# Appendix I

# Economic model and sensitivity analyses for Framework 21 to the Scallop FMP

## 1.1 ECONOMIC MODEL

### 1.1.1 ESTIMATION OF PRICES, COSTS, PROFITS AND NATIONAL BENEFITS

The economic model includes an ex-vessel price equation, a cost function and a set of equations describing the consumer and producer surpluses. The ex-vessel price equation is used in the simulation of the ex-vessel prices, revenues, and consumer surplus along with the landings and average meat count from biological projections. The cost function is used for projecting harvest costs and thereby for estimating the producer benefits as measured by the producer surplus. The set of equations also includes the definition of the consumer surplus, producer surplus, profits to vessels, and total economic benefits.

### 1.1.2 Estimation of annual ex-vessel prices

Fish prices constitute one of the important channels through which fishery management actions affect fishing revenues, vessel profits, consumer surplus, and net economic benefits for the nation. The degree of change in ex-vessel price in response to a change in variables affected by management, i.e., scallop landings and meat count, is estimated by a price model, which also takes into account other important determinants of price, such as disposable income of consumers and price of imports.

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

- To develop a price model that uses inputs of the biological model and available data. Since the biological model projects annual (rather than monthly) landings, the corresponding price model should be estimated in terms of annual values.
- 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 the past SAFE reports and Scallop Amendment and Frameworks, the average ex-vessel price for scallops was estimated from an annual price model as a function of total landings, average meat count of scallops landed, disposable income of consumers, and average import prices. Collection of price data by market category of scallops since 1998, however, made it possible to improve the price model by taking into account the changes in the size composition of scallops. The composition of scallops changed significantly in the last ten years toward larger sizes as a result of effort-reduction measures, area closures, and an increase in ring sizes implemented by the Sea Scallop FMP. The share of U10's increased to 27% in 2007 from 7% in 2000 and the share of count 11-20 scallops increased from 18% in 2000 to over 50% in 2007 (**Table 1**).

The scallop price by market category is affected by the relative abundance or supply of that size category relative to total scallop landings. Until the 2005 fishing year, U10 scallops had a significant price premium, but as their supply in landings increased, the difference in the annual average price of U10's and other size categories declined and in 2006, average price of U10s actually was lower than the price for other size categories (Table 2). The price model developed originally for Framework 18 captured these changes by estimating the prices by major meat count categories and including the relative share of each category in total supply of scallops as an explanatory variable.

**Table 1. Composition of scallop landings by market category**

| Year | U10 | 11 to 20 | 21 to 30 | Over 30 |
|---|---|---|---|---|
| 1999 | 19% | 13% | 29% | 39% |
| 2000 | 8% | 21% | 49% | 22% |
| 2001 | 4% | 27% | 56% | 13% |
| 2002 | 5% | 16% | 73% | 5% |
| 2003 | 7% | 25% | 65% | 3% |
| 2004 | 8% | 45% | 46% | 2% |
| 2005 | 14% | 62% | 22% | 2% |
| 2006 | 24% | 55% | 20% | 1% |
| 2007 | 26% | 56% | 14% | 4% |
| 2008 | 24% | 55% | 19% | 1% |

**Table 2. Average annual price of scallops by market category (2008 prices)**

| Year | U10 | 11 to 20 | 21 to 30 | Over 30 |
|---|---|---|---|---|
| 2000 | 7.8 | 7.9 | 7.3 | 6.4 |
| 2001 | 8.7 | 6.8 | 5.9 | 6.1 |
| 2002 | 7.2 | 4.7 | 4.4 | 4.7 |
| 2003 | 6.7 | 4.8 | 4.5 | 5.1 |
| 2004 | 5.7 | 4.8 | 4.8 | 5.3 |
| 2005 | 6.8 | 5.8 | 5.5 | 5.7 |
| 2006 | 8.8 | 8.6 | 8.5 | 8.3 |
| 2007 | 6.6 | 7.3 | 7.6 | 7.6 |
| 2008 | 7.2 | 6.9 | 6.8 | 6.2 |

In addition to the changes in size composition and landings of scallops, other determinants of ex-vessel price include level of imports, import price of scallops, disposable income of seafood consumers, and the demand for U.S. scallops by other countries. The main substitutes of sea scallops are the imports from Canada, which are almost identical to the domestic product, and imports from other countries, which are generally smaller in size and less expensive than the domestic scallops. An exception is the Japanese imports, which have a price close to the Canadian imports and could be a close substitute for the domestic scallops as well.

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. This is equivalent to assuming that the U.S. market conditions have little impact on the import prices. 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-colinearity 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.

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

- Meat count (MCOUNT)
- Average price of all scallop imports (PIMPORT)
- Per capita personal disposable income (PCDPI)
- Total annual landings of scallop minus exports (SCLAND-SCEXP)
- Percent share of landings by market category in total landings (PCTLAND)
- A dummy variable as a proxy for price premium for Under 10 count scallops (DU10).

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 1999-2008 period. All the price variables were corrected for inflation and expressed in 2008 prices by deflating current levels by the consumer price index (CPI) for food. The ex-vessel prices are estimated in semi-log form to restrict the estimated price to positive values only as follows:

Log (PEXMRKT) = f(MCOUNT, PIMPORT, PCDPI, SCLAND-SCEXP, PCTLAND, DU10)

The coefficients of this model are shown in Table 3. Adjusted $R^2$ indicates that changes in meat count, composition of landings by size of scallops, domestic landings net of exports, average price of all imports, disposable income, and price premium on under 10 count scallops and 2005 dummy variable explain 82 percent of the variation in ex-vessel prices by market category. In contrast to the price model estimates for the earlier years, the coefficient for the landings net of exports was not statistically significant for the period 1999-2008 for the range of landings observed in this period probably because annual variation in landings in recent years were relatively small and the change in the composition of landings toward larger scallops had a larger impact on prices. If in actuality, the prices were more responsive to landings than were predicted with this model, the revenues *for the proposed action* would be higher than estimated in the FRM 21 document for year 2010.

In addition, values of the all the explanatory variables are held at the recent levels. For example, disposable income per capita and import prices are assumed to stay constant at the 2008 level. This is because it is not possible to predict accurately the changes in the future values of the explanatory variables and also because our goal is determine the response in prices to the change in landings and the composition in terms of market category given other things held constant. Therefore, future prices could be higher (lower) than predicted depending on the values of the explanatory variables. The changes in the future values of those variables are not expected to change, however, the relative ranking of the alternatives.

**Table 3. Regression results for price model**

| **Regression Statistics** | |
|---|---|
| R Square | 0.85 |
| Adjusted R Square | 0.82 |
| Observations | 40 |

**Table 4. Coefficients of the Price Model**

| Variables | Coefficients | Standard Error | t Stat |
|---|---|---|---|
| INTERCEPT | -1.18096 | 0.49743 | -2.37 |
| MCOUNT | -0.00414 | 0.00185 | -2.23 |
| PIMPORT | 0.21944 | 0.05449 | 4.03 |
| PCDPI | 0.06606 | 0.01124 | 5.87 |
| SCLAND-SCEXP | -0.00131 | 0.00458 | -0.29 |
| DU10 | 0.05008 | 0.05106 | 0.98 |
| PCTLAND | -0.23569 | 0.08327 | -2.83 |

These numerical results should be interpreted with caution, however, since the analysis covers only 10 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.

### 1.1.3 Estimation of trip costs

### 1.1.4 Trip Costs

Data for variable costs, i.e., trip expenses include food, fuel, oil, ice, water and supplies and obtained from observer cost data for 1994-2008. The trip costs per day-at-sea (ffiwospda) is postulated to be a function of vessel crew size (CREW), vessel size in gross tons (GRT), fuel prices (FUELP), and dummy variables for trawl (TRW) and small dredge (DFT) vessels. This cost equation was assumed to take a double-logarithm form and estimated with data obtained from observer database. The empirical equation presented in Table 5 estimated more than 70% of the variation in trip costs and has proper statistical properties.

**Table 5. Estimation of total trip costs per DAS used**

The MODEL Procedure

Nonlinear GMM Summary of Residual Errors

| Equation | DF Model | DF Error | SSE | MSE | R-Square | Adj R-Sq | Durbin Watson |
|---|---|---|---|---|---|---|---|
| lnffiwospda | 6 | 206 | 24.9349 | 0.1210 | 0.7159 | 0.7090 | 1.8100 |

Nonlinear GMM Parameter Estimates

| Parameter | Estimate | Approx Std Err | t Value | Approx Pr > \|t\| |
|---|---|---|---|---|
| intc | 3.991271 | 0.3129 | 12.76 | <.0001 |
| grtco | 0.286919 | 0.0499 | 5.75 | <.0001 |
| crewco | 0.632637 | 0.1411 | 4.48 | <.0001 |
| dftco | -0.27828 | 0.0794 | -3.51 | 0.0006 |
| trwco | -0.39799 | 0.1559 | -2.55 | 0.0114 |
| fuelpco | 0.84357 | 0.0846 | 9.97 | <.0001 |

The result indicate that fuel prices have a significant impact on the trip costs. This model was estimated using for the limited access vessel data and characteristics and fuel prices for 2005 to 2008 (Table 6). Predicted costs differ from the actual costs because the actual costs are obtained form a small sample of vessels included in the observer data set, whereas predicted results are obtained from estimates for all vessels using the trip cost function in Table 5. The trips costs per day-at-sea increased a lot in 2008 because of the unusual increase in the average fuel prices in this year. For the purposes of the cost-benefit analyses, it is assumed that the average trip costs will be similar to the levels in 2007 rather than in 2008. The PPI for fuel and related products for 2009 for the months of January to November is about 10% lower than the levels in 2007, but given the recession the economy has experienced in 2009, these lower prices may not last either. For these reasons, for the purposes of the cost-benefit analyses it is assumed that the trip costs per day-at-sea will be closer to the 2007 levels rather than 2008 or 2009 levels, and will equal to $1600 for an average vessel in the fishery. Assuming a higher trip cost would increase the economic benefits of the proposed action as the sensitivity analyses below show.

**Table 6. Comparison of actual and estimated values for trip costs**

| | | Year | | | |
|---|---|---|---|---|---|
| | | 2005 | 2006 | 2007 | 2008 |
| Estimated trip costs per DAS | | 1483.39 | 1445.47 | 1603.01 | 1896.45 |
| Actual trip costs per DAS | | 1306.36 | 1672.22 | 1684.29 | 2094.69 |
| % Difference | | 15.46 | -8.16 | -2.48 | -1.94 |
| DAS per trip | | 11.29 | 9.36 | 11.00 | 10.50 |
| LPUE | Mean | 2143.67 | 1365.38 | 1229.04 | 1158.69 |
| Actual fuel costs per DAS | | 939.45 | 1265.24 | 1284.92 | 1703.74 |
| Estimated fuel costs per DAS | | 1034.55 | 1022.35 | 1182.27 | 1545.78 |
| % Difference | | 14.42 | -12.15 | -5.31 | -0.61 |
| Fuel price (06) | | 2.08 | 2.16 | 2.33 | 3.15 |
| GRT | Mean | 163.14 | 146.91 | 167.64 | 124.00 |
| HP | Mean | 857.00 | 897.55 | 1025.07 | 507.25 |
| LEN | Mean | 82.41 | 80.64 | 86.01 | 76.13 |
| Built | Mean | 1981.00 | 1989.18 | 1982.50 | 1976.25 |
| % Fuel | | 0.72 | 0.75 | 0.77 | 0.81 |
| % Fuel Predicted cpred | | 0.70 | 0.70 | 0.74 | 0.81 |
| N | | 7.00 | 11.00 | 14.00 | 4.00 |

## 1.1.5 Estimation of fixed costs

The fixed costs include those expenses that are not usually related to the level of fishing activity or output. These are insurance, maintenance, license, repairs, office expenses, professional fees, dues, taxes, utility, interest, communication costs, association fees and dock expenses. According to the observer data on fixed costs for the period 2001 to 2007, the fixed costs including maintenance, repairs, engine and gear replacement and hull and liability insurance averaged $162,000 per full-time vessel (Table 7). Table 8 shows that fixed costs of the vessels varies by the ton class and larger vessels have higher fixed costs than the smaller boats.

**Table 7. Annual fixed costs for full-time limited access scallop vessels by year (in 2006 inflation-adjusted prices and includes only those observations for insurance cost was available)**

| Data | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2001-2007 |
|---|---|---|---|---|---|---|---|---|
| Number of vessels | 7 | 20 | 36 | 50 | 40 | 24 | 39 | 216 |
| Maintenance ($) | 96,659 | 52,308 | 79,108 | 49,953 | 69,048 | 91,045 | 38,717 | 63,452 |
| Repairs and replacement ($) | 86,912 | 65,400 | 81,452 | 73,349 | 44,287 | 38,714 | 33,414 | 58,283 |
| Insurance ($) | 40,980 | 35,127 | 60,501 | 57,117 | 61,933 | 65,896 | 62,129 | 57,941 |
| Total fixed costs ($ ) | 224,552 | 141,719 | 206,304 | 155,711 | 159,542 | 171,252 | 122,631 | 161,819 |
| GRT | 148 | 156 | 157 | 156 | 156 | 144 | 150 | 153 |
| HP | 876 | 799 | 832 | 825 | 813 | 792 | 840 | 822 |

**Table 8. Annual fixed costs of full-time limited access scallop vessels by ton class (2006 inflation adjusted prices, including only those observations for which insurance data were available)**

| Data | 51-100 GRT | 101-150 GRT | >150 | Average (2001-07) |
|---|---|---|---|---|
| Number of vessels | 18 | 75 | 123 | 216 |
| GRT | 75 | 129 | 180 | 153 |
| HP | 461 | 690 | 957 | 822 |
| Maintenance ($) | 32,657 | 60,145 | 70,585 | 63,452 |
| Repairs ($) | 26,152 | 47,860 | 70,255 | 58,283 |
| Insurance ($) | 46,784 | 48,615 | 65,295 | 57,941 |
| Total fixed cost ($) | 100,780 | 142,482 | 182,652 | 161,819 |
| Ratio of fixed costs to the average for the fleet | 0.62 | 0.88 | 1.13 | 1.0 |

The 2006 and 2007 fixed cost survey data included other cost items such as office, accounting, and interest payments in addition to the repairs, maintenance and insurance. The model shown in Table 9 is based on the fixed cost survey data and estimates fixed costs as a function of length, year built, horse power and a dummy variable for boats that have multispecies permit. The data included 196 observations and the fixed costs are estimated by using the 97 observations for vessels with dredge and trawl gear. Because the data on communications costs and association fees were missing for most observations, these costs were not included in the estimation but their average values for the scallop vessels were deducted from the gross stock when estimating net boat and crew shares (Table 10).

**Table 9. Estimation of basic fixed costs**

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                              GMM with HCCME=1                                  235

                            The MODEL Procedure

                      Nonlinear GMM Summary of Residual Errors

                  DF      DF                                         Adj   Durbin
Equation       Model   Error        SSE        MSE  Root MSE  R-Square    R-Sq   Watson

lnfcbasic          5      92    15.8206     0.1720    0.4147    0.7283  0.7165   2.2736


                        Nonlinear GMM Parameter Estimates

                                        Approx                  Approx
            Parameter       Estimate      Std Err    t Value     Pr > |t|
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```
intc           -242.988     65.7063      -3.70       0.0004
lenco          1.588635      0.1986       8.00       <.0001
bltco          32.51993      8.6562       3.76       0.0003
d10co          -0.51566      0.1039      -4.96       <.0001
hpco           0.168211      0.1174       1.43       0.1554


     Number of Observations     Statistics for System

     Used               97    Objective        2.3E-18
```

**Table 10. Average association fee and communication costs by vessel size**

| | Average annual association fee | Average annual Communication Costs |
|---|---|---|
| All Vessels | 1610 | 3446 |
| Large (>=80 feet) | 1895 | 3939 |
| Medium (<80 feet) | 1459 | 3185 |

Using the survey cost data, total fixed costs are estimated to be $176,516 per full-time vessel in 2006 constant dollars and $188,343 in 2008 dollars (Table 11). These estimates exclude vessel improvement costs (other than repairs and maintenance) which could be considered as discretionary investment and could be postponed when there is a temporary shortfall in cash earnings.

**Table 11. Estimated fixed costs per full-time vessel**

| Data | 2007 | In 2008 Inflation adjusted prices |
|---|---:|---:|
| Estimated basic fixed costs | $176,516 | $188,342 |
| Improvement Costs (Difference) | $50,023 | $53,375 |

### 1.1.6 Profits and crew incomes

As it is well known, the net income and profits could be calculated in various ways depending on the accounting conventions applied to gross receipts and costs. The gross profit estimates used in the economic analyses in the FSEIS simply show the difference of gross revenue over variable (including the crew shares) and fixed expenses rather than corresponding to a specific accounting procedure. It is in some ways similar to the net income estimated from cash-flow statements since depreciation charges are not subtracted from income because they are not out-of-pocket expenses.

Gross profits per vessel are estimated as the boat share (after paying crew shares) minus the fixed expenses such as maintenance, repairs and insurance (hull and liability). Based on the input from the scallop industry members and Dan Georgianna on the lay system, the profits and crew incomes are estimated as follows:

- The association fees, communication costs and a captain bonus of 5% are deducted from the gross stock to obtain the net stock.

- Boat share is assumed to be 48% and the crew share is assumed to be 52% of the net stocks.
- Profits are estimated by deducting fixed costs from the boat share.
- Net crew income is estimated by deducting the trip costs from the crew shares.

### 1.1.7 Consumer surplus

Consumer surplus measures the area below the demand curve and above the equilibrium price. For simplicity, consumer surplus is estimated here by approximating the demand curve between the intercept and the estimated price with a linear line as follows:

CS= (PINT*SCLAN-EXPR*SCLAN)/2

$$PVCS = \sum_{t=2000}^{t=2008} (CS_t /(1+r)^t)$$

Where: r=Discount rate.

$CS_t$= Consumer surplus at year "t" in 1996 dollars.

PVCS= Present value of the consumer surplus in 1996 dollars.

EXPR= Ex-vessel price corresponding to landings for each policy option.
PINT=Price intercept i.e., estimated price when domestic landings are zero.
SCLAN= Sea scallop landings for each policy option.

Although this method may overestimate consumer surplus slightly, it does not affect the ranking of alternatives in terms of highest consumer benefits or net economic benefits.

### 1.1.8 Producer surplus

The producer surplus (PS) is defined as the area above the supply curve and the below the price line of the corresponding firm and industry (Just, Hueth & Schmitz (JHS)-1982). The supply curve in the short-run coincides with the short-run MC above the minimum average variable cost (for a competitive industry). This area between price and the supply curve can then be approximated by various methods depending on the shapes of the MC and AVC cost curves. The economic analysis presented in this section used the most straightforward approximation and estimated PS as the excess of total revenue (TR) over the total variable costs (TVC). It was assumed that the number of vessels and the fixed inputs would stay constant over the time period of analysis. In other words, the fixed costs were not deducted from the producer surplus since the producer surplus is equal to profits plus the rent to the fixed inputs. Here fixed costs include various costs associated with a vessel such as depreciation, interest, insurance, half of the repairs (other half was included in the variable costs), office expenses and so on. It is assumed that these costs will not change from one scenario to another.

PS=EXPR*SCLAN- ΣOPC
ΣOPC = Sum of operating costs for the fleet.

$$PVPS = \sum_{t=2000}^{t=2008} (PS_t / (1+r)^t)$$

Where: r=Discount rate.
$PS_t$= Producer surplus at year "t" in 1996 dollars.
PVPS= Present value of the producer surplus in 1996 dollars.
SCALN= Sea scallop landings for each policy option.
EXPR= Price of scallops at the ex-vessel level corresponding to landings for each policy option in 1996 dollars.

Producer Surplus also equals to sum of rent to vessels and rent to labor. Therefore, rent to vessels can be estimated as:

RENTVES=PS – CREWSH

Rentves= Quasi rent to vessels
Crewsh= Crew Shares

### 1.1.9 Total economic benefits

Total economic benefits (TOTBEN) is estimated as a sum of producer and consumer surpluses and its value net of status quo is employed to measure the impact of the management alternatives on the national economy.

TOTBEN=PS+CS

Present value of the total benefits= PVTOTBEN= PVPS+PVCS

## 1.2 SENSITIVITY ANALYSES

The numerical estimates of the revenues, costs and benefits provided in Section 5.4.2 of the Framework 21 document should be used in comparing one option with another rather than is predicting the future values of the economic variables. The absolute values of the net economic benefits and its components would change if the actual landings, size composition of landings and LPUE are different than the forecasted values from the biological model.

The prices are estimated using the updated ex-vessel price model described in Section 1.1.2 above. This model takes into account the impacts of changes in meat count, domestic landings, exports, price of imports, income of consumers, and composition of landings by market category (i.e., size of scallops) including a price premium on under count 10 scallops. The important changes in these external factors, i.e., in exports, imports, value of dollar, export and import prices, and changes in disposable income will result in actual prices differing from the estimated prices. Section 5.4.8 of the Framework 21 document provided a sensitivity analysis using a 10% decline in the import prices. The results of this analyses showed that the e-vessel prices would decline in about the same proportion to the change in import prices. Lower prices would reduce the negative impact of the proposed action in the short-run, in 2010. But the proposed action was still estimated to increase scallop fleet revenue both in the medium term from 2010-2016 and the long-term from 2010 to 2023. Similarly, the ranking of the alternatives in terms of the cumulative present value of the revenues, producer surplus, consumer surplus and total economic benefits compared to no action is not expected to change when lower prices are used to estimate the economic impacts. Furthermore, the percentage difference of the revenues, producer surplus, consumer surplus and total economic benefits compared to no action would stay almost exactly the same whether lower or higher price estimates are used in the analysis. Therefore, the results of the cost-benefit analyses of the proposed action and the alternatives do not change when the economic benefits are compared to the no action levels and in terms of ranking of the alternatives, the results are not sensitive to the values of price estimates obtained from the same price model, but using a different value for the import prices.

In addition to the change in the values of the exogenous variables, the estimates for landings and prices are subject to statistical errors and variability. If the standard deviations in various variables and coefficients are taken into account, the range of values for revenues, consumer and producer surpluses and net economic benefits will fall within a confidence interval around the mean values. The ranking of the options in terms of their net economic benefits relative to each other are likely to stay the same, however, since statistical errors and variability would impact the no action and the proposed alternatives in the roughly same proportions. For example, a lower bound using 95% confidence interval estimate for the coefficient of the domestic consumption variable resulted in prices within a range of $6 or lower (Table 12). Assuming that the domestic landings has no impact on prices (given that t-value for the coefficient is still low) resulted in prices within a range of $7.30 to $7.50 (Table 14). Although the net economic benefits are lower (higher) prices, the proposed action was still estimated to increase scallop fleet revenue both in the medium term from 2010-2016 and the long-term from 2010 to 2023. Similarly, the ranking of the alternatives in terms of the cumulative present value of the revenues, producer surplus, consumer surplus and total economic benefits compared to no action did not change when lower (higher) prices are used to estimate the economic impacts (Table 13 and Table 15).

**Table 12. Estimated Prices, lower bound for a 95% confidence interval (estimate in inflation adjusted 2008 prices)**

| Fishing Year | No Action | No Closure $F$ = 0.20 (Status Quo) | No Closure $F$ = 0.24 | Closure $F$ = 0.20 | Closure $F$ = 0.18 |
|---|---|---|---|---|---|
| 2010 | 5.8 | 6.2 | 6.0 | 5.7 | 5.9 |
| 2011 | 5.5 | 5.4 | 5.4 | 5.5 | 5.5 |
| 2012 | 5.3 | 5.2 | 5.2 | 5.5 | 5.4 |
| 2013 | 5.4 | 5.3 | 5.4 | 5.3 | 5.3 |
| 2014 | 5.4 | 5.3 | 5.4 | 5.3 | 5.2 |
| 2015 | 5.4 | 5.4 | 5.5 | 5.4 | 5.3 |
| 2016 | 5.6 | 5.6 | 5.6 | 5.5 | 5.5 |
| 2017 | 5.5 | 5.5 | 5.5 | 5.5 | 5.5 |
| 2018 | 5.6 | 5.5 | 5.5 | 5.6 | 5.5 |
| 2019 | 5.8 | 5.7 | 5.7 | 5.8 | 5.7 |
| 2020 | 5.7 | 5.6 | 5.6 | 5.6 | 5.6 |
| 2021 | 5.7 | 5.6 | 5.6 | 5.6 | 5.6 |
| 2022 | 5.8 | 5.7 | 5.8 | 5.7 | 5.8 |
| 2023 | 5.6 | 5.6 | 5.6 | 5.6 | 5.6 |

Note: Projections assume that import prices will equal to $4 per pound of scallops and that scallop exports constitute 45% of the domestic landings.

**Table 13. Short and long-term cumulative present value of benefits using lower bound for prices (Million $, in 2008 inflation-adjusted prices, discount rate of 3%**

| Period | Data | No Closure $F$ = 0.20 (Status Quo) | No Closure $F$ = 0.24 | Closure $F$ = 0.20 | Closure $F$ = 0.18 |
|---|---|---|---|---|---|
| 2010-2016 | PV of Revenues | 2.5 | -5.8 | -4.3 | 21.2 |
| | PV of Producer Surplus | 6.1 | -2.0 | -8.1 | 15.0 |
| | PV of Consumer Surplus | 6.9 | -0.2 | -0.6 | 11.0 |
| | PV of Total Economic Benefits | 13.0 | -2.2 | -8.7 | 26.0 |
| 2010-2023 | PV of Revenues | 59.2 | 51.8 | 33.7 | 56.4 |
| | PV of Producer Surplus | 48.3 | 41.4 | 27.3 | 46.3 |
| | PV of Consumer Surplus | 22.3 | 15.9 | 10.6 | 16.9 |
| | PV of Total Economic Benefits | 70.6 | 57.3 | 37.9 | 63.1 |
| 2010-2023 | PV of Revenues | 61.6 | 45.9 | 29.4 | 77.6 |
| | PV of Producer Surplus | 54.4 | 39.3 | 19.2 | 61.3 |
| | PV of Consumer Surplus | 29.2 | 15.8 | 10.0 | 27.9 |
| | PV of Total Economic Benefits | 83.6 | 55.1 | 29.2 | 89.2 |

**Table 14. Estimated Prices, assuming a “0” value for the coefficient of domestic consumption (estimate in inflation adjusted 2008 prices)**

| Fishing Year | No Action | No Closure $F = 0.20$ (Status Quo) | No Closure $F = 0.24$ | Closure $F = 0.20$ | Closure $F = 0.18$ |
|---|---|---|---|---|---|
| 2010 | 7.32 | 7.53 | 7.52 | 7.45 | 7.46 |
| 2011 | 7.35 | 7.30 | 7.30 | 7.32 | 7.31 |
| 2012 | 7.26 | 7.24 | 7.22 | 7.34 | 7.32 |
| 2013 | 7.37 | 7.33 | 7.31 | 7.28 | 7.25 |
| 2014 | 7.42 | 7.39 | 7.39 | 7.35 | 7.33 |
| 2015 | 7.45 | 7.44 | 7.45 | 7.41 | 7.43 |
| 2016 | 7.50 | 7.49 | 7.49 | 7.48 | 7.50 |
| 2017 | 7.54 | 7.52 | 7.52 | 7.53 | 7.52 |
| 2018 | 7.57 | 7.56 | 7.56 | 7.57 | 7.57 |
| 2019 | 7.56 | 7.56 | 7.56 | 7.56 | 7.56 |
| 2020 | 7.61 | 7.60 | 7.61 | 7.59 | 7.62 |
| 2021 | 7.63 | 7.62 | 7.64 | 7.62 | 7.65 |
| 2022 | 7.58 | 7.58 | 7.58 | 7.57 | 7.57 |
| 2023 | 7.65 | 7.65 | 7.64 | 7.63 | 7.64 |

Note: Projections assume that import prices will equal to $4 per pound of scallops and that scallop exports constitute 45% of the domestic landings.

**Table 15. Short and long-term cumulative present value of benefits using assuming a “0” value for the coefficient of domestic consumption (Million $, in 2008 inflation-adjusted prices, discount rate of 3%**

| Period | Data | No Closure $F = 0.20$ (Status Quo) | No Closure $F = 0.24$ | Closure $F = 0.20$ | Closure $F = 0.18$ |
|---|---|---|---|---|---|
| 2010-2016 | PV of Revenues | 17.3 | -9.9 | -10.8 | 45.4 |
| | PV of Producer Surplus | 21.0 | -6.1 | -14.6 | 39.2 |
| | PV of Consumer Surplus | 2.8 | 0.9 | 1.2 | 4.4 |
| | PV of Total Economic Benefits | 23.8 | -5.1 | -13.4 | 43.6 |
| 2010-2023 | PV of Revenues | 113.7 | 99.0 | 64.7 | 107.5 |
| | PV of Producer Surplus | 102.8 | 88.6 | 58.3 | 97.4 |
| | PV of Consumer Surplus | 7.3 | 3.0 | 2.0 | 2.8 |
| | PV of Total Economic Benefits | 110.1 | 91.5 | 60.4 | 100.2 |
| 2010-2023 | PV of Revenues | 131.0 | 89.1 | 53.9 | 152.9 |
| | PV of Producer Surplus | 123.8 | 82.5 | 43.7 | 136.6 |
| | PV of Consumer Surplus | 10.2 | 3.9 | 3.2 | 7.2 |
| | PV of Total Economic Benefits | 133.9 | 86.4 | 46.9 | 143.8 |

The absolute value of the net benefits would change also if the disposable income increased during the future years. If it was assumed, as an example, the disposable income per capita will increase at an average of 3% rate per year, the ex-vessel prices would increase under all options, increasing the value of total net benefits. Because those options with lower fishing mortality result in higher yield compared to others, the economic benefits associated with the proposed action would increase slightly relative the options that result in higher landings in the short-term but lower landings in the long-term. The reverse would happen if disposable income declined by 3% over the same period. Even under this unlikely scenario, however, more conservative options would result in larger net economic benefits compared to the other alternatives. In general, however, the percentage differences in net benefits one option versus another is not expected change in any significant way by changes in prices.

The change in the fishing costs would also impact the absolute values of economic benefits compared to no action values. For example, higher fuel prices would increase the trip costs per day-at-sea and increase the cost savings from the proposed action and other alternatives that have lower DAS and trip allocations compared to the no action. As a result, the net economic benefits of the proposed action relative to no action and other alternatives would increase especially in the short-term. Table 16 shows provides a sensitivity analysis by assuming a 10% increase in the trip costs. A decline in fishing cost, will result in opposite effect because it would reduce the impacts of fishing costs in overall benefits.

**Table 16. Short and long-term cumulative present value of benefits using assuming a 10% increase in trip costs (Million $, in 2008 inflation-adjusted prices, discount rate of 3%**

| Period | Data | No Closure $F = 0.20$ (Status Quo) | No Closure $F = 0.24$ | Closure $F = 0.20$ | Closure $F = 0.18$ |
|---|---|---|---|---|---|
| 2010-2016 | PV of Revenues | 14 | -9 | -10 | 41 |
| | PV of Producer Surplus | 18 | -5 | -14 | 34 |
| | PV of Consumer Surplus | 4 | 1 | 1 | 6 |
| | PV of Total Economic Benefits | 22 | -4 | -13 | 40 |
| 2010-2023 | PV of Revenues | 104 | 91 | 59 | 98 |
| | PV of Producer Surplus | 92 | 79 | 52 | 87 |
| | PV of Consumer Surplus | 10 | 5 | 4 | 5 |
| | PV of Total Economic Benefits | 102 | 84 | 56 | 93 |
| 2010-2023 | PV of Revenues | 118 | 81 | 50 | 139 |
| | PV of Producer Surplus | 110 | 74 | 38 | 121 |
| | PV of Consumer Surplus | 14 | 6 | 4 | 11 |
| | PV of Total Economic Benefits | 124 | 80 | 43 | 132 |

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