1.1 ANNUAL PRICE MODEL

Annual ex-vessel price model is updated each year to take into account the recent changes in sea scallop markets both domestically and internationally. This model estimates the degree of change in ex-vessel price in response to a change in variables affected by management, i.e., scallop landings and size composition of landed scallops, as well as to a change in other important determinants of price, including price of imports, exports and disposable income of consumers. Estimated prices are then used in the cost benefit model to evaluate the impacts of the fishery management actions on fishing revenues, vessel profits, consumer surplus, and net economic benefits for the nation.

Given that there are many variables that could affect the price of scallops, it is important to identify the objectives in price model selection. These objectives (in addition to developing a price model with sound statistical properties) are as follows:

- To develop a price model that would explain the main determinants of the scallop ex-vessel prices on an annual basis: In the real world, prices are affected by an exhaustive list of factors; however, the data limitations often curtail the number of variables that can be included in a model. In addition, many of these variables have marginal impacts on the prices with little use is estimating the impacts of the management actions on prices. Even when a sufficiently long time-series data is available, the measurement errors associated with many variables would compound the uncertainty of the estimates.

- To develop a price model that uses inputs of the biological model, including landings by market size category: Since the biological model projects annual (rather than monthly) landings by fishyear, the corresponding price model should be estimated in terms of annual values (by fishyear). As a result, such model could only be used to project average annual price of scallops rather than the daily or monthly changes in prices.

- To select a price model that will predict prices within a reasonable range without depending on too many assumptions about the exogenous variables: For example, the import price of scallops from Japan could impact domestic prices differently than the price of Chinese imports, but making this separation in a price model would require prediction about the future import prices from these countries. This in turn would complicate the model and increase the uncertainty regarding the future estimates of domestic scallop prices.

In addition to the changes in size composition and landings of scallops, price model incorporates other determinants of ex-vessel price including import price of scallops, disposable income of seafood consumers and the demand for U.S. scallops by other countries into the model.

The ex-vessel price model estimated below includes the price, rather than the quantity of imports as an explanatory variable, based on the assumption that the prices of imports are, in general, determined exogenously to the changes in domestic supply. An alternative model would estimate

the price of imports according to world supply and demand for scallops, separating the impacts of Canadian and Japanese imports from other imports since U.S. and Canadian markets for scallops, being in proximity, are highly connected and Japanese scallops tend to be larger and closer in quality to the domestic scallops. The usefulness of such a simultaneous equation model is limited for our present purposes, however, since it would be almost impossible to predict how the landings, market demand, and other factors such as fishing costs or regulations in Canada or Japan and in other exporting countries to the U.S. would change in future years.

Since the average import price is equivalent to a weighted average of import prices from all countries weighted by their respective quantities, the import price variable takes into account the change in composition of imports from Canadian scallops to less expensive smaller scallops imported from other countries. This specification also prevents the problem of multi-collinearity among the explanatory variables, i.e., prices of imports from individual countries and domestic landings. In terms of prediction of future ex-vessel prices, this model only requires assignment of a value for the average price of imports, without assuming anything about the composition of imports, or the prices and the level of imports from individual countries. The economic impact analyses of the fishery management actions usually evaluate the impact on ex-vessel prices by holding the average price of imports constant. The sensitivity of the results affected by declining or increasing import prices could also be examined, however, using the price model presented in this section.

Price model also takes into account the demand for US scallops by other countries. One of most significant change in the trend for foreign trade for scallops after 1999 was the striking increase in scallop exports. The increase in landings of especially larger sized scallops increased U.S. exports of scallops from about 5 million pounds in 1999 fishing year to a record amount of over 32 million pounds in 2011 fishing year. Western European Countries constituted the largest markets for sea scallop exports (Figure 1). During the same period, export prices increased as scallop landings continued to include a higher proportion of larger sized scallops (Figure 2). Increase in exports reduced the supply of domestically produced scallops, as measured by landings net of exports, increased ex-vessel prices further. For these reasons, net landings (net of exports) are included in the price model as a proxy of the net supply of domestically harvested scallops.

Figure 1 - Scallop Exports by Country

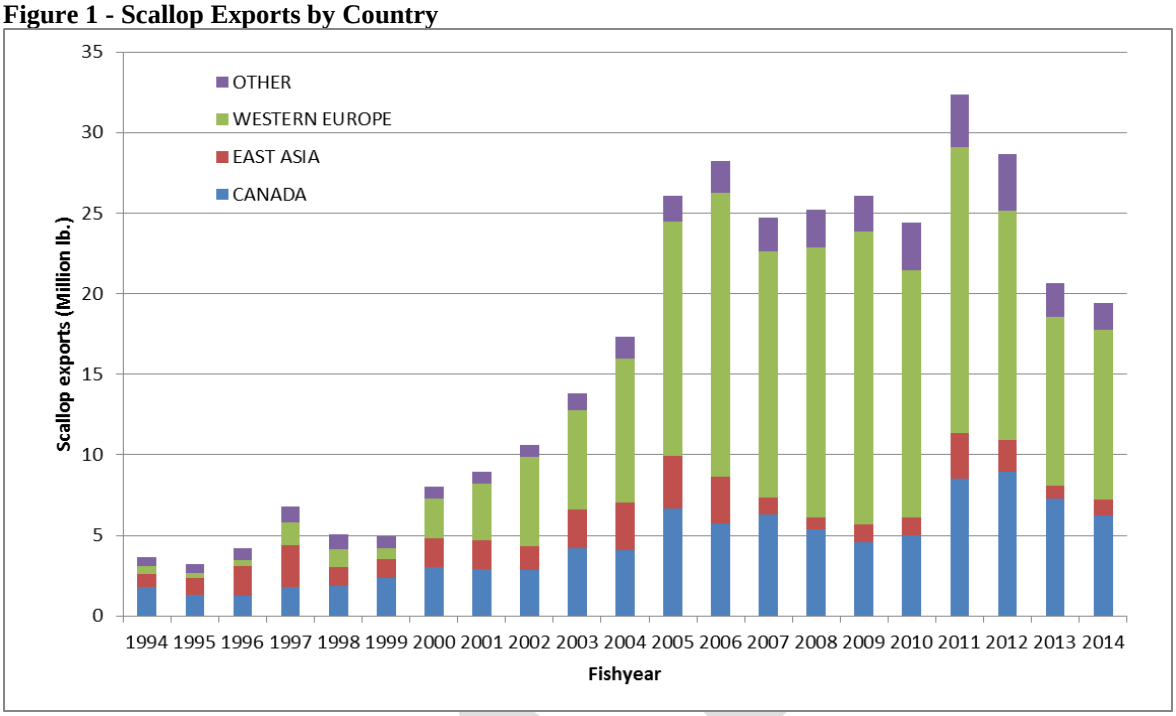
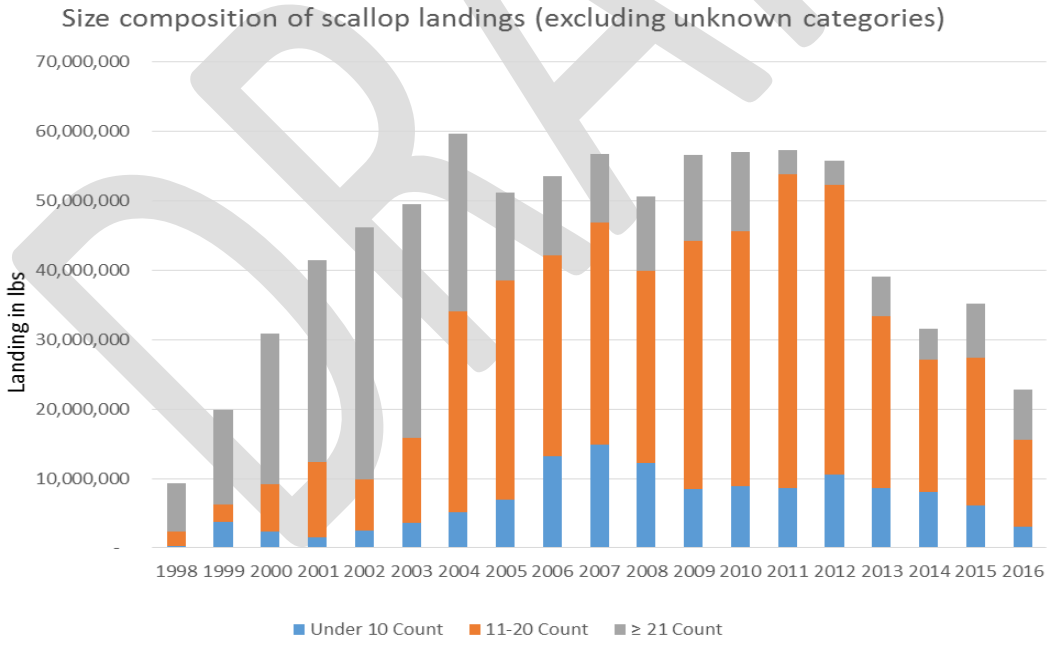


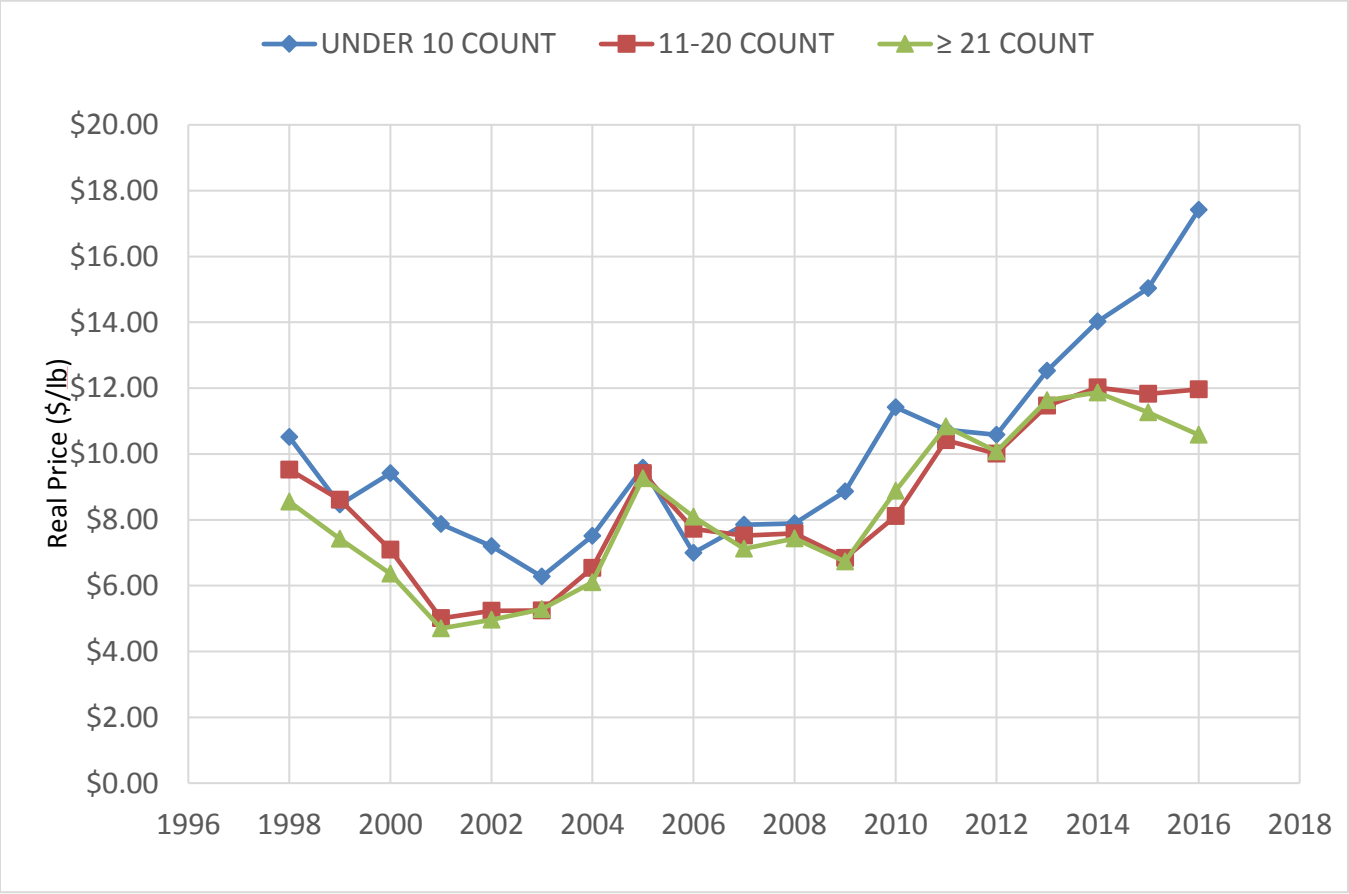
Figure 2 - Percentage composition of landings and ex-vessel price by market size category



In addition to changes in examined above in the U.S. scallop fishery, several external factors played a role in shifting the international demand for large scallops exported from the U.S. In

2005, a combination of such factors including problems with Japanese aquaculture, reduction in Canadian scallop landings, increase in oil and import prices by 30% as well as the increase in landings of U10s and 10-20s led to a surge in U.S exports by 50% compared to the 2004. As a result, scallop ex-vessel prices jumped from $6.4 per lb. in 2004 to $9.3 per lb. in 2005. Similarly, the problems with the Japanese aquaculture starting in 2010 and release of radiation from the Fukushima Nuclear power plant in 2011 reduced the supply of large scallops from this country and increased the demand for US sea scallops. Imports of scallops from Japan declined by 48% in 2010 and by 34% in 2011 while imports from Canada remained low. Scallop ex-vessel prices increased from $9 in 2010 to $10.5 in 2011 and exports increased by 32% establishing U.S. as one of the major exporters of large scallops. The plunge of the scallop catch in Hokkaido, Japan by more than 30% in the 2015/2016 fishing year, (ending March 31), and by 15% for the 2016/2017 year, and the collapse of the Canadian scallop fishery due to the oil spill in the last 3 years, led to a jump of the U.S scallop prices of U10's and U12s in 2015 and 2016 fishing years (Figure 3).

Figure 3 - Percentage composition of landings and ex-vessel price by market size category



The price model presented below estimates annual average scallop ex-vessel price by two market categories (PEXMRKT) as a function of

- Average price of all scallop imports (PRIMPORT)
- Per capita personal disposable income (PCDPI)
- Total annual landings net of exports in million lb. (NETLAN)
- Dummy variables for 2005 (D05) and for 2010 on (D10) to take into account changes in the markets for large scallops mainly due to issues with Canadian and Japanese scallop fisheries that supply large size scallops similar to the U.S. product.
- Percentage change in the share of total landings of each market size from the previous year (PCTCHSHARE).
- Dummy variable for U10 scallops to estimate price premium

Because the data on scallop landings and revenue by meat count categories were mainly collected since 1998 through the dealers' database, this analysis included the 1998-2015 fishing years. However, year 1998 dropped from the estimation sample due to large proportion of scallops in the unknown category. All the price variables were corrected for inflation and expressed in 2015 prices by deflating current levels by the consumer price index (CPI). The market categories above 10-count are grouped together. Landings of scallops over 40-, 50- or 60-count were almost nonexistent since 1998 and prices of 20plus categories were highly correlated with prices of 10 plus category of scallops. Thus price of 10p category were estimated using average price weighted by landings for these categories. The data for the regression analysis did not include the landings of scallops with unclassified market category.

The ex-vessel prices are estimated in semi-log form to restrict the estimated price to positive values only as follows:

$$\text{Log (PEXMRKT)} = f(\text{DU10, PRIMPORT, PCDPI, NETLAN, D05, D10, PCTCHSHARE})$$

The estimation of the price model produced robust estimates of the coefficient of variation and the parameters (except for DPI variable) as shown in Table 1. Adjusted R2 indicates that meat count, changes in the size composition of scallops, average price of imports, disposable income, 2005 and 2010 dummy variables and landings net of exports explain over 87 percent of the variation in ex-vessel prices by market category. With the exception of disposable income variable, all other coefficients are statistically significant.

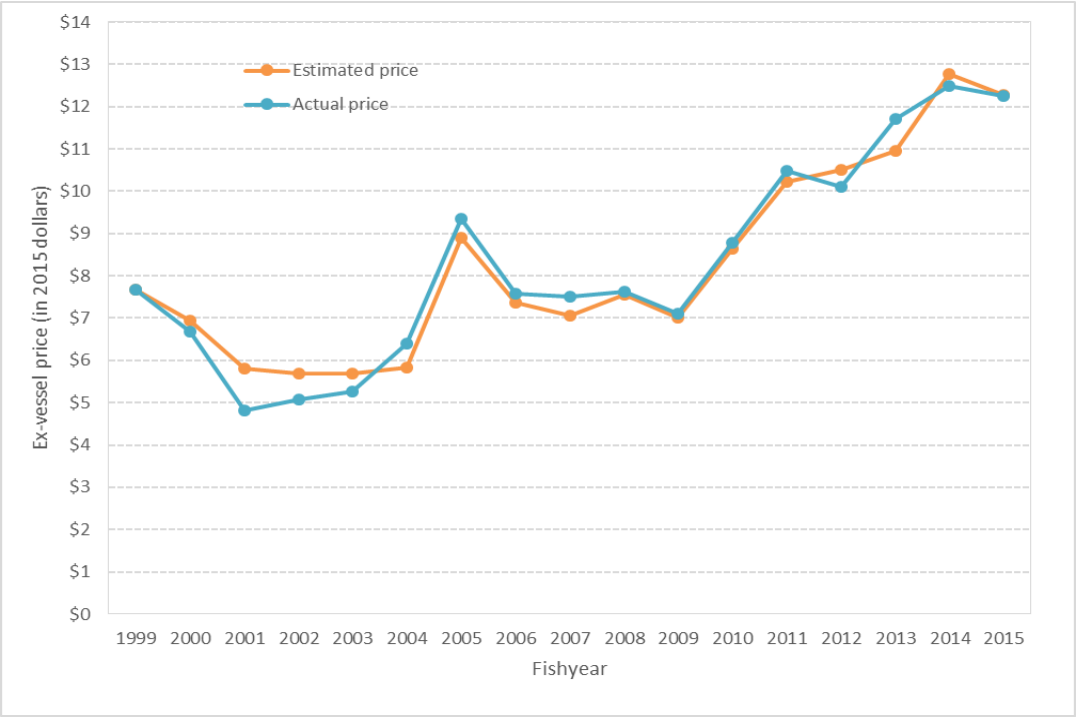
Table 1 - Estimation results for price model

Nonlinear GMM Summary of Residual Errors								
Equation	**DF Model**	**DF Error**	**SSE**	**MSE**	**Root MSE**	**R-Square**	**Adj R-Sq**	**Durbin Watson**
lnprice	8	26	0.2581	0.00993	0.0996	0.9014	0.8749	1.2756

Nonlinear GMM Parameter Estimates				
Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**
intc	0.524903	0.7178	0.73	0.4712
PRIMPORT	0.077232	0.0579	1.33	0.1936
D10	0.183681	0.0777	2.36	0.0258
D05	0.177816	0.0671	2.65	0.0135
PCDPI	0.034098	0.0159	2.15	0.0411
PCTCHSHARE	-0.01775	0.0115	-1.55	0.1343
DU10	0.176773	0.0385	4.60	<.0001
NETLAN	-0.00819	0.00391	-2.09	0.0462

The coefficients of the model are used first to estimate the prices by market category and then a weighted (by share in total landings) average of the estimated prices is calculated to estimate the annual average price. Figure 4 shows that this model provides a very good fit to the actual values of ex-vessel prices especially given that data is imperfect and there are possibly several other factors that affect prices in some small degree that cannot be practically included in the model. In terms of data, a percentage of unclassified landings ranged from 3% in 2014 to 12% in 1999. Average annual prices were estimated assuming that composition of the unclassified landings is similar to the composition of the landings by classified market categories. Therefore, price would be different than estimated to the degree that actual distribution was different from what was assumed. Another data issue is that dealer data combines U12 scallops, which usually demand a higher premium, with scallops up to 20-count scallops. Because of that, the price model cannot take into account the proportion of U12's in landings. Again, this introduces uncertainties in price estimates to the degree that composition of 11-20 landings in terms of U12s changes from one year to another.

Figure 4 – Estimated and actual annual ex-vessel prices (in 2015 dollars)



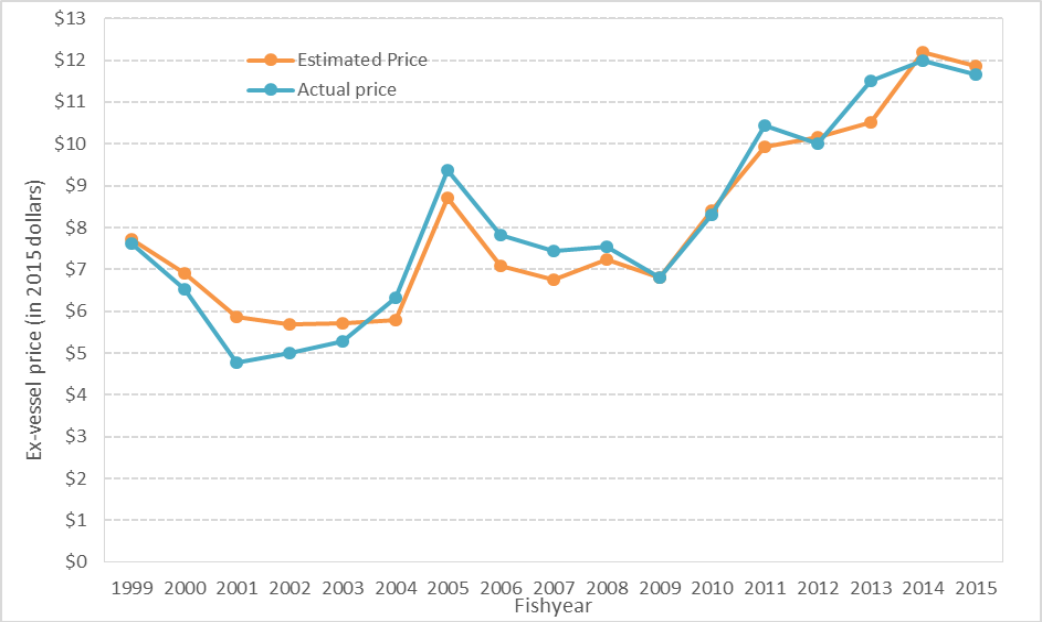
The price model was estimated for period from 1999 to 2014 as well as for 1999 to 2015 to validate the accuracy of model estimates for 2015. In fact, the model coefficients were pretty stable for these two periods and resulted in close estimates to actual prices (Table 2). The estimated and actual prices for these two market categories are depicted in Figure 5 and Figure 6.

Table 2. Estimated prices for 2015 fishing year estimating model for two periods

Fishyear	Market category	Actual prices	1999-2014 model estimates	1999-2015 model estimates
2015	U10	15.03	14.28	14.26
2015	11+	11.67	11.94	11.86
2015	All	12.25	12.34	12.27

Figure 5 - Estimated and actual prices of U10s

Figure 6 - Estimated and actual prices of 11+ scallops



These numerical results should be interpreted with caution, since the analysis covers about 16 years of annual data from a period during which the scallop fishery underwent major changes in management policy including area closures, controlled access, and rotational area management. However, the above price model has the proper statistical properties and, overall, provides a robust estimate of average annual prices.