differentiation in the BC Pacific oyster industry but unlike other growing areas where brands such as Cherrystones, Shooting Points, Painters Creeks, Yorksters, Nassawaddox Salts, Choptank Sweets, Barcats and Old Plantations are gaining in popularity, the BC Pacific oyster industry has yet to establish a brand that captures the consumer's attention (Eaton, 2012). Producing an aesthetically appealing oyster is a labour intensive enterprise. Pacific oyster grown on trays similar to those shown in figure 1 must be regularly lifted and inspected by the grower. Anti-fouling technologies must be applied to remove barnacles and other bioaccumulation that attach to the outer shell and degrade the overall appearance of the oyster. To create a shell with a desired form and shape, the grower must regularly chip the outer edge of the oyster shell to encourage the growth of a deeper and more rounded cup. Specialized equipment such as oyster tumblers are often used to remove bio-fouling and to chip off the thin edge of the oyster shell (fig 2).

The labour intensive nature and the associated costs with producing oysters that are aesthetically pleasing to the consumer have deterred some growers from participating in the high value market. Instead, these growers simply choose to produce oysters for the shucked market where the meat is sold in containers by weight or volume. Removing oyster meat from the shell is also a labour intensive activity but the costs are borne by the processor rather than the oyster grower. As a consequence, the grower receives a lower farm gate price for shucked oysters than for oysters in the shell. Therefore, shellfish aquaculture tenures growing Pacific oyster destined to be sold into the shucked market will produce less revenue than those tenures growing Pacific oyster for the high end market resulting in the underutilization of the economic potential of the tenured growing area.

According to the Province of British Columbia Land Policy, "Crown land is a public asset and the Province has a responsibility to ensure it is managed to maximize and sustain the flow of economic, social and environmental benefits to British Columbians, now and in the future" (British Columbia Land Policy Pricing, p.2). Growers of Pacific oyster should therefore be encouraged to produce oysters of high quality that will return the maximum economic value. The purpose of this report is to determine the difference in revenue per hectare between those licenced aquaculture tenures growing Pacific oyster for sale as shucked meat and Pacific oysters grown for sale in the shell. Furthermore, a methodology will be developed that will predict the probability that a grower will produce oysters for the shucked market based on information provided on the aquaculture licence application.

METHODOLOGY

Information concerning species sold, quantity, value and the product type (whether processed as shucked or in the shell) was collected from the Annual Aquaculture Statistical Reports for the 2011, 2012 and 2013 reporting years. The size of the aquaculture tenures producing Pacific oyster as measured in hectares was obtained from AQUIIS, the aquaculture licencing database used by Aquaculture Resource Management. The data from these sources were collated on an Excel spreadsheet and two regression analyses were performed using Eviews statistical software.

It was hypothesized that the revenue per hectare generated by a typical aquaculture farm growing Pacific oyster is a function of the biomass of Pacific oyster produced measured in tonnes, the size of the farm tenure measured in hectares and whether the Pacific oyster produced is to be sold into the shucked market or the in-shell market. This function is given by equation 1 below:

$$\text{Revenue per hectare} = f\,(\overset{+}{\text{tonnes}},\ \overset{-}{\text{hectares}},\ \overset{-}{\text{shucked}}) + \epsilon \qquad (1)$$

Keeping all other variables constant, an increase in the biomass of oysters produced on a shellfish farm would result in an increase in revenue per hectare earned by the grower. Therefore, a positive relationship was expected between the quantity of Pacific oyster grown on a farm of fixed sized tenure and the revenue per hectare generated from its sale. On the other hand as the aquaculture farm tenure increases in size and keeping all other variables constant, revenue earned per hectare would decrease. Therefore, it was expected that an increase in farm tenure size would have a negative relationship to the revenue per hectare the grower would receive when stock is sold at market. Finally, it was expect that Pacific oysters sold for shucked meat would lose the benefit of product differentiation and therefore would receive less revenue per tonne than if sold to market in-shell. To accommodate for the concept of diminishing rates of marginal returns, the function was expected to be logarithmic in form resulting in the equation:

$$\ln(\text{VALUE/TENURE}) = \beta_0 + \beta_1 \ln(\text{TONNES}) - \beta_2 \ln(\text{TENURE}) - \beta_3(\text{SHUCKED}) + \epsilon \qquad (2)$$

As given in equation 2 the variable VALUE/TONNES represents the amount of revenue measured in dollars received by the grower for the sale of each tonne Pacific oyster produced, the variable TENURE represents the size of the farm tenure measured in hectares and SHUCKED is a dummy variable taking the value of 1 if the product is sold for shucked meat market or 0 if sold in-shell. When the regression was run, the estimate with the following coefficients was found:

$$\ln(VALUE/TENURE) = 7.58 + 0.917\ln(TONNES) - 0.942\ln(TENURE) - 0.743(SHUCKED) \quad (3)$$

SE	0.031	0.016	0.020	0.040
P-val	0.000	0.000	0.000	0.000

The coefficients in equation 3 all have the expected sign and all variables are statistically significant. The constant in the estimate is meaningless as neither of the variables TONNES nor TENURE take a zero value.

In order to determine the probability that an oyster grower will sell product for shucked meat, a binomial probit regression was constructed of the form:

$$Z_i = \phi^{-1}(P_i) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2j} + \epsilon \quad (4)$$

where ϕ^{-1} is the inverse of the normal cumulative distribution, P_i is the probability that the dummy variable is equal to 1, X_1 and X_2 are independent variables and β_1 and β_2 are their respective coefficients.

It was hypothesized that oyster growers practicing intensive aquaculture producing a higher ratio of biomass to hectare would be more likely to sell into the in-shell market than growers practicing extensive aquaculture which produces a lower ratio of biomass to hectare. The variable TONNES/TENURE measured in tonnes per hectare was therefore included as an independent variable in the regression. It was further hypothesized that as the farm gate value per tonne of oyster increases, growers would be less likely to forgo the increased nominal revenue associated with in-shell sales. The variable VALUE/TONNES was also included into the regression as an independent variable. The binomial probit regression was of the form:

$$Z_i = \phi^{-1}(P_i) = \beta_0 + \beta_1(TONNES/TENURE) + \beta_2(VALUE/TONNES) + \epsilon \quad (5)$$

and produced the estimated equation:

$$Z_i = \phi^{-1}(P_i) = 2.52 - 0.015(TONNES/TENURE) - 0.002(VALUE/TONNES) \quad (6)$$

SE	**0.227**	**0.004**	**0.000**
P-val	**0.000**	**0.000**	**0.000**

The coefficients produced are all statistically significant and have the expected negative sign.

ANALYSIS

The coefficients produced in the estimate in equation 3 illustrate some important points in the relationship between the revenue earned per hectare on a shellfish farm growing Pacific oyster and the production in tonnes per hectare. These points are more clearly seen by taking the antilog of equation 3 to produce:

$$VALUE/TENURE = e^{7.58} (TONNES)^{0.917}(TENURE)^{-0.942} e^{-0.743(SHUCKED)} \quad (7)$$

Common sense dictates that increasing the tenure size in hectares while holding biomass production constant as measured in tonnes, will result in reduced revenue generated per hectare. Similarly, increasing the production per tenure as measured in biomass while holding the size of the aquaculture tenure constant will produce an increase in the revenue generated per hectare. It is important to note that the exponent of the variable TONNES is less than one which points to a diminishing marginal rate of revenue per hectare with an increase in production on a tenure of fixed size. Of greatest interest, however, is the effect of the dummy variable SHUCKED in the estimate. When SHUCKED takes the value 0, meaning that oysters are sold in-shell, the exponent produces a value of 1 and has no effect on the estimate. If the variable SHUCKED takes the value 1, meaning that oysters are sold for meat out of the shell, the exponent takes the value 0.47 thus reducing the dependent variable VALUE/TENURE. Therefore it can be concluded that Pacific oysters sold for meat into the out of shell market will produce approximately half the revenue per hectare than Pacific oysters sold into the in-shell market.

The estimate given in equation 6 is the result of a binomial probit regression and produces a z value for a cumulative normal distribution for different values of the variables TONNES/TENURE, which is the biomass of Pacific oyster produced on a shellfish farm tenure and VALUE/TONNES which is the revenue in dollars per tonne received from the sale of Pacific Oyster produced. These values have been converted to probabilities and displayed in Table 1 for selected values of biomass Pacific oyster produced per hectare (TONNES/TENURE) and market price per tonne of Pacific oyster (VALUE/TONNES). Moving from the top left corner to the bottom right corner of Table 1 shows a decreasing probability that Pacific oyster will be sold for meat and out of shell. From the information contained in Table 1 it can be concluded that Pacific oyster under intensive cultivation producing a large biomass per hectare and selling into a market offering a high value per tonne is likely to be sold into the in shell market. Conversely, Pacific oyster cultured extensively producing a small biomass per hectare and selling into a market offering a low value per tonne is likely to be sold for meat into the out of shell market.

CONCLUSION

Since it is the stated policy that government should seek to maximize the economic potential of tenured Crown Land, policies should be adopted that encourage the production of Pacific oysters for the high value market. It is clear from the previous analysis that selling Pacific oyster into the in-shell market generates greater revenue per hectare of shellfish tenure than Pacific oyster sold for meat in the out-of-shell market. Product differentiation allows for the creation of brand names and may lead to higher potential revenue. Pacific oyster, however, depends on both the aesthetic quality of the shell and the taste of the meat to create a unique product. Pacific oyster sold in-shell therefore increases the productive value of shellfish tenures and will advance the goal of maximizing economic benefit to the shellfish grower. Policies should be developed that encourage more intensive culture of Pacific oyster that is conducive for in-shell sales and that will aid in the establishment of British Columbia branded oysters.

When making application for licence to conduct aquaculture, all prospective shellfish growers must apply for an aquaculture licence and submit a management plan to the Department of Fisheries and Oceans which includes a statement of tenure size in hectares and the estimated biomass production measured in tonnes. The market value of Pacific oyster is a matter of public record and is published annually by the Province of British in the Seafood Industry Year in Review and other sources. With this information at hand, it is possible for licencing officers to determine the probability that the applicant will grow Pacific oyster for sale into the out-of-shell market. Amendments to the licence application could be made to increase the probability Pacific oysters under culture will be sold into the in-shell market at harvest.

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FIGURES

Figure 1 – Culture Trays **Photo taken by author**

Figure 2 – Oyster Tumbler **Photo taken by author**

TABLE 1

Probability that a shellfish grower will sell Pacific oyster for shuck

Farm-gate price of Pacific oyster ($/tonne)

Pacific Oyster production (tonnes/hectare)

	$100	$200	$300	$400	$500	$600	$700	$800	$900	$1,000	$1,100	$1,200	$1,300	$1,400	$1,500	$1,600	$1,700	$1,800	$1,900	$2,000	$2,100
0.5	0.989154	0.98091	0.967851	0.948164	0.919916	0.88134	0.831198	0.769168	0.696133	0.614287	0.526992	0.438375	0.352756	0.274023	0.205115	0.147713	0.102204	0.067864	0.043201	0.026343	0.015375
1.0	0.988938	0.980558	0.967308	0.947364	0.918796	0.879846	0.829304	0.766883	0.693508	0.611419	0.524009	0.435424	0.349978	0.271534	0.202992	0.145992	0.100875	0.066887	0.042518	0.025889	0.015088
1.5	0.988718	0.980202	0.966757	0.946555	0.917664	0.87834	0.827397	0.764585	0.690874	0.608545	0.521026	0.432477	0.347207	0.269056	0.200883	0.144283	0.099558	0.065922	0.041844	0.025441	0.014805
2.0	0.988494	0.979839	0.966198	0.945735	0.91652	0.87682	0.825476	0.762274	0.688229	0.605665	0.518041	0.429533	0.344445	0.266589	0.198787	0.142588	0.098254	0.064967	0.041179	0.025	0.014527
2.5	0.988267	0.979471	0.965632	0.944906	0.915364	0.875288	0.823542	0.759952	0.685575	0.602779	0.515055	0.426594	0.341691	0.264134	0.196704	0.140907	0.096963	0.064023	0.040523	0.024566	0.014253
3.0	0.988035	0.979098	0.965058	0.944066	0.914196	0.873741	0.821594	0.757617	0.682912	0.599888	0.512069	0.423658	0.338945	0.26169	0.194635	0.139239	0.095684	0.06309	0.039875	0.024137	0.013984
3.5	0.9878	0.978718	0.964476	0.943217	0.913016	0.872182	0.819633	0.75527	0.680239	0.596991	0.509082	0.420727	0.336208	0.259258	0.192579	0.137585	0.094417	0.062167	0.039235	0.023715	0.013719
4.0	0.98756	0.978333	0.963886	0.942357	0.911824	0.870609	0.817658	0.75291	0.677556	0.594089	0.506094	0.4178	0.33348	0.256838	0.190536	0.135944	0.093163	0.061255	0.038604	0.0233	0.013458
4.5	0.987317	0.977942	0.963288	0.941488	0.91062	0.869023	0.81567	0.750539	0.674864	0.591182	0.503106	0.414878	0.33076	0.25443	0.188506	0.134317	0.091922	0.060353	0.037981	0.02289	0.013202
5.0	0.98707	0.977545	0.962682	0.940608	0.909404	0.867424	0.813668	0.748155	0.672163	0.588269	0.500118	0.41196	0.32805	0.252033	0.18649	0.132703	0.090692	0.059462	0.037366	0.022487	0.01295
5.5	0.986818	0.977142	0.962068	0.939717	0.908176	0.865811	0.811653	0.745759	0.669453	0.585352	0.497129	0.409048	0.325348	0.249649	0.184487	0.131102	0.089475	0.058581	0.036759	0.022089	0.012702
6.0	0.986562	0.976733	0.961446	0.938816	0.906935	0.864184	0.809625	0.743352	0.666735	0.58243	0.494141	0.40614	0.322655	0.247276	0.182498	0.129515	0.08827	0.057711	0.036161	0.021698	0.012459
6.5	0.986302	0.976318	0.960815	0.937905	0.905682	0.862545	0.807583	0.740933	0.664007	0.579504	0.491154	0.403237	0.319972	0.244916	0.180522	0.127941	0.087077	0.05685	0.03557	0.021312	0.012219
7.0	0.986037	0.975896	0.960176	0.936983	0.904416	0.860891	0.805528	0.738502	0.66127	0.576573	0.488166	0.40034	0.317298	0.242568	0.17856	0.126381	0.085896	0.056	0.034988	0.020932	0.011983
7.5	0.985768	0.975468	0.959529	0.936051	0.903138	0.859225	0.803459	0.736059	0.658526	0.573637	0.48518	0.397448	0.314634	0.240232	0.176611	0.124834	0.084727	0.05516	0.034413	0.020558	0.011752
8.0	0.985495	0.975034	0.958873	0.935108	0.901848	0.857544	0.801378	0.733605	0.655772	0.570698	0.482194	0.394562	0.311979	0.237908	0.174676	0.1233	0.083571	0.05433	0.033846	0.02019	0.011524
8.5	0.985217	0.974594	0.958208	0.934154	0.900545	0.855851	0.799283	0.731139	0.653011	0.567755	0.479209	0.391682	0.309334	0.235597	0.172754	0.121779	0.082426	0.053509	0.033287	0.019827	0.0113
9.0	0.984935	0.974147	0.957535	0.933189	0.899229	0.854143	0.797174	0.728662	0.650241	0.564808	0.476226	0.388807	0.306699	0.233298	0.170846	0.120272	0.081293	0.052699	0.032735	0.01947	0.01108
9.5	0.984648	0.973693	0.956853	0.932213	0.897901	0.852423	0.795053	0.726173	0.647463	0.561858	0.473243	0.385939	0.304074	0.231012	0.168951	0.118778	0.080171	0.051898	0.032191	0.019118	0.010863
10.0	0.984356	0.973233	0.956162	0.931227	0.89656	0.850688	0.792919	0.723674	0.644678	0.558904	0.470263	0.383077	0.301459	0.228738	0.16707	0.117297	0.079062	0.051107	0.031655	0.018771	0.01065
10.5	0.98406	0.972766	0.955463	0.930229	0.895206	0.84894	0.790771	0.721163	0.641884	0.555946	0.467283	0.380221	0.298854	0.226477	0.165202	0.115829	0.077964	0.050326	0.031126	0.01843	0.010441
11.0	0.983758	0.972293	0.954754	0.92922	0.89384	0.847179	0.78861	0.718641	0.639083	0.552986	0.464306	0.377372	0.296259	0.224228	0.163348	0.114374	0.076878	0.049554	0.030604	0.018095	0.010236
11.5	0.983452	0.971812	0.954036	0.9282	0.89246	0.845404	0.786437	0.716108	0.636275	0.550023	0.461331	0.374529	0.293675	0.221992	0.161507	0.112932	0.075803	0.048792	0.030089	0.017764	0.010034
12.0	0.983141	0.971325	0.95331	0.927169	0.891068	0.843615	0.78425	0.713564	0.633459	0.547056	0.458358	0.371693	0.291101	0.219769	0.15968	0.111503	0.07474	0.048039	0.029582	0.017439	0.009835
12.5	0.982825	0.97083	0.952574	0.926127	0.889663	0.841813	0.782051	0.71101	0.630636	0.544088	0.455387	0.368864	0.288537	0.217559	0.157867	0.110088	0.073688	0.047295	0.029082	0.017119	0.00964
13.0	0.982504	0.970329	0.951828	0.925073	0.888245	0.839997	0.779838	0.708445	0.627806	0.541117	0.452419	0.366043	0.285985	0.215362	0.156067	0.108685	0.072648	0.046561	0.028589	0.016804	0.009449
13.5	0.982178	0.96982	0.951074	0.924008	0.886814	0.838168	0.777613	0.705869	0.624969	0.538143	0.449453	0.363228	0.283443	0.213178	0.154281	0.107295	0.071618	0.045836	0.028102	0.016493	0.00926
14.0	0.981846	0.969304	0.95031	0.922931	0.88537	0.836325	0.775375	0.703283	0.622125	0.535167	0.44649	0.360421	0.280912	0.211006	0.152508	0.105918	0.0706	0.04512	0.027623	0.016188	0.009075
14.5	0.98151	0.968781	0.949536	0.921843	0.883913	0.834469	0.773124	0.700686	0.619274	0.53219	0.44353	0.357621	0.278392	0.208848	0.150749	0.104554	0.069594	0.044413	0.027151	0.015888	0.008893
15.0	0.981168	0.968251	0.948753	0.920743	0.882442	0.832599	0.770861	0.69808	0.616417	0.52921	0.440574	0.354829	0.275883	0.206703	0.149004	0.103202	0.068598	0.043715	0.026685	0.015592	0.008715

APPENDIX

Regression 1

Dependent Variable: LN(VALUE/TENURE)
Method: Least Squares
Sample: 1 657
Included observations: 657

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.584104	0.031682	239.3809	0.0000
LN(TENURE)	-0.942351	0.020130	-46.81313	0.0000
LN(TONNES)	0.917557	0.010618	86.41754	0.0000
SHUCKED	-0.743686	0.040960	-18.15647	0.0000

R-squared	0.926438	Mean dependent var	8.062263
Adjusted R-squared	0.926100	S.D. dependent var	1.688023
S.E. of regression	0.458880	Akaike info criterion	1.286015
Sum squared resid	137.5029	Schwarz criterion	1.313337
Log likelihood	-418.4558	Hannan-Quinn criter.	1.296607
F-statistic	2741.303	Durbin-Watson stat	1.218739
Prob(F-statistic)	0.000000		

Regression 2

Dependent Variable: SHUCKED
Method: ML - Binary Probit (Quadratic hill climbing)
Sample: 1 657
Included observations: 657
Convergence achieved after 6 iterations
Covariance matrix computed using second derivatives

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	2.526069	0.227650	11.09628	0.0000
TONNES/TENURE	-0.014981	0.004474	-3.348376	0.0008
VALUE/TONNES	-0.002228	0.000165	-13.53848	0.0000

McFadden R-squared	0.424640	Mean dependent var	0.270928
S.D. dependent var	0.444778	S.E. of regression	0.312718
Akaike info criterion	0.681360	Sum squared resid	63.95643
Schwarz criterion	0.701852	Log likelihood	-220.8267
Hannan-Quinn criter.	0.689304	Deviance	441.6535
Restr. deviance	767.6127	Restr. log likelihood	-383.8063
LR statistic	325.9592	Avg. log likelihood	-0.336114
Prob(LR statistic)	0.000000		

Obs with Dep=0	479	Total obs	657
Obs with Dep=1	178		