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Economic Analysis of Alternative Harvest Strategies for Eastern Georges Bank Haddock [5Zjm; 551, 552, 561, 562]

by

**Eric M. Thunberg, Doreen S.K. Liew,
Charles M. Fulcher, and Jon K.T. Brodziak**

October 2005

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Executive Summary

This report examines the potential economic benefits of pursuing alternative harvest strategies for the Eastern Georges Bank haddock resource. Pursuit of this line of inquiry was prompted by the potential market impacts of the size of the 2003 year class of haddock; once thought to be 900 million fish but now assessed at 365 million age-1 fish. Even at this smaller size, the 2003 year class is large enough to have a material affect on haddock markets.

Estimation of economic effects on ex-vessel prices to United States and Canadian fishermen and effects on import quantities and prices was accomplished by applying an econometric model to projected landings under four alternative harvest strategies for Eastern Georges Bank haddock; constant catch of 30,000 mt, constant catch of 40,000 mt, constant catch of 50,000 mt, and constant fishing at $F_{Ref} = 0.26$. The econometric model was estimated using monthly data from 1989 to 2003 and was based on processor raw material demand for fresh whole haddock.

Per guidance provided by the TRAC, projections of Eastern Georges Bank haddock landings were accomplished a using a stochastic approach. Specifically, realizations of recruitment were generated using two-stanza re-sampling from the empirical cumulative distribution functions below and above approximately 40,000 mt adult (ages 3+) biomass. Mean weights at age and partial recruitment were based on the most recent 3-year averages. Landings from the Western Georges Bank were calculated by subtracting projected Eastern Georges Bank haddock landings from landings projected for the entire stock area (Eastern and Western areas). The latter used stochastic projection methods based on advice from the Groundfish Assessment Review Meeting held in Woods Hole in August, 2005. Landings from non-Georges Bank sources of haddock were held constant at their most recent 3-year average.

The 30,000 mt constant catch strategy would be first achieved in 2007 and would be maintained through 2014. The 40,000 mt constant catch strategy would be first achieved in 2007 and would continue through 2012. The 50,000 mt constant catch strategy would be reached in 2007 and could be maintained through 2009. Of these strategies, harvesting at a constant F_{Ref} produced the highest present value of ex-vessel revenues in both the United States and in Canada and produced the highest present value of import sales of haddock from Canada to the United States. This finding was robust with respect to the choice of discount rate and assumed weights-at-age. Taking uncertainty over projected landings into account, also favored the constant F_{Ref} strategy as it more readily takes advantage of future recruitment events.

Of the alternative constant catch strategies evaluated herein the 50,000 mt constant catch strategy came closest to the revenue streams predicted for the constant F_{Ref} strategy. In fact, the projected landings between the two harvest strategies were quite similar since harvest at 50,000 mt would be sustained for only three years and there were only minor differences in accumulated benefit streams.

1. INTRODUCTION

This report examines the potential economic benefits of pursuing alternative harvest strategies for the Eastern Georges Bank haddock resource. Pursuit of this line of inquiry was prompted by the potential market impacts of the size of the 2003 year class of haddock; once thought to be 900 million fish but now assessed at 365 million age-1 fish. Even at this smaller size, the 2003 year class is still considered to be very large. A harvest strategy that differs from that of current recommendations would have market effects on ex-vessel markets in both the United States and Canada and would affect trade in haddock products between the two countries.

In this report, we evaluate the impact of alternative harvest strategies for the Eastern Georges Bank haddock resource on ex-vessel prices in the United States and in Canada, and estimate how these changes would affect prices and import quantities of fresh whole haddock from Canada. The first section of the report provides an overview of global haddock supplies and the role of U.S. and Canadian haddock in domestic as well as international markets. The second section describes an econometric model developed to forecast how changes in haddock supplies affect import sales and revenues received by Canadian and U.S. vessels. The third section contains a discussion of several key assumptions and briefly describes how the econometric model was applied to a series of projected landings streams provided per guidance from the TRAC. The fourth section presents economic forecasts for four different harvest strategies; constant fishing mortality ($F_{Ref} = F_{MSY} = 0.26$) and constant harvests of 30,000, 40,000, and 50,000 mt. Sensitivity analyses of the selected discount rate, the likelihood of achieving the highest benefit stream, and the effect of different average weights-at-age are presented in a fifth section. A final section provides conclusions, and discusses factors that were not possible to quantify yet may affect the economic impacts of a change in harvest strategy.

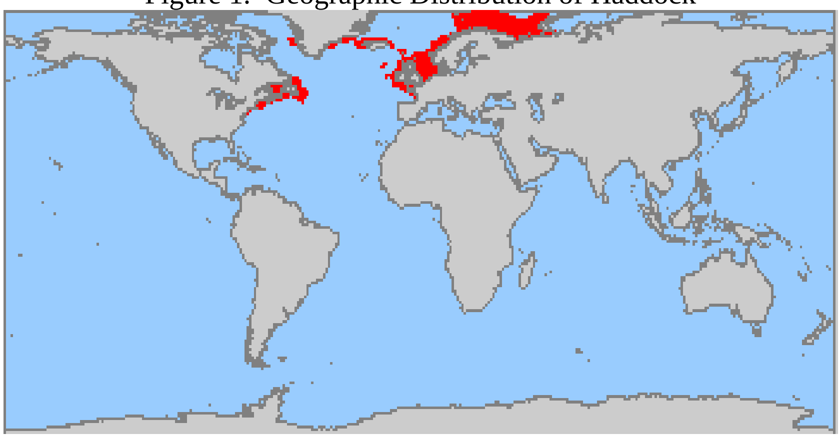
The landings streams produced under TRAC guidance for the purposes of this report were developed using a stochastic projection method. As such, the landings reported herein differ from those provided in the TRAC Status Report 2005/02. The TRAC used the stochastic projection method due to uncertainty over whether, and for how long, a given stream of constant harvest levels could be realized. A stochastic approach is better suited to this line of inquiry and has been used for exploratory purposes where a change in harvest strategy is being considered. The projected landings serve the purpose of providing input data only for the economic analysis (which itself is exploratory) and should not be used for purposes of quota setting. Additionally, where projections of landings were made (Eastern and Western Georges Bank resource areas) they were based on what would be allowable given the harvest strategy and prevailing resource conditions.

2. GLOBAL HADDOCK SUPPLY OVERVIEW

2.1 World Haddock Landings

There are two major haddock fishing regions in the world, the Northeast Atlantic/Arctic and the Northwest Atlantic (shaded red areas in Figure 1). In the Northeast Atlantic/Arctic, the main fishing areas are the Barents Sea, the Norwegian Sea, the North Sea, and the waters around Iceland, the Faroe Islands, and west of Scotland. In the Northwest Atlantic, the main fishing areas are on the Scotia Shelf (NAFO Areas 4TVW and 4X), Gulf of Maine (NAFO Area 5Y) Georges Bank (5ZE) and the Eastern United States.

Figure 1. Geographic Distribution of Haddock



Source: FAO – Fisheries Global Information System (FIGIS)

The Northeast Atlantic/Arctic region has accounted for over 90% of the world haddock landings in recent years. In 2003, landings from the Northeast Atlantic/Arctic totalled about 252,000 mt (Table 1). This compares to about 23,000 mt caught from the Northwest Atlantic. World landings from 1950-2003 have ranged from a low of 190,000 mt (in 1992) to a high of 960,000 mt (in 1970), and averaged 427,000 mt (Figure 2). In 2003, landings of 275,200 mt were about 64% of the long term average.

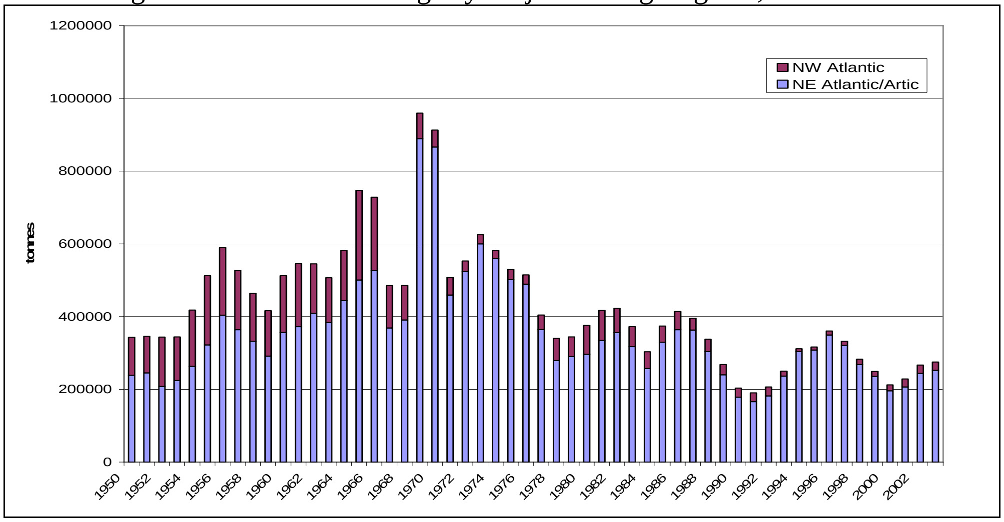
Table 1: Haddock Landings by Fishing Area, 2001-2003 (mt)

Region	2001	2002	2003
Northeast Atlantic/Arctic			
Barents Sea (I)	35,071	40,559	53,124
Norwegian Sea (IIa)	39,449	30,630	36,124
Spitzbergen/Bear Island (IIb)	7,323	12,537	7,743
Skagerrak/Kattegat (IIIa)	2,121	4,194	1,808
North Sea (IV)	46,837	56,328	43,428
Iceland (Va)	39,647	50,469	60,884
Faroes (Vb)	16,530	25,131	26,865
West of Scotland (VIa)	6,432	7,073	5,776
Rockall (VIb)	2,036	3,123	6,055
Irish Sea (VIIa)	1,380	2,498	1,972
Celtic Sea & West of Ireland (VIIb-k)	8,746	6,813	7,804
Total Northeast Atlantic/Arctic[1]	**205,572**	**239,355**	**251,583**
Northwest Atlantic			
Canada: 4TVW+4X5Y	8,819	8,480	8,982
Canada: Georges Bank	6,774	6,489	6,789
Canada: Total[2]	15,593	14,969	15,771
U.S: Eastern Georges Bank	608	916	1,563
U.S.: Western Georges Bank	4,022	5,414	4,001
U.S: Gulf of Maine	1,196	1,211	1,221
U.S: Total[3]	5,826	7,541	6,785
Other Countries[4]	134	329	418
Total Northwest Atlantic	**21,553**	**22,839**	**22,974**
GRAND TOTAL	**227,125**	**262,194**	**274,557**

1. Source: ICES Advice 2004, ACFM/ACE Report. Stock descriptions in parenthesis are ICES Fishing Areas.
2. Source: DFO Statistics.
3. Source: National Marine Fisheries Service (NMFS).
4. Source: FAO

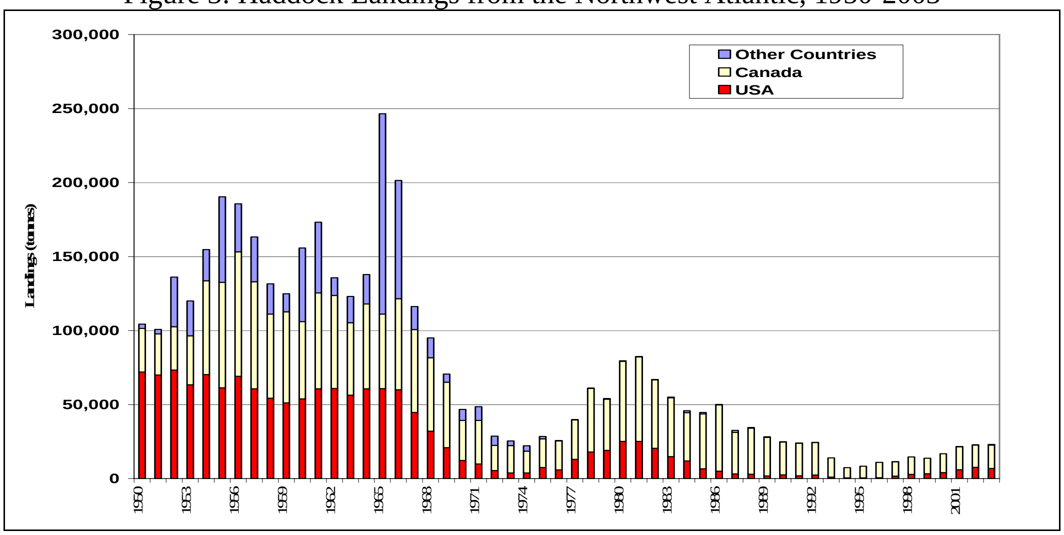
Until the mid- 1960's, total landings from the Northwest Atlantic area were in the 100,000 to 200,000 mt range, and reached a high of 246,000 in 1965 (Figure 3). Since then, landings have been significantly lower and fell to a record-low of 7,300 mt in 1994. Landings in 2003 were about 23,000 mt.

Figure 2: Haddock Landings by Major Fishing Regions, 1950-2003



Source: FAO

Figure 3: Haddock Landings from the Northwest Atlantic, 1950-2003



Source: FAO

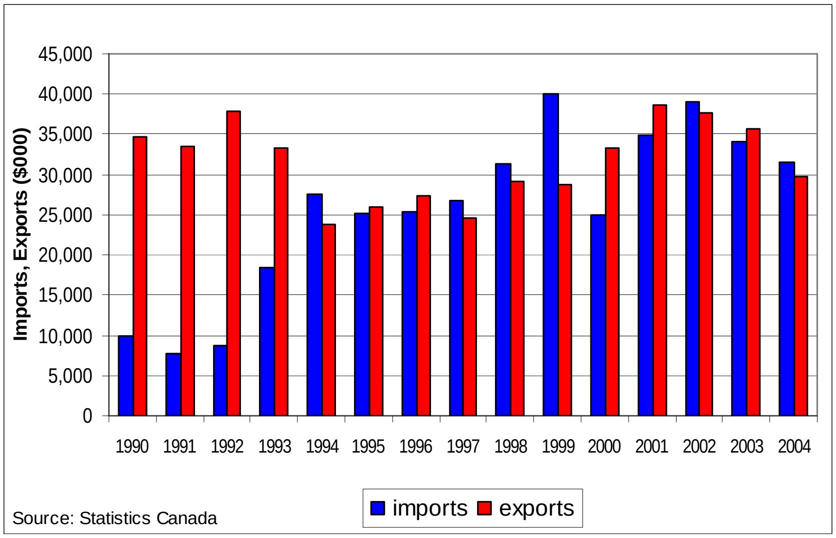
2.2 United States – Canada Haddock Markets

Currently, haddock landings from the Northwest Atlantic are mainly sold in the New England states and in Canada. In addition, landings from the Northeast Atlantic/Arctic are imported, making Canada and U.S. collectively a net importer of primary haddock products. Primary products in this context includes fresh or frozen whole or dressed fish, fillets or blocks and also salted or dried haddock.

Canada

Since 1994, Canada imports as much as it exports of primary haddock products, measured in dollar value (Figure 4). Imports are mostly frozen fillets and to a lesser extent, frozen whole fish. Exports are mainly fresh whole dressed fish. In 2003, Canada imported the equivalent of about 18,100 mt of haddock in round weight, while it exported the equivalent of about 12,500 mt, and thus was a net importer of primary haddock products. Estimated Canadian "consumption" of primary haddock products in 2003 was about 21,300 mt (landings of 15,700 mt plus net imports of 5,600 mt). Note that "consumption" here is of primary haddock product forms. Some of the primary products may have been sold directly to consumers or to processors to be further processed and exported. The flow of the secondary product is not traced here.

Figure 4: Haddock Imports and Exports, Canada (C$000), 1990-2004



Canada imports mainly from the United Kingdom, Norway, Russia and China. Since 2000, China has emerged as a major player in imports of processed haddock products to Canada. In 1999, there were hardly any haddock imports from China. In 2000, it accounted for 14% of the haddock import value, and by 2003, that percentage had risen to 60%. These fish are predominantly imported in a frozen fillet form, but the country/countries of origin for the raw material supporting China's exports are not known. Almost all of Canada's haddock exports are to the U.S. Table 2 shows the imports and exports of haddock by country.

Table 2: Canadian and U.S. Haddock Imports and Exports, 2003 (US $1,000)

Exports From	Imports By			
	Canada	United States[2]	Other Countries	Total
Canada		24,605	23	24,628
United States	555[1]		64	615
Iceland	209	43,542	n/a	
Norway	2,649	14,808	n/a	
Faroes Islands	0	5,768	n/a	
United Kingdom	2,766	77	n/a	
Russia	1,837	2,944	n/a	
China	14,496	1,641	n/a	
Others	1,765	689	n/a	
Total	24,273	94,074		

1. Figure on imports into Canada from the U.S. was from Statistics Canada, converted to US$.
2. Source: National Marine Fisheries Service (NMFS)

United States

The United States is a net importer of primary haddock products and exports very little. Total imports in 2003 were about US$94.1 million, of which US$24.6 million were from Canada (Table 2).

Imports consist of fresh and frozen fillets, and also fresh and frozen whole fish. The U.S. imports the equivalent of about 52,000 mt of round fish while exports are negligible. U.S. landings of 6,800 mt plus the net imports of 52,000 mt puts the U.S. “consumption” at about 58,800 mt in 2003.

The U.S. imports mainly from Iceland, Canada and Norway. Canada supplies mostly fresh whole fish while Iceland supplies mainly fresh and frozen fillets. The 2003 value of U.S. imports by country and product form are tabulated in Table 3.

Table 3: United States Imports of Haddock Products by Country, 2003 (US$1,000)

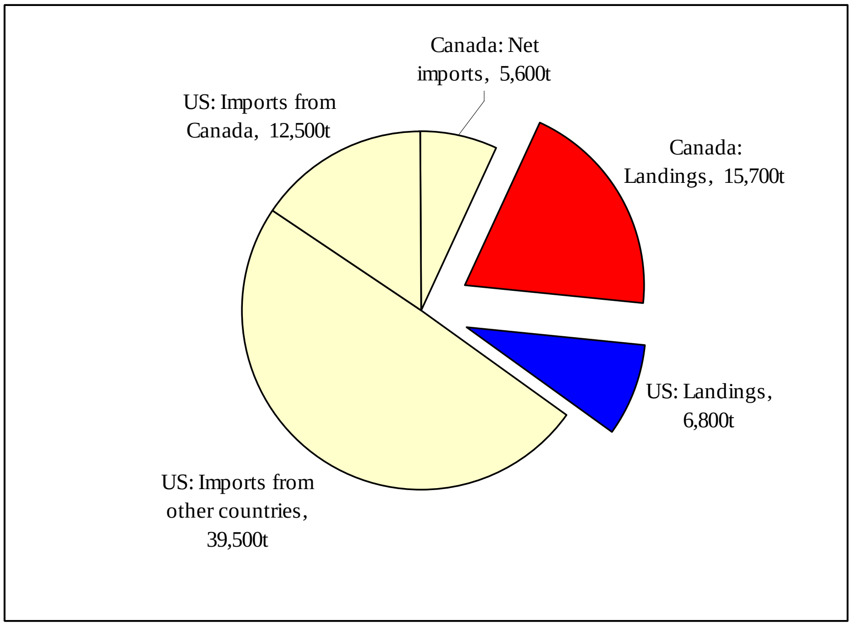
COUNRTY	Fresh			Frozen					Total	% of Total
	Fresh	Fresh Fillets	Total	Frozen Fillets Blocks	Frozen Fillets	Frozen	Frozen Meat	Total		
Canada	22,050	1,747	23,797	112	616	77	3	808	24,605	26.2
China				1,570		71		1,641	1,641	1.7
Denmark					531			531	531	0.6
Faroes Is.				911	4,619	201	37	5,768	5,768	6.1
Finland		9	9						9	0.0
Iceland	9	12,670	12,679	1,847	27,792	7	1,217	30,863	43,542	46.3
Norway		4	4	854	7,339	6,611		14,804	14,808	15.7
Poland				78				78	78	0.1
Portugal				38				38	38	0.0
Russia				634	2,180	130		2,944	2,944	3.1
South Korea					8			8	8	0.0
St.Pierre&Miquelon				13	10			23	23	0.0
United Kingdom					77			77	77	0.1
Total	22,059	14,430	36,489	6,057	43,172	7,097	1,257	57,583	94,072	100.0[1]
% Share	23.5	15.3	38.8	6.4	45.9	7.5	1.3	61.2	100.0	

1 Percentages do not sum to 100% due to rounding.
Source: National Marine Fisheries Service (NMFS)

Overall size of the United States – Canada Market

The estimated overall size of the United States - Canada market was the equivalent of about 80,100 mt of round haddock in 2003. Of these, landings from the Northwest Atlantic were 22,556 mt (Canada, 15,771 mt and U.S., 6,785 mt). Landings from the Northwest Atlantic account for only 28% of the total Canadian and U.S. "consumption" of primary haddock products. This leaves net imports of about 72% or the equivalent of 57,600 mt of round fish from the landings of the Northeast Atlantic/Arctic to supply the overall United States - Canada market. Figure 5 shows the relative sizes of the Canadian and U.S. market. The total area shaded in yellow shows the estimated amount of haddock imported into the combined Canadian and U.S. market.

Figure 5: Estimated United States - Canada Haddock Market Size, 2003



2.3 Resource Outlook

The major stock areas in the Northeast Atlantic/Arctic in 2003 are Iceland (comprising of 24% of total landings), Barents Sea (21%), North Sea (17%), Norwegian Sea (14%) and Faroe Islands (11%). Outlook for 2006 for some of the major stock areas are presented in Table 4. It appears that the only major stock area in the Northeast Atlantic/Arctic with a predicted increase in catches in 2006 is Iceland. This is somewhat offset by the slight declines in the Barents Sea, Norwegian Sea and Faroe Islands. Predicted allowable catches of haddock from the Western Georges Bank area in the U.S. are greater than the proposed TAC for the Eastern Georges Bank area. However, just as U.S. landings from the Eastern Georges Bank area have been well below allowable TACs due to management actions taken to protect other groundfish species in the U.S. EEZ, realized landings from the Western Georges Bank area are likely to be well below allowable levels.

Table 4: Haddock TACs and Predicted Catches of Selected Stocks, 2004-2006 (mt)

	TAC 2004	TAC 2005	Predicted Allowable Catch 2006
Northeast Atlantic/Arctic[1]			
Barents Sea, Norweigian Sea & Spitzbergen (I, IIa & IIb)	130,000	117,000	< 112,000
North Sea (IV)[2]	77,000	66,000	n.a.
Iceland (Va)	75,000	90,000	< 110,000
Faroe (Vb)[3]	21,000	19,000	18,000
Northwest Atlantic[4]			
Eastern Georges Bank	15,000	23,000	22,000
Canada: 4VW+4X5Y	10,000	8,000	n.a.
U.S.: Western Georges Bank	n.a.[5]	n.a.	23,000[6]

1. Source: ICES Advice 2005.
2. Source: Aberdeenshire Council Fisheries Statistics: TACs and Quotas 2005, June 2005.
3. TACs not available, figures are predicted catches.
4. Sources: DFO, NMFS and TRAC Status Reports.
5. Not applicable because the U.S. does not set TACs by area.
6. Preliminary projections based on advice from the Groundfish Assessment Review Meeting August, 2005

3. UNITED STATES – CANADA HADDOCK MARKET ECONOMETRIC MODEL

3.1 Modeling Considerations

The economic implications of a change in haddock harvest strategy will depend on how international markets adjust to the change and how these adjustments are transmitted through the marketing chain to prices received in ex-vessel markets. Although no known studies of international markets for haddock have been conducted, available studies (Gordon and Hannesson 1996; Asche and Hannesson, 2002) of the cod market suggest that linkages between North American (United States and Canada) and European markets exist, but they are weak, while links within the two regional markets are strong. This means that the North American market for cod can be modeled separately from the European market and we assume that the same is likely to be true for haddock.

In developing a model of haddock markets between the United States and Canada, the own-price elasticity of demand measures how haddock price will respond to changes in quantities. If haddock demand is inelastic, then a proportional change in price will exceed an equi-proportional change in quantity and total revenues will go down. Conversely, total revenues will go up if haddock demand is elastic since a proportional change in price will be less than an equi-proportional change in quantity.

Modeling the United States and Canadian trade in groundfish products received considerable attention during the early to mid- 1980's as United States harvesters argued that Canadian imports were driving down ex-vessel prices. Given time constraints, an exhaustive review of this literature was not possible. Nevertheless, citations to many of these studies contained in both

Felixson, Allen, and Storey (1987) and Hogan and Georgianna (1989) indicate that past modeling efforts have developed a system of equations to reflect supply and demand relationships at different market levels including imports, but focused on undifferentiated groundfish. Further, most of the cited econometric models focused only on processed products (fresh or frozen filets or frozen blocks).

Based on data presented in Section 2, the United States domestic market is assumed to be the primary market for domestic landings and for imported haddock from Canada, Iceland, and Norway. In evaluating the economic effect of different harvest strategies for haddock, the market of most interest is a raw material market. In effect, this market is a derived demand by United States processors for factor inputs. Within this context, it is important to determine the substitutability between domestic and imported whole haddock (fresh or frozen) and the impact that market substitution has on United States and Canadian ex-vessel prices. If United States processors substitute domestic landings for imported haddock, then an increase in United States landings would reduce the quantity demanded for Canadian raw material imports. Ex-vessel prices in both the United States and Canada would be expected to decline, but Canadian ex-vessel price may decline proportionally more due to the lowered demand for raw material imports.

The empirical model developed for this study was adapted from that of Hogan and Georgianna (1989). These authors estimated separate models for combined haddock and cod and for flatfish consisting of a three-equation system including import demand, import supply, and United States ex-vessel price. We made several modifications to Hogan and Georgianna's original model to include a price equation for Canadian ex-vessel prices and to accommodate estimation issues encountered in developing a haddock-only model.

3.1 Econometric Model of the United States – Canada Haddock Market

Demand for Fresh Whole Canadian Imports

Processor demand for whole haddock imports was modeled as a function of the price of fresh whole haddock imports from Canada, the United States ex-vessel price of haddock lagged one period, the ex-vessel price of cod, United States domestic haddock landings, and a time trend.

The import price is expected to be negatively related to quantity demanded; as import prices go up, processor quantities demanded go down. The U.S. ex-vessel price of haddock is expected to be positively related to import demand; as domestic prices of haddock increase, processors substitute imports resulting in higher import demand. Note that our specification of the ex-vessel price variable in lagged form differs from that of Hogan and Georgianna. Although the demand equation was initially specified with the current U.S. ex-vessel price (as done by Hogan and Georgianna), it was not significant, whereas the lagged price was. The lagged price is likely reflective of some underlying adjustment process perhaps due to contractual obligations.

The ex-vessel price of cod is included to reflect demand for processed products and is a substitute for fresh whole haddock. The price of cod is expected to be positively related to import quantities; as the price of cod increases processors substitute away from cod to haddock increasing the demand for raw material imports.

Import demand is expected to be negatively related to the quantities of haddock landed by U.S. vessels; as available domestic landings go up, processors substitute away from imported haddock. Note that this variable also differs from that of Hogan and Georgianna. In their study, Hogan and Georgianna measure the substitution effect by constructing a measure of excess capacity. Implicit in their specification is the assumption that processors prefer domestic sources of haddock, importing only when domestic landings are insufficient to meet raw material requirements. In our study we make no assumptions as to the desirability of U.S. or imported haddock. Further, since the excess capacity variable in Hogan and Georgianna's model was defined as the difference between capacity (measured using a modified peak-to-peak method) and U.S. landings, our specification should detect the same general effect. The expected sign for the time trend is indeterminate.

Supply of Fresh Whole Canadian Imports

Canadian fresh whole supply was specified as a function of fresh whole import price, Canadian haddock landings, Canadian haddock landings lagged one period, and the price of alternative product forms (frozen blocks and fresh and frozen filets). Import supply is expected to be positively related to import price as well as the quantity of Canadian landings. The sign of Canadian landings lagged one period is indeterminate but was included to reflect the possible presence of an adjustment process.

In Hogan and Georgianna's model, Canadian importers were assumed to have a number of alternative markets for cod and haddock products. To reflect these alternatives they included a separate price series for each product form: frozen blocks, fresh filets, and frozen filets. Following Hogan and Georgianna, a haddock-only price series for each product was constructed from import data but none of these variables were found to be statistically significant. Further, there were a number of occasions where imported quantities were zero in a given month. Therefore, we estimated a price series based on a weighted average for all product forms and used this to capture the potential diversion of whole fresh haddock into products processed in Canada. The expected sign for this variable is negative; as the price of alternative products increases, Canadian exports of fresh whole haddock decreases.

United States Ex-Vessel Price

The U.S. ex-vessel price was specified as a function of the quantity of fresh whole imports, the quantity of U.S. landings, the ex-vessel price of cod, and the ex-vessel price of haddock lagged one period. Import quantity is expected to have a negative effect on U.S. ex-vessel price; as processors import more raw materials, the demand for U.S. raw material declines and ex-vessel prices decline. Ex-vessel price is expected to be negatively related to domestic landings; as landings increase, market-clearing prices decline. The expected sign of the ex-vessel price lagged one period is expected to be positive reflecting some stickiness or inertia in price determination. The ex-vessel price of cod is expected to be positively related to ex-vessel price;

as cod prices increase, demand for haddock increases as processors substitute away from cod to haddock.

Canadian Ex-Vessel Price

Following Hogan and Georgiana, demand and supply of fresh whole imports of haddock were assumed to be simultaneously determined in a market clearing process. The Canadian ex-vessel price of haddock was assumed to be exogenously determined by the quantity of Canadian landings, the quantity of fresh whole exports to the United States, the Canadian ex-vessel price lagged one period, and the price of alternative products handled by Canadian processors. The quantity of Canadian landings is expected to be negatively related to ex-vessel price; as landings go up market-clearing prices go down. Ex-vessel price is expected to be positively related to export quantities; as export demand increases, ex-vessel prices increase. The expected sign of the Canadian ex-vessel price lagged one period is positive. As was the case for U.S. ex-vessel prices the lagged effect is intended to reflect some inertia or adjustment period in price determination. The expected sign for the price of alternative processed products is expected to be positive; as the value of alternative higher-valued processed product markets increases, Canadian ex-vessel prices increase.

3.3 Data

The system of equations described above was estimated using monthly data obtained from several source (see Appendix B) for calendar years 1989 through 2003. These years were selected due to constraints on the ability to obtain reliable import quantities of haddock prior to the conversion in 1989 to a 10-digit harmonized code. In previous years most haddock was combined with a grouping of species including cod, pollock, and hakes and so the data were not useable. Data on monthly U.S. landings in live weight and value were obtained from the Northeast region dealer weighout data. Data on monthly Canadian landings in live weight and value were obtained from the Department of Fisheries and Oceans in Canada. Import quantities in product weight and values were obtained from NMFS headquarters Fisheries Statistics Division. These data are purchased by the Division from the Foreign Trade Division of the United States Census Bureau. All price data were expressed in nominal terms converted to U.S. dollars. Also, since both United States and Canada landings were measured in live weight, ex-vessel prices are expressed as dollars per pound live weight. By contrast, import quantities were measured in product weight so import prices are expressed in product weight.

3.4 Results

The supply and demand system was estimated using two-stage least squares. All but one of the estimated parameters (the intercept in the Canadian ex-vessel price equation) were statistically significant (Table 5). The signs of all variables were consistent with theoretical expectations; all own-price relationships were negative in the import demand and ex-vessel price equations, and positive in the import supply equation. Similarly, all substitution effects were positive as were variables reflecting demand for United States processed products.

The F-test of all variables being simultaneously equal to zero was rejected for each of the four estimated equations. The adjusted R-square values for the import supply and Canadian ex-vessel price indicate that these equations fit the data reasonably well. However, the adjusted R-square values for the import demand and U.S. ex-vessel price indicate that though the signs of the model parameters are consistent with expectations, these models are estimated with considerably more error, perhaps due to some form of unaccounted for specification or measurement error. Model performance (see Appendix A for a more detailed discussion) over the time series suggests that haddock markets have undergone some structural changes that have not been completely captured, although the model does appear to reasonably capture contemporary market conditions. The reliability of model forecasts is uncertain as potential supplies of haddock may lie outside the range of observed data. However, even though the point estimates of model predictions are subject to uncertainty, underlying structural relationships capturing market behavior would be unaffected. This means that the econometric model is still likely to produce reasonably reliable relative or ordinal rankings of alternative harvest strategies affecting aggregate haddock markets.

The system of equations was specified in a double-log form so that the coefficients are interpretable as elasticities. The estimated import price elasticity of demand is quite high (-11.6) indicating that United States processor demand for imported whole fish from Canada is very responsive to the raw material price. By contrast, the substitution elasticity for United States domestic haddock landings is inelastic (-0.27) suggesting that processor demand for Canadian raw material imports is not particularly responsive to domestic landings.

The own-price elasticity in the supply equation is elastic indicating that Canadian exporters are responsive to changes in import price. Similarly, Canadian landings are responsive to the import price. The price of alternative products that may be processed in Canada is negatively related to supply of whole fresh haddock imports, but the proportional effect is less than unity.

Table 5. Results of Estimated United States – Canada Market Model

Variable	Import Demand (Pounds)	Import Supply (Pounds)	U.S. Ex-Vessel Price ($US/Pound)	Canadian Ex-Vessel Price ($US/Pound)
Intercept	8.862*	-3.244*	1.154*	0.030
	(0.442)	(0.716)	(0.107)	(0.072)
Import Price	-11.642*	3.515*		
	(1.328)	(0.666)		
Haddock Price t-1 (US)	1.325*		0.161*	
	(0.586)		(0.059)	
Haddock Price t-1 (CA)				0.319*
				(0.051)
Ex-vessel Cod Price (US)	2.120*		0.162*	
	(0.417)		(0.031)	
Landings (US)	-0.276*		-0.060*	
	(0.085)		(0.007)	
Landings (CA)		1.220*		-0.251*
		(0.088)		(0.034)
Landings t-1 (CA)		0.113*		
		(0.048)		
Import Quantity			-0.088*	0.173*
			(0.013)	(0.035)
Alternative Processed Products Price		-0.411*		0.314*
		(0.165)		(0.036)
Time Trend	0.007*			
	(0.002)			
F-Value	22.73*	150.06*	63.25*	134.24*
Adjusted R-square	0.38	0.77	0.58	0.75

*Denotes statistically significant at the 0.05 level or greater.
Figures in parentheses are standard errors.

The price equations for the United States and Canadian ex-vessel markets were specified as price-dependent demand which means that the estimated parameters should be interpreted as price flexibilities which under some conditions are theoretically equivalent to the inverse of the price elasticity. A price flexibility less than one is interpreted in the same manner as a price elasticity greater than one. The own-price flexibilities for both the Canadian and United States ex-vessel demand are less than one suggesting that prices respond proportionally less than quantities supplied, so that total ex-vessel revenues may be expected to increase even though prices decline. However, the Canadian own-price flexibility is larger (-0.23) than that of the United States (-0.06) suggesting that a proportional increase in United States landings will have a proportionally lower impact on ex-vessel prices than would be the case for an equi-proportional increase in Canadian landings. The negative substitution elasticity for imported haddock in the United States ex-vessel demand suggests that the availability of imports has a price dampening effect on prices received by United States harvesters.

Based on the Eastern Georges Bank haddock TAC of 23,000 mt for calendar year 2005, and assuming haddock from other U.S. and Canada sources remain at their recent average levels, the predicted ex-vessel price in Canada would be $0.56 per pound in U.S. dollars. Applying the current exchange rate the harvester price would be $0.67 per pound or $1,477 per metric ton. In the U.S. the predicted ex-vessel price would be $1.07 per pound and the import price would be $0.77 per pound in live weight.

4. ECONOMIC FORECAST OF DIFFERENT HARVEST STRATEGIES

4.1 Proposed Harvest Strategies for Eastern Georges Bank Haddock

Four alternative harvest strategies for Eastern Georges Bank haddock were evaluated. These alternatives were a constant harvest strategy of 30,000, 40,000 and 50,000 mt and a harvest strategy of constant fishing mortality set equal to F_{Ref}=0.26. Projected catches of eastern Georges Bank haddock were based on the most recent stock assessment (van Eeckhaute and Brodziak 2005). Initial stock size at age in 2005 was estimated with a sequential population analysis. Variability in the 2005 estimate of stock was characterized using 1000 bias-corrected bootstrap realizations. The resulting bootstrap distribution of the initial stock size was used for projections to account for uncertainty in the initial stock size. Recruitment was simulated using a two-state spawning biomass-dependent recruitment function, similar to the recruitment model used for the entire Georges Bank haddock stock (Brodziak et al. 2001, Brodziak et al. 2002). A cutoff of 40,000 mt was used to define the high and low spawning biomass states, as recommended by the Transboundary Resource Assessment Committee [TRAC]. This partitioned the set of observed recruitments into high and low spawning biomass states for simulating recruitment. As a result, projections of future catch streams accounted for both uncertainty in initial stock size and uncertainty in future recruitment (Brodziak et al. 1998).

The 3-year average of fishery selectivities and weights at age during 2002-2004 were used to characterize the projected catch under each harvesting scenario as recommended by the TRAC. The distribution of projected catches from 100 simulations for each bootstrap initial stock size were used to generate revenue streams for economic analyses. Since the 2003 year class is also a dominant feature in the Western Georges Bank portion of the haddock resource, a set of projections from this source was also produced based on the harvest strategy adopted by the New England Fishery Management Council in 2004. Note that all projected landings are based on what could be landed at prescribed levels of fishing mortality rates and may not necessarily reflect realized landings given constraints imposed by management action taken to protect other stocks. For example, the U.S. portion of the Eastern Georges Bank area was closed effective August 26, 2005 because the Georges Bank cod TAC had been taken. This means that the 2005 U.S. haddock TAC from this area will not be taken. Adjustments to management measures in the U.S. portion of the resource sharing area coupled with ongoing gear research may enable the U.S. to take its share of the TAC in the future.

A second set of projections were provided based on the possibility that environmental conditions would return to the longer term average. These projections were run using long term average weights-at-age (from 1987-2003), while retaining the same recent partial recruitment pattern. The economic effects of alternative harvest strategies under this environmental scenario were treated as a sensitivity analysis for purposes of this report. Procedures to evaluate the economic implications of the different harvest strategy are detailed below.

4.2 Procedures for Estimating Economic Effects of Different Harvest Strategies

The econometric model of haddock raw material market described previously generates an estimate of (a) the monthly haddock import price, (b) import quantity, (c) the Canadian ex-vessel price, and (d) the U.S. ex-vessel price. The economic model includes several exogenous variables that may affect any one of these endogenous but developing forecasts of these exogenous variables was outside the scope of analysis so they were held constant. These exogenous variables included the monthly pattern of landings, the U.S. ex-vessel price of cod, and the price of processed haddock imports (Table 6).

Table 6. Monthly Average Values for Exogenous Variables (2001-2003)

Month	Canadian Monthly Share	U.S. Monthly Landing Share	U.S. Cod Price ($US/lb)	Processed Import Price ($US/lb)	Average December Haddock CA Price ($US/lb)	Average December Haddock U.S. Price ($US/lb)	Average Canadian December Landings (1,000 lbs)
January	0.07	0.09	1.18	2.53			
February	0.04	0.10	1.32	2.63			
March	0.08	0.11	1.00	2.51			
April	0.03	0.13	0.92	2.64			
May	0.03	0.09	1.18	2.57			
June	0.08	0.10	0.91	2.73			
July	0.16	0.07	1.05	2.65			
August	0.13	0.06	1.15	2.90			
September	0.14	0.07	1.21	2.90			
October	0.11	0.08	1.25	2.78			
November	0.08	0.05	1.13	2.78			
December	0.05	0.06	1.08	2.79	0.84	1.25	1,860

As projected landings were provided on an annual basis, the annual time-step was converted to a monthly time step to match the economic model. Since there was no reason to believe that the proposed harvest strategies would fundamentally alter the seasonal pattern of landings, annual projected landings were multiplied by the most recent 3-year average monthly share of total landings. Further, since the reduced form equations (Table 7) in the market model include a one-month lag for U.S. haddock landings, Canadian haddock landings, and Canadian ex-vessel price, the 3-year December average for each of these variables was used for the first period of the economic forecasts. Predicted values for all subsequent periods were obtained by substitution of projected landings into the reduced form equations. These monthly values were then summed by year to obtain an annual estimate of import sales, import quantities, and ex-vessel revenues to Canadian and U.S. vessels.

Under the existing US/Canada resource sharing agreement, TACs for allocating the haddock resource between the two countries are established on an annual basis. This resource share was estimated to be 34/66, 33/67, and 34/66 percent for 2004, 2005 and 2006 respectively (Gavaris, Mayo, and O'Brien, 2005). Given the recent stability in the resource shares the most recent estimate of resource shares (66% Canadian and 34% U.S.) was assumed to remain constant for the period of analysis (2005 to 2014).

Table 7. Reduced Form Coefficients for Predicted Prices and Import Quantity

Variable[1]	Logged Import Price	Logged Import Quantity	Logged U.S. Ex-Vessel Price	Logged CA Ex-Vessel Price
Intercept	0.7985	-0.4374	1.1927	-0.0452
Log US Haddock Price t-1	0.0874	0.3072	0.1343	0.0532
Log US Cod Price	0.1398	0.4915	0.1183	0.0850
Log US Haddock Landings	-0.0182	-0.0641	-0.0541	-0.0111
Time	0.0005	0.0017	-0.0002	0.0003
Log CA Haddock Landings	-0.0805	0.9375	-0.0825	-0.0890
Log CA Haddock Landings t-1	-0.0074	0.0867	-0.0076	0.0150
Log Alternative Product Price	0.0271	-0.3158	0.0278	0.2597
Log CA Price t-1	0.0000	0.0000	0.0000	0.3192

1 Quantity variables measured in 1,000 pound; prices measured in $US per pound; log refers to natural logarithm;

4.3 Results of Economic Projections

In addition to landing haddock from the Eastern Georges Bank area, U.S. vessels also land haddock from the Western Georges Bank area and the Gulf of Maine. Canadian vessels also land haddock from non-Georges Bank stocks. Landings from these sources contribute to the overall haddock raw material market and affect import demand as well as ex-vessel prices in the U.S. and Canada. At this time, neither the U.S. nor Canada is considering a change in harvest strategy for any of these alternative haddock resources so the landings from these sources were invariant across all harvest alternatives for the Eastern Georges Bank area (Table 8). For this reason, reported results will focus on landings and revenue streams from the Eastern Georges Bank haddock resource, although landings and revenue totals for both countries will also be reported for completeness. Results include the median values of the projected landings by stock area, predicted prices, predicted total sales for imported Canadian whole fresh haddock, and predicted total ex-vessel revenues to Canadian and U.S. harvesters. Estimates of gross sales are reported in both nominal as well as present value terms by applying a discount rate of 7.0%. All quantities and prices are reported in live weight. These results provide an ordinal ranking of harvest strategies in terms of the expected present value of the benefit stream. Since calendar year 2005 is nearing completion, all forecasted results will be reported beginning in calendar year 2006 through 2014.

Table 8. Summary of Landings from Sources Other than the Eastern Georges Bank Haddock Resource

Year	Non-Georges Bank Canada Landings (1,000 lbs)	Western GB US Commercial Landings (1,000 lbs)	Gulf of Maine (1,000 lbs)
2006	19,313	52,487	2,537
2007	19,313	111,881	2,537
2008	19,313	124,055	2,537
2009	19,313	90,430	2,537
2010	19,313	83,841	2,537
2011	19,313	74,608	2,537
2012	19,313	59,978	2,537
2013	19,313	59,978	2,537
2014	19,313	52,156	2,537

Constant Harvest Strategy 1: 30,000 mt

A constant harvest strategy of 30,000 mt would be first achieved in calendar year 2007 and would remain constant through 2014 (Table 9). This strategy would result in a potential annual catch of 43.7 million pounds by Canadian fishermen and 22.5 million pounds by U.S. fishermen. Given additional haddock supplies from other haddock resources total U.S. haddock supplies would be 74 million pounds in 2006, increase to 149 million pounds then gradually decline to 72 million pounds in 2014. This pattern of total landings is due to the projected allowable landings from the Western Georges Bank haddock resource. For reasons noted previously, realized landings from this resource are likely to be lower. In Canada, total landings would increase from 46.7 million pounds to 63 million pounds.

Table 9. Projected Annual Landings for a 30 Thousand MT Constant Harvest Strategy of Eastern Georges Bank Haddock

Year	Eastern Georges Bank Landings MT (1,000)	Eastern Georges Bank Canada Landings (1,000 lbs)	Total Canada Landings (1,000 lbs)	Eastern GB US Commercial Landings (1,000 lbs)	Total US Landings (1,000 lbs)
2006	25	37,067	56,380	19,095	74,120
2007	30	43,651	62,964	22,487	136,906
2008	30	43,651	62,964	22,487	149,079
2009	30	43,651	62,964	22,487	115,455
2010	30	43,651	62,964	22,487	108,865
2011	30	43,651	62,964	22,487	99,632
2012	30	43,651	62,964	22,487	85,003
2013	30	43,651	62,964	22,487	77,181
2014	30	43,651	62,964	22,487	72,108

Given that the economic model predicts prices and quantities on a monthly time step, annual average prices were computed as the average of monthly predicted price and annual were computed by summing predicted values across months. Due to increased supplies, average annual live weight prices decline from 2006 to 2008 by $0.05 per pound in the U.S. ex-vessel market as aggregate haddock supplies peak in 2008 (Table 10). As aggregate haddock supplies decline, the U.S. ex-vessel price rises to $0.96 per pound in 2014. The average ex-vessel live weight price in Canada was predicted to initially decline from $0.53 per pound in 2006 to $0.52 per pound in 2008. Over the longer term, predicted ex-vessel price in Canada increases to $0.55 per pound due to the influence of both a decline in aggregate haddock supplies and to a small positive time trend. Similarly, the import price was predicted to decline initially from $0.75 to $0.74 per pound but recover to be above its 2006 level by 2014. Predicted imports from Canada increase from 38 million pounds in 2006 to 50 million pounds in 2014; again due to the effect of a positive time trend. Note that total import quantities may come from any source in Canada so the total presented in Table 10 does not represent imports only from the Eastern Georges Bank resource.

Table 10. Predicted Values for Prices, Import Quantities and Gross Sales for 30 Thousand MT Constant Harvest Strategy of Eastern Georges Bank Haddock

Year	Annual Average Predicted US Ex-Vessel Price ($US/lbs)	Annual Average Predicted Canada Ex-Vessel Price ($US/lbs)	Annual Average Predicted Import Price ($US/lbs)	Predicted Import Quantity (1,000 lbs)
2006	0.98	0.53	0.75	38,008
2007	0.93	0.52	0.74	41,126
2008	0.93	0.52	0.74	41,637
2009	0.94	0.53	0.75	43,363
2010	0.94	0.53	0.76	44,462
2011	0.94	0.53	0.76	45,687
2012	0.95	0.54	0.77	47,218
2013	0.95	0.54	0.77	48,558
2014	0.96	0.55	0.78	49,815

The total value of import sales increases from $28 million in 2006 to $38 million in 2014. Discounted at a rate of 7% the present value of the cumulative import sales was estimated to be $216 million (Table 11). Even though U.S. ex-vessel prices were predicted to go down, ex-vessel revenues from sales of haddock from the Eastern Georges Bank resource were predicted to increase from $19 million in 2006 to $22 million in 2014. This increase is due to the fact that haddock demand is elastic such that price goes down proportionally less than the increase in quantity. The present value of US ex-vessel revenue from the Eastern Georges Bank haddock resource was estimated to be $188 million and present value of total harvest revenue from all U.S. sources of haddock were estimated to be $641 million. Predicted returns from the Eastern Georges Bank resource to harvesters in Canada increased from $19 million in 2006 to $24 million in 2014. The present value of Canada revenues from the Eastern Georges Bank resource over the 9 years was estimated to be $147 million while discounted revenues in Canada from all sources of haddock were $214 million.

Table 11. Predicted Value of Import and Harvest Revenues in The U.S. and Canada for a 30 Thousand MT Constant Harvest of Eastern Georges Bank Haddock

Year	Total Import Sales ($1,000 US)	Eastern Georges Bank Canada Harvest Revenue ($1,000 US)	Total Canada Harvest Revenue ($1,000 US)	Eastern Georges Bank US Harvest Revenue ($1,000 US)	Total US Harvest Revenue ($1,000 US)
2006	28,648	19,677	29,930	18,764	72,833
2007	30,396	22,694	32,734	20,978	127,719
2008	30,872	22,742	32,804	20,809	137,957
2009	32,524	22,971	33,134	21,095	108,306
2010	33,588	23,122	33,351	21,132	102,304
2011	34,782	23,281	33,582	21,204	93,950
2012	36,286	23,475	33,862	21,370	80,781
2013	37,614	23,644	34,105	21,456	73,642
2014	38,869	23,799	34,328	21,503	68,953
Total Nominal Value	303,580	205,405	297,830	188,311	866,446
Total Present Value	216,092	147,624	214,384	135,627	641,080

Constant Harvest Strategy 2: 40,000 mt

A 40,000 mt constant harvest strategy of haddock taken from the Eastern Georges Bank area is achieved in 2007 and is sustainable until 2012 (Table 12). In 2013 projected median landings decline to 38,000 mt and decline to 33,000 mt in 2014. Total Canadian catches from the Eastern Georges Bank haddock resource peak at 58.2 million pounds then decline to 48.5 million pounds in 2014. Potential catches to U.S vessels peak at 30 million pounds then decline to 25 million pounds in 2014.

Table 12. Projected Annual Landings for a 40 Thousand MT Constant Harvest Strategy for Eastern Georges Bank Haddock

Year	Eastern Georges Bank Landings MT (1,000)	Eastern Georges Bank Canada Landings (1,000 lbs)	Total Canada Landings (1,000 lbs)	Eastern GB US Commercial Landings (1,000 lbs)	Total US Landings (1,000 lbs)
2006	25	37,067	56,380	19,095	74,120
2007	40	58,201	77,514	29,983	144,401
2008	40	58,201	77,514	29,983	156,575
2009	40	58,201	77,514	29,983	122,951
2010	40	58,201	77,514	29,983	116,361
2011	40	58,201	77,514	29,983	107,128
2012	40	58,201	77,514	29,983	92,498
2013	38	54,865	74,178	28,264	82,958
2014	33	48,486	67,799	24,978	74,599

From 2006 through 2014 average annual ex-vessel prices in the U.S. and Canada rise and fall with changes in total harvested supplies (Table 13). That is, predicted prices decline in 2006, 2007, and 2008 with the rise in landings from the Eastern Georges Bank resource. As landings decline in 2013 and 2014, predicted prices increase. Import prices follow a similar pattern as import quantities follow the same general pattern as landings from the Eastern Georges Bank resource even though not imports do come from other sources of haddock.

Table 13. Predicted Values for Prices, Import Quantities and Gross Sales for 40 Thousand MT Constant Harvest Strategy for Eastern Georges Bank Haddock

Year	Annual Average Predicted US Ex-Vessel Price ($US/lbs)	Annual Average Predicted Canada Ex-Vessel Price ($US/lbs)	Annual Average Predicted Import Price ($US/lbs)	Predicted Import Quantity (1,000 lbs)
2006	0.98	0.53	0.75	38,008
2007	0.91	0.51	0.72	50,290
2008	0.90	0.51	0.73	50,966
2009	0.91	0.51	0.73	53,019
2010	0.92	0.52	0.74	54,346
2011	0.92	0.52	0.74	55,816
2012	0.93	0.52	0.75	57,630
2013	0.93	0.53	0.76	56,799
2014	0.95	0.54	0.77	53,472

As noted previously the value of harvest revenues from the Eastern Georges Bank haddock resource increases in both countries in every year through 2012 even though average ex-vessel price is lower than the 2006 predicted price (Table 14). The present value of harvest revenue to vessels in Canada was estimated to be $182 million from the Eastern Georges Bank resource and a total of $248 million from all sources of haddock. In the U.S. discounted revenues from the Eastern Georges Bank resource were estimated to be $167 million and a cumulative total of $662 million from the entire Georges Bank and Gulf of Maine stock areas.

Table 14. Predicted Value of Import and Harvest Revenues in The U.S. and Canada for a 40 Thousand MT Constant Harvest of Eastern Georges Bank Haddock

Year	Total Import Sales ($1,000 US)	Eastern Georges Bank Canada Harvest Revenue ($1,000 US)	Total Canada Harvest Revenue ($1,000 US)	Eastern Georges Banks US Harvest Revenue ($1,000 US)	Total US Harvest Revenue ($1,000 US)
2006	28,648	19,677	29,930	18,764	72,833
2007	36,394	29,523	39,320	27,294	131,453
2008	36,991	29,565	39,375	27,068	141,357
2009	38,915	29,854	39,760	27,416	112,427
2010	40,171	30,047	40,017	27,458	106,563
2011	41,572	30,250	40,288	27,542	98,409
2012	43,316	30,495	40,615	27,737	85,571
2013	43,226	29,105	39,350	26,390	77,457
2014	41,384	26,179	36,606	23,646	70,622
Total Nominal Value	350,619	254,695	345,262	233,315	896,691
Total Present Value	249,433	182,836	248,274	167,811	662,379

Constant Harvest Strategy 3: 50,000 mt

A constant harvest of 50,000 mt of haddock from the Eastern Georges Bank area is achieved in 2007 and is sustainable for three consecutive years (2007 through 2009) before declining gradually from 47,000 mt in 2010 to 30,000 mt in 2014 (Table 15). Canadian landings from the Eastern Georges Bank resource peak at 72.7 million from 2007 through 2009 and decline to 43.5 million pounds in 2014. Similarly, U.S. haddock harvest from the resource peaks at 37 million pounds then declines to 22 million pounds in 2014. Total landings from all sources in Canada peak at 92 million pounds then decline to 63 million pounds. Aggregate U.S. harvest peaks at 164 million pounds then declines to 72 million pounds in 2014.

Table 15. Projected Annual Landings for a 50 Thousand MT Constant Harvest Strategy for Eastern Georges Bank Haddock

Year	Eastern Georges Bank Landings MT (1,000)	Eastern Georges Bank Canada Landings (1,000 lbs)	Total Canada Landings (1,000 lbs)	Eastern GB US Commercial Landings (1,000 lbs)	Total US Landings (1,000 lbs)
2006	25	37,067	56,380	19,095	74,120
2007	50	72,752	92,065	37,478	151,897
2008	50	72,752	92,065	37,478	164,071
2009	50	72,752	92,065	37,478	130,446
2010	47	68,518	87,831	35,297	121,675
2011	40	57,938	77,251	29,847	106,992
2012	38	54,917	74,230	28,291	90,807
2013	33	47,805	67,118	24,627	79,321
2014	30	43,516	62,829	22,417	72,038

Predicted average ex-vessel prices and import price rise and fall with the change in harvested quantities (Table 16). As was the case for other harvest strategies, predicted prices in 2006 and 2007 decline as harvested quantities from the Eastern Georges Bank resource increase. Average prices then stabilize with constant harvests in 2007 through 2009. However, as landed quantities decline, predicted average prices rise through 2014.

Table 16. Predicted Values for Prices, Import Quantities and Gross Sales for 50 Thousand MT Constant Harvest Strategy for Eastern Georges Bank Haddock

Year	Annual Average Predicted US Ex-Vessel Price ($US/lbs)	Annual Average Predicted Canada Ex-Vessel Price ($US/lbs)	Annual Average Predicted Import Price ($US/lbs)	Predicted Import Quantity (1,000 lbs)
2006	0.98	0.53	0.75	38,008
2007	0.89	0.50	0.71	59,367
2008	0.88	0.50	0.71	60,217
2009	0.89	0.50	0.72	62,579
2010	0.90	0.51	0.73	61,299
2011	0.92	0.52	0.74	55,656
2012	0.93	0.53	0.76	55,298
2013	0.95	0.54	0.77	51,634
2014	0.96	0.55	0.78	49,722

As was the case for the 40,000 mt constant harvest strategy, decreases in prices are more than offset by increases in landings resulting in rising ex-vessel revenues from the Eastern Georges Bank resource in both Canada and the U.S. at least through 2009 (Table 17). Similarly the volume of import quantities more than offsets declines in import price resulting in higher value of sales through 2009. By contrast, lower landings from 2010 to 2014 are not offset by price increases so total value of import sales and harvest revenues declines. Applying a discount rate of 7% to annual sales, results in a present value of $262 million. The present value of Canadian and U.S. ex-vessel revenue from the Eastern Georges Bank resource was estimated to be $198 million and $249 million respectively.

Table 17. Predicted Value of Import and Harvest Revenues in The U.S. and Canada for a 50 Thousand MT Constant Harvest of Eastern Georges Bank Haddock

Year	Total Import Sales ($1,000 US)	Eastern Georges Bank Canada Harvest Revenue ($1,000 US)	Total Canada Harvest Revenue ($1,000 US)	Eastern Georges Banks US Harvest Revenue ($1,000 US)	Total US Harvest Revenue ($1,000 US)
2006	28,648	19,677	29,930	18,764	72,833
2007	42,214	36,157	45,755	33,420	135,449
2008	42,934	36,185	45,790	33,138	145,070
2009	45,108	36,530	46,227	33,538	116,733
2010	44,714	34,821	44,636	31,815	109,671
2011	41,459	30,111	40,148	27,421	98,296
2012	41,753	28,927	39,100	26,318	84,474
2013	39,716	25,676	36,049	23,297	75,036
2014	38,801	23,725	34,254	21,439	68,895
Total Nominal Value	365,349	271,807	361,888	249,149	906,457
Total Present Value	262,834	198,130	263,120	181,928	671,295

Current Harvest Strategy: F_{Ref} = F_{MSY} = 0.26

Employing a constant fishing mortality harvest strategy of $F_{Ref} = F_{MSY} = 0.26$ for haddock in the Eastern Georges Bank area would result in an increase in potential landings from this area to 64,000 mt in 2008. Landings in 2009 would decline to 51,000 mt and would further decline in every year thereafter to 28,000 mt in 2014 (Table 18). The overall pattern of landings over time is similar to that of the 50,000 mt constant harvest strategy except that by landing fewer fish in 2008, the latter provides for elevated landings over the final five years, although by 2014 the difference between the two strategies is only 2,000 mt.

Table 18. Projected Annual Landings for a Constant Fishing Mortality Harvest Strategy of F_{Ref}=0.26 for Eastern Georges Bank Haddock

Year	Eastern Georges Bank Landings MT (1,000)	Eastern Georges Bank (1,000 lbs)	Total Canada Landings (1,000 lbs)	Eastern GB US Commercial Landings (1,000 lbs)	Total US Landings (1,000 lbs)
2006	25	37,067	56,380	19,095	74,120
2007	51	74,379	93,692	38,316	152,735
2008	64	92,593	111,906	47,699	174,292
2009	51	74,016	93,329	38,130	131,098
2010	44	63,370	82,683	32,645	119,023
2011	37	53,797	73,110	27,714	104,859
2012	35	51,098	70,411	26,323	88,839
2013	31	44,726	64,039	23,041	77,735
2014	28	41,004	60,317	21,123	70,745

Predicted average prices rise and fall with projected haddock landings (Table 19). Predicted ex-vessel prices and import price are lowest in 2008 when landings peak. Given roughly equivalent landings in 2007 and 2009, predicted prices and estimates of import quantities are also similar in those two years although both import price and import quantity are higher in 2009 as compared to 2007. This small difference is due to the time trend which has a positive influence on both import price and import quantity. From 2010 onward predicted imports as well as ex-vessel prices increase as landed quantities decline.

Table 19. Predicted Values for Prices, Import Quantities and Gross Sales for a Constant Fishing Mortality Harvest Strategy of F_{Ref}=0.26 for Eastern Georges Bank Haddock

Year	Annual Average Predicted US Ex-Vessel Price ($US/lbs)	Annual Average Predicted Canada Ex-Vessel Price ($US/lbs)	Annual Average Predicted Import Price ($US/lbs)	Predicted Import Quantity (1,000 lbs)
2006	0.98	0.53	0.75	38,008
2007	0.89	0.50	0.71	60,376
2008	0.86	0.49	0.70	72,675
2009	0.89	0.50	0.72	63,442
2010	0.91	0.51	0.73	57,853
2011	0.93	0.52	0.75	52,783
2012	0.94	0.53	0.76	52,570
2013	0.95	0.54	0.77	49,366
2014	0.96	0.55	0.78	47,821

Revenues to harvesters from the Eastern Georges Bank haddock resource in Canada peak at $45 million in 2008 then decline steadily with resource abundance to $22 million in 2014 (Table 20). The present value of these revenue streams was estimated to be $201 million. The present value of harvest revenue from all sources of haddock in Canada was estimated to be $266 million. Predicted commercial fishing revenue from Eastern Georges Bank haddock in the U.S. also peaked in 2008 at $41 million then declined over the remainder of the projection period to $20 million in 2014. The present value of Eastern Georges Bank haddock sales in the U.S. was estimated to be $184 million and was estimated to be $673 million in sales from all U.S. sources of haddock.

Table 20. Predicted Value of Import and Harvest Revenues in The U.S. and Canada for a Constant Fishing Mortality Harvest Strategy of F_{Ref}=0.26 for Eastern Georges Bank Haddock

Year	Total Import Sales ($1,000 US)	Eastern Georges Bank Canada Harvest Revenue ($1,000 US)	Total Canada Harvest Revenue ($1,000 US)	Eastern Georges Banks US Harvest Revenue ($1,000 US)	Total US Harvest Revenue ($1,000 US)
2006	28,648	19,677	29,930	18,764	72,833
2007	42,855	36,888	46,466	34,095	135,907
2008	50,788	44,990	54,373	41,189	150,503
2009	45,650	37,074	46,748	34,047	117,062
2010	42,465	32,438	42,324	29,645	108,087
2011	39,548	28,152	38,258	25,640	97,014
2012	39,918	27,094	37,335	24,656	83,213
2013	38,164	24,165	34,600	21,931	73,990
2014	37,482	22,471	33,055	20,311	68,024
Total Nominal Value	365,518	272,950	363,090	250,278	906,633
Total Present Value	264,577	200,665	265,643	184,301	672,529

Harvest Strategy Comparison

Cumulative projected landings are highest (384,000 mt) for the F_{Ref} harvest strategy but by only 2,000 mt when compared to a constant catch harvest strategy of 50,000 mt (Table 21). Although the 30,000 mt constant harvest strategy would be sustainable from 2007 through 2014, it also results in the lowest cumulative yield (284,000 mt). The 40,000 mt constant harvest strategy has the third lowest cumulative yield (355,000 mt); a difference of 27,000 and 29,000 mt respectively as compared to the 50,000 mt constant harvest and F_{Ref} strategies.

Table 21. Summary of Projected Landings by Harvest Strategy (1,000 mt)

	Harvest Strategy			
Year	30,000 mt	40,000 mt	50,000 mt	F_{Ref}
2006	25	25	25	25
2007	30	40	50	51
2008	30	40	50	64
2009	30	40	50	51
2010	30	40	47	44
2011	30	40	40	37
2012	30	40	38	35
2013	30	38	33	31
2014	30	33	30	28
Total	284	355	382	384

On an annual basis, the 30,000 mt constant harvest strategy produces estimates of yield that exceed any other strategy in only the terminal year and only compared to the F_{Ref} strategy. The 40,000 mt harvest strategy produces annual yields lower than either the 50,000 mt or F_{Ref} harvest strategies through 2011 but produces higher yield in each of the last three years of the projection period. As noted earlier, the 50,000 mt and F_{Ref} harvest strategies produce annual yields that are not markedly different from one another with the exception of 2008 where F_{Ref} yield is greater by 16,000 mt.

Compared to other harvest strategies predicted cumulative import demand for fresh whole haddock from Canada is largest for the 50,000 mt and constant F_{Ref} harvest strategies (Table 22). Further, both cumulative import quantities and value of sales for these two harvest strategies are virtually identical. As noted above, the 30,000 mt harvest strategy does not produce higher import sales than other alternatives until the terminal year of the projection period. Similarly, the 40,000 mt harvest strategy produces lower value of import sales in years up to 2011 but does produce higher import sales from 2012 through 2014. The present value of import sales for the 50,000 mt harvest strategy exceeds that of the 40,000 mt strategy by $13 million and the constant F_{Ref} strategy exceeds the 40,000 mt strategy by $15 million.

Table 22. Predicted Import Quantities and Nominal Value of Sales by Harvest Strategy

	Predicted Import Quantities by Harvest Strategy (1,000 lbs)				Predicted Import Sales by Harvest Strategy ($1,000 US)			
Year	30,000 mt	40,000 mt	50,000 mt	FRef	30,000 mt	40,000 mt	50,000 mt	FRef
2006	38,008	38,008	38,008	38,008	28,648	28,648	28,648	28,648
2007	41,126	50,290	59,367	60,376	30,396	36,394	42,214	42,855
2008	41,637	50,966	60,217	72,675	30,872	36,991	42,934	50,788
2009	43,363	53,019	62,579	63,442	32,524	38,915	45,108	45,650
2010	44,462	54,346	61,299	57,853	33,588	40,171	44,714	42,465
2011	45,687	55,816	55,656	52,783	34,782	41,572	41,459	39,548
2012	47,218	57,630	55,298	52,570	36,286	43,316	41,753	39,918
2013	48,558	56,799	51,634	49,366	37,614	43,226	39,716	38,164
2014	49,815	53,472	49,722	47,821	38,869	41,384	38,801	37,482
Total Nominal Value	399,874	470,346	493,780	494,893	303,580	350,619	365,349	365,518
Total Present Value					216,092	249,433	262,834	264,577

Predicted total ex-vessel revenues (cumulative 2006 to 2014) to both U.S. and Canadian harvesters is greatest under a constant F_{Ref} fishing strategy although the cumulative difference between the constant F_{Ref} and constant harvest strategy of 50,000 mt is no more than $1 million in nominal terms or $3 million in present value (Table 23). On an annual basis, the comparative stream of harvest revenues follows the same pattern as noted previously for landings and for imports. Specifically, the 30,000 mt harvest strategy produces lowest catches in all years except 2014 and the 40,000 mt strategy produces lower revenues from 2007 through 2010 but higher revenues from 2011 onward.

Table 23. Predicted Nominal Value of Eastern Georges Bank Haddock Ex-Vessel Harvest Revenue to Canadian and US Vessels

	Predicted Canadian Ex-Vessel Revenue by Harvest Strategy ($1,000 US)				Predicted US Ex-Vessel Revenue by Harvest Strategy ($1,000 US)			
Year	30,000 mt	40,000 mt	50,000 mt	FRef	30,000 mt	40,000 mt	50,000 mt	FRef
2005	0	0	0	0	0	0	0	0
2006	19,677	19,677	19,677	19,677	18,764	18,764	18,764	18,764
2007	22,694	29,523	36,157	36,888	20,978	27,294	33,420	34,095
2008	22,742	29,565	36,185	44,990	20,809	27,068	33,138	41,189
2009	22,971	29,854	36,530	37,074	21,095	27,416	33,538	34,047
2010	23,122	30,047	34,821	32,438	21,132	27,458	31,815	29,645
2011	23,281	30,250	30,111	28,152	21,204	27,542	27,421	25,640
2012	23,475	30,495	28,927	27,094	21,370	27,737	26,318	24,656
2013	23,644	29,105	25,676	24,165	21,456	26,390	23,297	21,931
2014	23,799	26,179	23,725	22,471	21,503	23,646	21,439	20,311
Total Nominal Value	205,405	254,695	271,807	272,950	188,311	233,315	249,149	250,278
Total Present Value	147,624	182,836	198,130	200,665	135,627	167,811	181,928	184,301

4.4 Sensitivity Analysis

The present value of benefits from any one harvest strategy will depend on the selected discount rate, the variability or likelihood of achieving higher or lower benefits, and the effect on projected yields of assumed average weights-at-age.

Discount Rate

The sensitivity of the ordinal ranking of the harvest strategies was examined by applying discount rates of 3%, 5%, 7%, and 9% to the annual nominal values for import sales, Canadian ex-vessel revenues, and U.S. ex-vessel revenues (Table 24). Although present values decline at higher discount rates, the ordinal ranking of harvest strategies was unaffected by the discount rate. That is, at all tested interest rates the constant F_{Ref} harvest strategy produced highest present value followed by the 50,000, 40,000, and 30,000 mt constant harvest strategies. Note that in all cases the difference between the constant F_{Ref} and 50,000 mt constant harvest strategies is slight.

Table 24. Sensitivity of Present Value Calculations to the Discount Rate

	3%	5%	7%	9%
Strategy	Import Sales ($1,000 US)			
30,000 mt	260,704	236,854	216,092	197,939
40,000 mt	301,076	273,480	249,433	228,388
50,000 mt	315,305	287,311	262,834	241,342
F_{Ref}	316,309	288,729	264,577	243,338
	Eastern Georges Banks Canadian Ex-Vessel Revenue ($1,000 US)			
30,000 mt	177,151	161,384	147,624	135,562
40,000 mt	219,601	199,981	182,836	167,788
50,000 mt	235,981	215,828	198,130	182,523
F_{Ref}	237,873	218,084	200,665	185,269
	Eastern Georges Bank United States Ex-Vessel Revenue ($1,000 US)			
30,000 mt	162,557	148,179	135,627	124,620
40,000 mt	201,334	183,447	167,811	154,084
50,000 mt	216,472	198,082	181,928	167,678
F_{Ref}	218,271	200,206	184,301	170,238

Variability in Projected Yield

A stochastic projection allows for consideration of variability in predicted catches due to uncertainty in recruitment. That is, catch in any given year may be at or near some average level or could be well above or below average because recruitment in prior years can affect the sustainability of any given harvest level or harvest strategy. To examine how potential present value of harvest revenues may be affected by this uncertainty, the present value of gross harvest revenue was calculated for different percentiles of the realized landings streams for each harvest strategy (Figure 6). In Figure 6 combined harvest revenues for U.S. and Canadian vessels are reported for convenience because separate plots of each value displayed the same pattern and are interpreted the same way. The values shown at 50% probability are equivalent to the median values reported in the results section for each harvest strategy. However, the cumulative probability means that there is a 50% probability that the present value of harvest revenues will be equal to the median or less. For example, there is a 50% chance that the 30,000 mt harvest strategy will yield a present value of approximately $283 million (U.S.) or less. By contrast, there is roughly a 10% probability that any of the other harvest strategies will be produce less than $283 million (U.S.).

Figure 6. Cumulative Probability Distribution for Combined Present Value of U.S. and Canadian Ex-Vessel Revenue ($1,000 US)

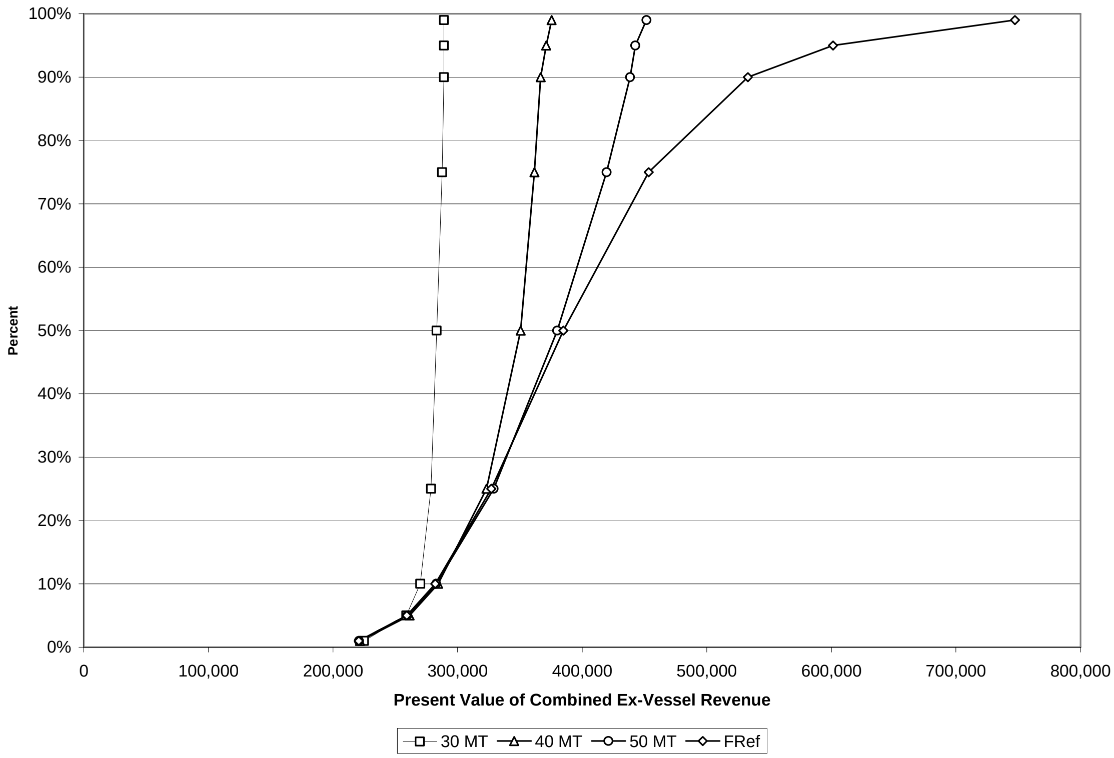


Figure 6 illustrates that at least up to the 50th percentile the cumulative probability distributions for the 50,000 mt constant harvest and constant F_{Ref} harvest strategies are virtually identical. The two distributions diverge at higher percentiles because the potential harvest revenue for the 50,000 mt constant harvest strategy is bounded by the TAC. This is also true of the 30,000 and 40,000 mt constant harvest strategies, which is why their cumulative probability distributions are nearly vertical. In essence, the constant harvest strategies may be well suited to take advantage of a particular recruitment event, but may not be as well suited to take advantage of future recruitment events.

Alternative Environmental Conditions

The TRAC provided a set of baseline projections using recent three-year average weights-at-age. These projections reflect current environmental conditions that have produced lower weight-at-age than the observed longer term average and are considered to be reflective of conditions that may be expected to prevail at least over the medium term. The TRAC also conducted a set of projections to examine how yields might differ if environmental conditions (and growth rates in particular) were to return to their long term average. The resulting projections indicate that the 30,000 mt constant harvest strategy would be achieved one year earlier than under the baseline condition and would be sustainable for all subsequent years of the projection period (Table 24). Compared to the baseline, the 40,000 mt harvest strategy would be achieved in the same year (2007) but would be sustainable through 2014 instead of 2012. Similarly, a 50,000 mt constant harvest would be achieved in the same year as that of the baseline projection but would be sustainable for three additional years. The constant F_{Ref} strategy would peak at 75,000 mt instead of 64,000 mt and the difference between in cumulative total landings between constant F_{Ref} and the 50,000 mt harvest strategy would be much larger.

Table 25. Summary of Projected Landings by Harvest Strategy for Favorable Environmental Conditions (1,000 mt)

	Harvest Strategy			
Year	30,000 mt	40,000 mt	50,000 mt	F_{Ref}
2006	30	30	30	30
2007	30	40	50	59
2008	30	40	50	75
2009	30	40	50	60
2010	30	40	50	52
2011	30	40	50	44
2012	30	40	50	42
2013	30	40	43	37
2014	30	40	38	33
Total	292	372	433	454

As the projected landings in Table 25 indicate, should environmental conditions become more favorable, any given constant harvest strategy would be sustainable over a longer period of time as compared to the baseline projections. However, the favorable conditions would prevail for all harvest strategies and the ordinal ranking of harvest strategy under baseline conditions would be unaffected. Specifically, in terms of present value of discounted import sales and harvest revenues in both countries, the F_{Ref} strategy produces highest gross benefits regardless of the selected discount rate (Table 26). Further, the separation between the F_{Ref} strategy and its next best alternative (a 50,000 mt constant harvest strategy) is larger than was the case under baseline environmental conditions.

Table 26. Sensitivity of Present Value Calculations Under Long-Term Average Environmental Conditions

	3%	5%	7%	9%
Strategy	Import Sales ($1,000 US)			
30,000 mt	263166.4	239,270	218,462	200,266
40,000 mt	308,619	280,189	255,444	233,812
50,000 mt	342,035	310,838	283,628	259,796
F_{Ref}	352,521	321,745	294,793	271,089
	Canadian Ex-Vessel Revenue ($1,000 US)			
30,000 mt	179,905	164,086	150,276	138,165
40,000 mt	227,242	206,813	188,989	173,370
50,000 mt	262,912	239,577	219,162	201,227
F_{Ref}	276,146	253,068	232,760	214,816
	United States Ex-Vessel Revenue ($1,000 US)			
30,000 mt	165,179	150,751	138,151	127,098
40,000 mt	208,343	189,728	173,480	159,237
50,000 mt	240,945	219,679	201,068	184,712
F_{Ref}	253,258	232,202	213,669	197,286

5.0 Summary and Caveats

The findings of this study demonstrate that haddock markets create interdependencies between the United States and Canada such that changes in management strategy will affect haddock trade and will have impacts on prices received by fishermen in both countries. Of the harvest strategies considered in this report, harvesting at a constant F_{Ref} produced the highest present value of ex-vessel revenues in both the United States and in Canada and produced the highest present value of import sales of haddock from Canada to the United States. This finding was robust with respect to the choice of discount rate and assumed weights-at-age. Taking uncertainty over projected landings into account, also favored the constant F_{Ref} strategy as it more readily takes advantage of future recruitment events.

Of the alternative constant catch strategies evaluated herein the 50,000 mt constant catch strategy comes closest to the revenue streams predicted for the constant F_{Ref} strategy. In fact, the projected landings between the two harvest strategies were quite similar and there were only minor differences in accumulated benefit streams. Throughout the report a number of caveats have been mentioned. These caveats are reiterated below.

As with any fitted statistical model, predictions will be more reliable when applied to conditions that are within the range of observed data. Even though the size of the 2003 haddock year class is less than once thought, landings are still projected to increase to levels that exceed the range of observed data used to estimate the econometric model. The potential directionality or magnitude of any forecast error is not known with certainty.

In this study, only haddock supplies from domestic fisheries in the United States and Canada were included. However, over the past several years both countries have been importing increasing supplies of haddock from Iceland and Norway, and in recent years Canada has imported growing amount of processed products from China. The role of these import supplies in U.S. and Canadian markets was not explicitly modeled because of data limitations principally due to missing observations over the time series used to develop the econometric model. With greater available domestic supplies, imports from these and other countries may decline as processors substitute away from imports and buy higher quantities of domestic haddock. Even if this is the case, the presence or opportunity to source haddock from other countries is likely to have some price dampening effect that would be transmitted down the marketing chain to processors and ex-vessel markets. Ultimately, the ability of domestic processors in the U.S. and Canada to compete with imported processed products will depend on cost and production efficiencies relative to import prices and the cost of shipping.

Where landings projections were made available (i.e. haddock from both Eastern and Western Georges Bank resource areas), they were based on what would be allowable under any of the four harvest strategies evaluated for this report. This does not necessarily mean that these landings or TAC levels would actually be realized. For example, the recent closure of the U.S. portion of the Eastern Georges Bank resource sharing area because of the U.S. cod TAC had been reached means that the U.S. TAC for Eastern Georges Bank haddock will not be taken. In the context of this study, 2005 import and ex-vessel prices would be underestimated as realized market supplies of haddock will be lower than projected. Given the comparatively low cod

TAC, bycatch rates of cod in the haddock fishery may make any one of the allowable levels of constant catch or constant F_{Ref} harvest strategies difficult to achieve.

The difference between the ex-vessel "scrod" and "large" haddock market categories in the U.S. averaged about $0.14 per pound between 1990 and 2003; a premium of approximately 25% of the scrod price. Unfortunately, the majority of haddock sold to U.S. dealers does not identify the market category and these data were not available in Canada so a price premium for larger fish was not included in the estimated price models. Including a price premium could affect the choice of harvest strategy because at lower harvest rates the proportion of larger more valuable fish in the exploitable population would increase compared to a harvest strategy where harvest rates were higher. Further exploration of this issue is not possible at this time given present data limitations and modeling approach.

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APPENDIX A – MARKET MODEL ASSESSMENT

A.1 Model Evaluation

The F-test of all variables being simultaneously equal to zero was rejected for each of the four estimated equations (Table 5). The adjusted R-squares for the import supply and Canadian ex-vessel price indicate that these equations fit the data reasonably well. The adjusted R-squares for the import demand and U.S. ex-vessel price indicate that though the signs of the models are consistent with expectations these models are estimated with considerably more error perhaps due to some form of unaccounted for specification or measurement error. To further investigate the model properties the reduced form parameters for predicted import price, fresh whole Canadian import quantities, U.S. ex-vessel price, and Canadian ex-vessel price were estimated. Deviations between predicted and observed values were calculated by subtracting observed from predicted values. In this manner, a negative deviation means that the model-prediction exceeded the observed value. For positive deviations, the observed value exceeded the model-predicted value.

Import Price

Model-predicted import prices tend to be overestimates when observed import prices were below $1.00 (US) and underestimates when observed import prices were above $1.25 (Figure A1). Between these upper and lower bounds, there was no strong bias in either under- or overestimates of import price, although the model predictions overestimated prices at a higher rate (54%).

Observed import prices follow a distinct seasonal pattern, which is captured by the model. However, model performance varied over the time period. Specifically, from 1989 through 1991, when prices were lowest, the model tended to underestimate import prices (Figure A2). The standard deviation of the deviations from observed prices over this time period was twice as large as for the rest of the time series.

Figure A1. Deviations from Observed Import Price

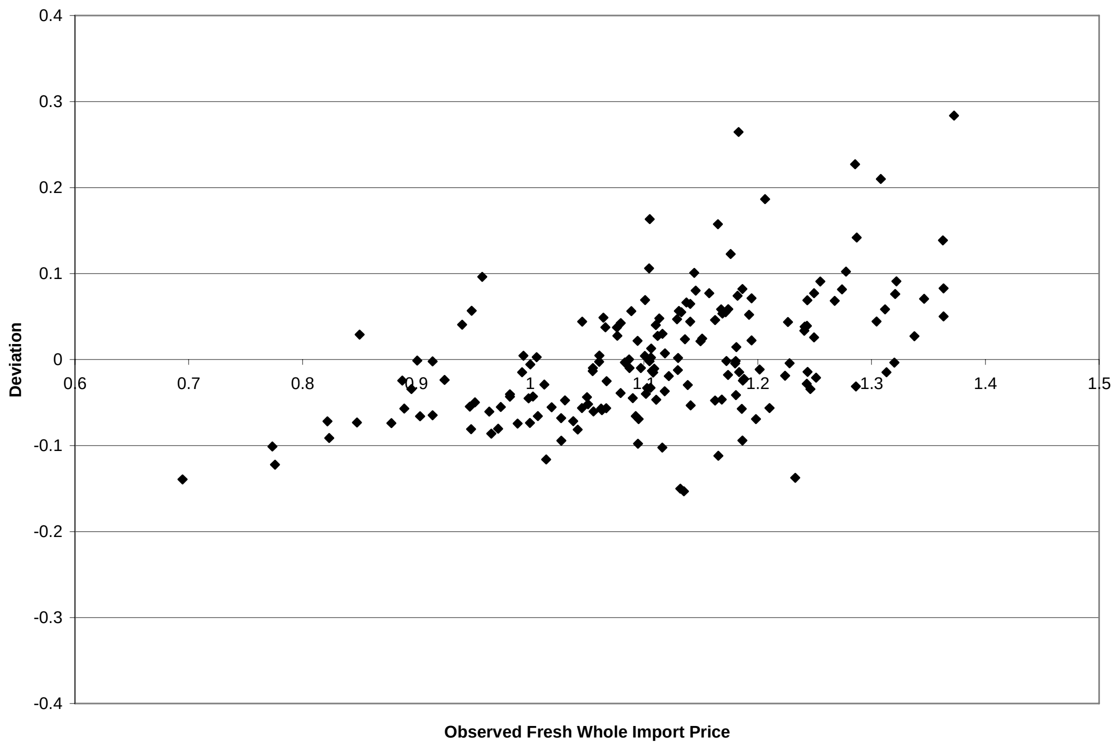
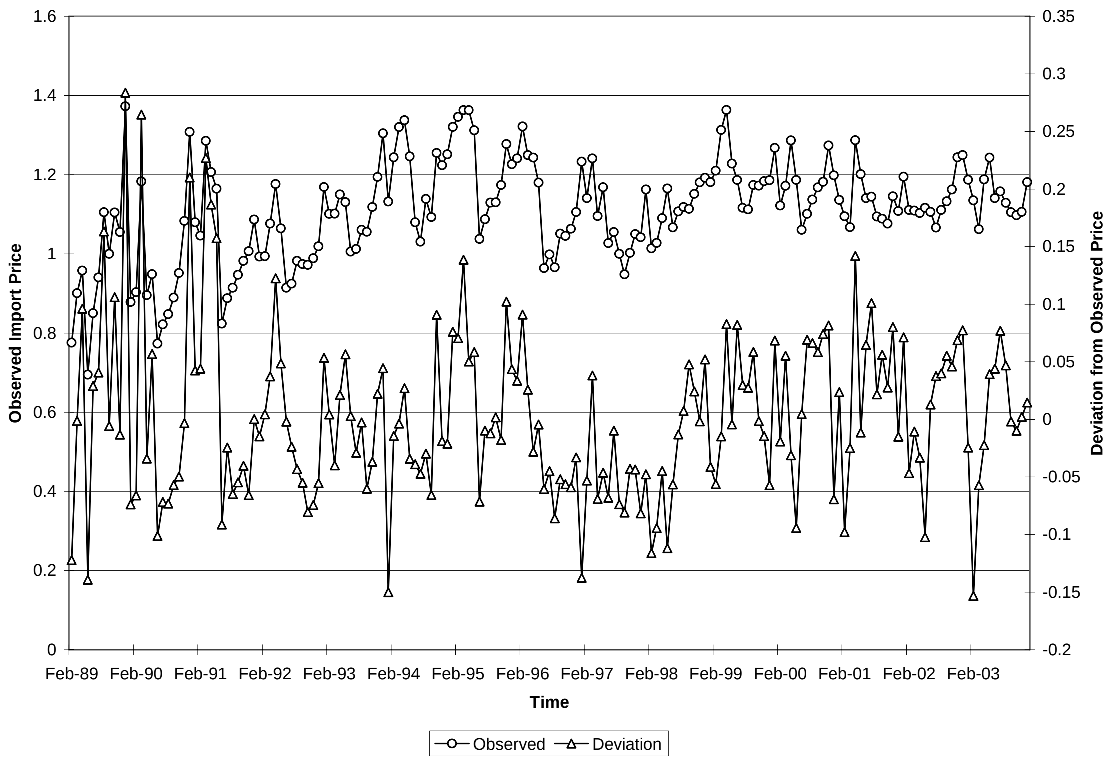


Figure A2. Time Series of Deviations from Observed Import Price



A second period of note is evident during calendar years 1996 through 1998. That is, the model-predicted import prices were consistently greater than observed prices. During calendar years 1992 through 1995 and from 1999 through 2003, import prices do not appear to be consistently under or overestimated

Model performance over the time series suggests that haddock markets have undergone some structural changes that have not been completely captured, although the model does appear to reasonably capture contemporary market conditions in import prices. Just how the model will perform as potential supplies of haddock increase is not, of course, known. Given known current and future abundance of haddock, increased supplies of haddock are probable and the import price is likely to go down. As noted above, the model tended to overestimate import prices when observed prices were low. This means that projected economic impacts could overstate realized impacts in the following manner. If import prices are overestimated, the Canadian ex-vessel price will also be overestimated because of the positive relationship between import price and ex-vessel price. Further, a higher import price would result in lower imported quantities that would, in turn, result in an overestimate of U.S. ex-vessel price because a reduction in import quantity will result in higher U.S. ex-vessel price.

Import Quantity

Deviations between observed values and predicted import quantities were larger (averaging almost 17% of the observed value) than deviations in import price (about 5% of observed prices) (Figure A3). This difference is to be expected since import demand is highly elastic. That is, import quantity responds proportionally more than a change in import price. Import quantity exhibits some of the same patterns over time as noted for import price (Figure A4). Note that the deviations follow a similar seasonal pattern as evident in the observed values. These seasonal peaks and valleys indicate that model predictions underestimate import quantities during observed peaks and overestimate import quantities during observed seasonal lows. Further, prediction error is greatest for these seasonal ups and downs and generally lower the rest of the year. This is because a fitted regression performs best at or near the average condition and is subject to greater error at the tails of the fitted data. For predictive purposes, this means that the model is likely to account for some of the seasonal nature of haddock markets, but the predicted seasonal highs and lows will be less pronounced than past observations.

Figure A3. Deviations from Observed Imported Quantities of Fresh Whole Haddock

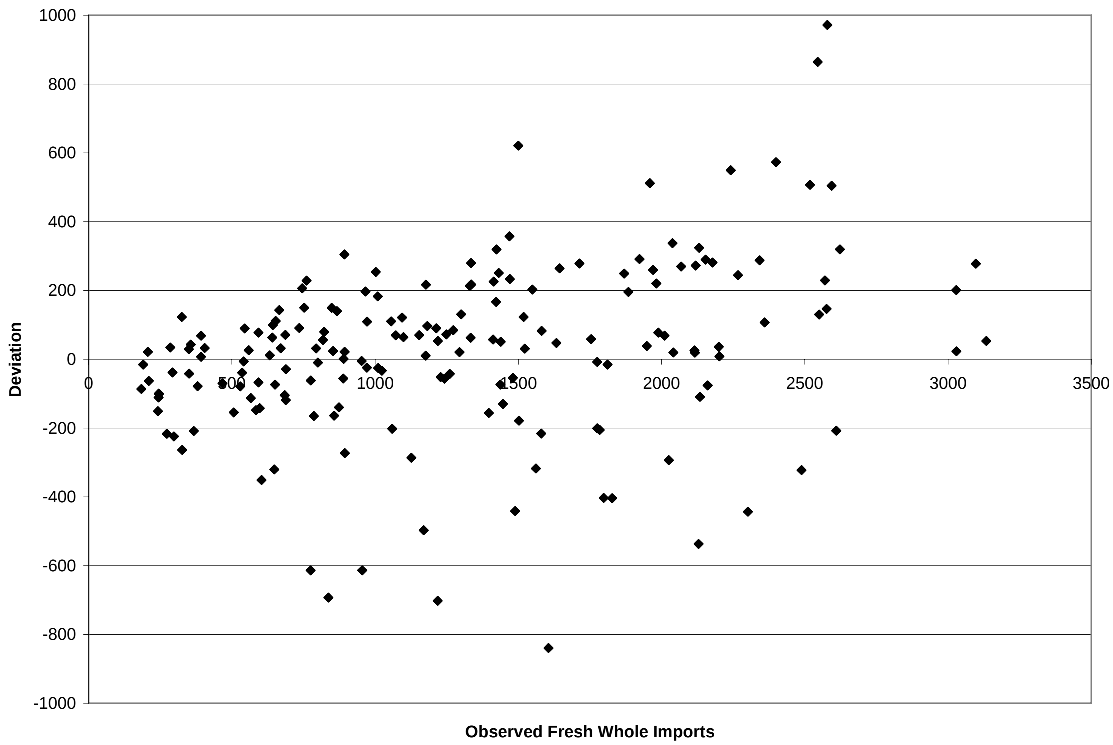
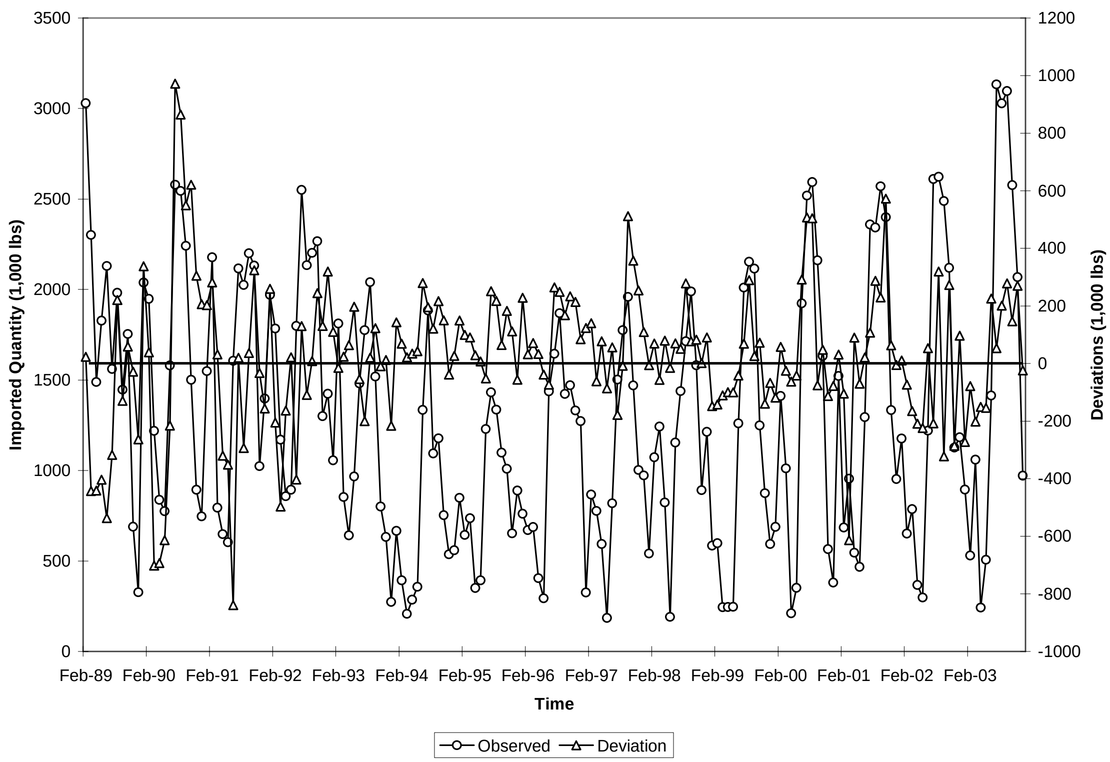


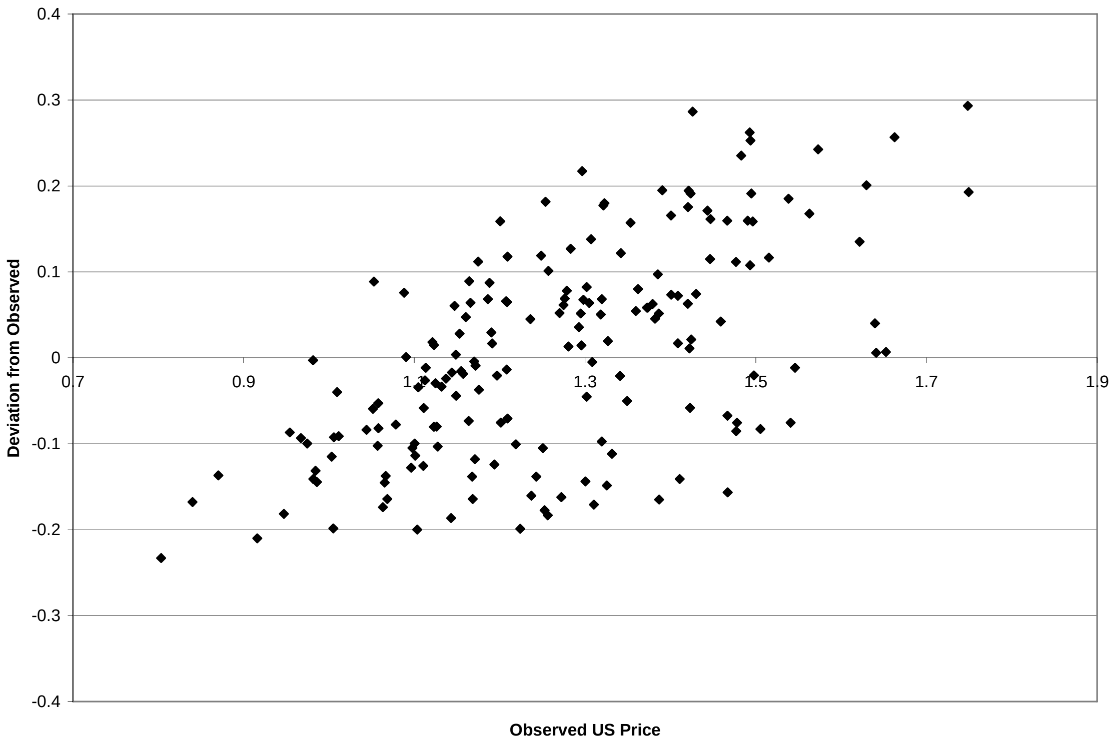
Figure A4. Time Series of Deviations from Imported Quantities of Fresh Whole Haddock



United States Ex-Vessel Price

The pattern of deviations between the predicted and observed ex-vessel price (Figure A5) in the United States is similar to that of the import price. Specifically, at lower observed ex-vessel prices (less than $0.95 per pound), the model consistently over-estimates price. The converse is true at higher prices. Overall, there was no systematic bias in terms of over- or underestimation of ex-vessel prices as half of the deviations were positive (price was underestimated) and the other half negative (price was overestimated). The average error was approximately 11% of the observed price.

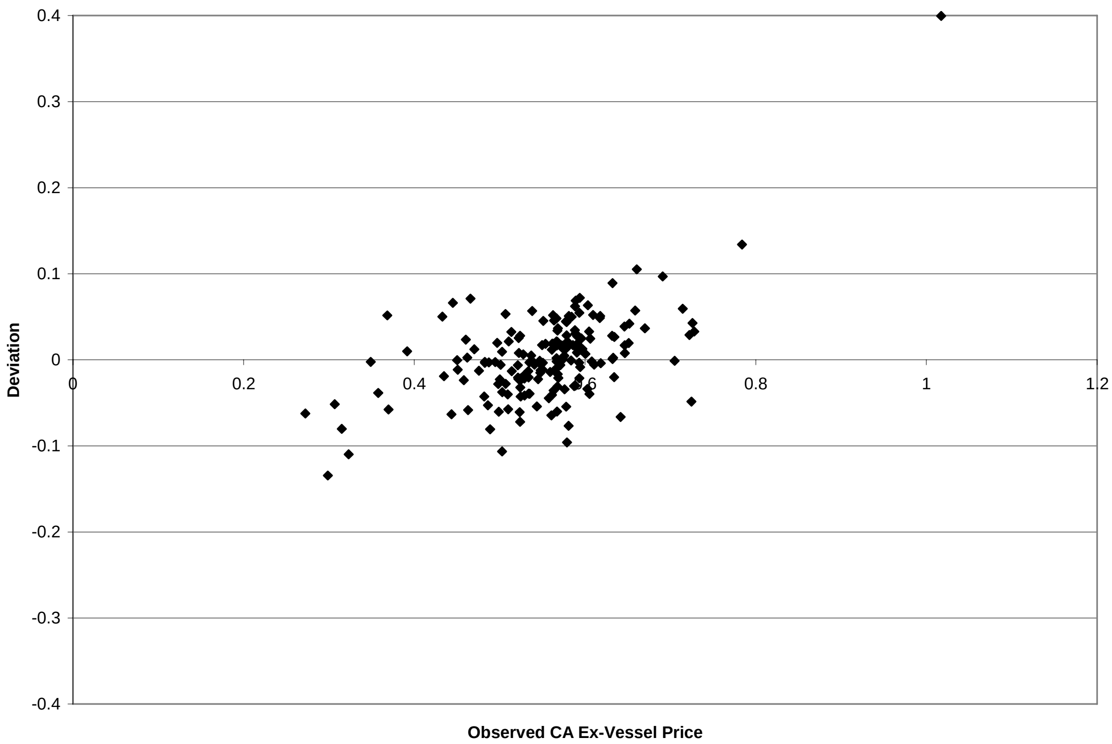
Figure A5. Deviations from Observed U.S. Ex-Vessel Prices of Haddock



Canadian Ex-Vessel Price

The predicted Canadian ex-vessel price equation provided the best overall fit to the data as the R-square value was 0.75, and with few exceptions, the distribution of deviations ranged within plus or minus $0.10 (Figure A6). As was the case for the U.S. ex-vessel price equation, there was no systematic tendency to either underestimate or overestimate ex-vessel price in Canada. The average estimation error was approximately 6% of the observed price.

Figure A6. Deviations from Observed Canadian Ex-Vessel Prices of Haddock



Appendix B – Data for Haddock Market Model

Table B1. Raw Data for Haddock Raw Material Market Model

Year	Month	Fresh Whole Import Price ($US)	US Ex-Vessel Haddock Price ($US)	Canadian Ex-Vessel Price ($US)	US Ex-Vessel Cod Price ($US)	US Live Weight Haddock Landings (1000 lbs)	Canadian Live Weight Haddock Landings (1000 lbs)	Fresh Whole Imports (1000 lbs)	Composite Import Price for Processed Products ($US)	Time Trend
1989	1	1.06	1.30	0.46	0.62	385	3818	2324	1.31	1
1989	2	0.78	1.01	0.36	0.63	227	7526	3029	1.60	2
1989	3	0.90	1.15	0.35	0.73	227	5913	2301	1.22	3
1989	4	0.96	1.09	0.31	0.51	666	5600	1489	1.55	4
1989	5	0.69	0.98	0.27	0.46	563	7003	1827	1.57	5
1989	6	0.85	1.05	0.37	0.48	538	8221	2129	1.53	6
1989	7	0.94	1.30	0.39	0.59	287	4743	1561	1.60	7
1989	8	1.11	1.43	0.47	0.64	281	4093	1982	1.54	8
1989	9	1.00	1.48	0.51	0.76	145	3303	1446	1.80	9
1989	10	1.10	1.49	0.46	0.73	144	3648	1754	1.79	10
1989	11	1.06	1.38	0.47	0.69	129	1361	689	1.42	11
1989	12	1.37	1.57	0.30	0.78	208	1102	327	1.10	12
1990	1	0.88	0.92	0.45	0.65	626	4899	2038	2.10	13
1990	2	0.90	1.16	0.43	0.86	126	4511	1948	2.18	14
1990	3	1.18	1.25	0.37	0.67	564	5248	1218	2.07	15
1990	4	0.90	1.16	0.32	0.64	830	4425	838	2.51	16
1990	5	0.95	1.20	0.32	0.49	654	4571	775	2.34	17
1990	6	0.77	0.87	0.43	0.51	954	5926	1580	2.31	18
1990	7	0.82	1.01	0.46	0.58	334	5004	2579	2.37	19
1990	8	0.85	1.09	0.45	0.63	310	4801	2545	2.32	20
1990	9	0.89	1.11	0.45	0.69	282	4577	2242	2.47	21
1990	10	0.95	1.16	0.51	0.72	454	2269	1500	2.41	22
1990	11	1.08	1.39	0.54	0.77	117	1399	893	2.53	23
1990	12	1.31	1.50	0.61	0.74	189	1333	745	2.60	24
1991	1	1.08	1.21	0.58	0.88	450	3289	1549	2.49	25
1991	2	1.05	1.10	0.57	0.88	205	4649	2177	2.87	26
1991	3	1.29	1.42	0.58	0.87	314	1810	794	2.82	27
1991	4	1.21	1.28	0.54	0.70	408	2601	648	2.60	28
1991	5	1.16	1.35	0.55	0.67	327	2662	604	2.87	29
1991	6	0.82	0.80	0.51	0.70	1180	7489	1606	2.77	30
1991	7	0.89	1.17	0.54	0.72	263	6006	2116	2.71	31
1991	8	0.91	1.26	0.55	0.88	263	5366	2025	2.62	32
1991	9	0.95	1.15	0.57	0.90	220	4803	2200	2.63	33
1991	10	0.98	1.27	0.58	0.97	207	3964	2131	2.66	34
1991	11	1.01	1.37	0.57	0.84	105	2321	1024	2.86	35
1991	12	1.09	1.40	0.60	1.03	109	3285	1397	3.03	36
1992	1	0.99	1.08	0.58	0.89	687	4057	1970	2.59	37
1992	2	0.99	1.12	0.46	0.91	293	4771	1784	2.64	38
1992	3	1.08	1.49	0.44	1.00	191	3531	1169	2.63	39

1992	4	1.18	1.42	0.50	0.82	507	2448	857	3.03	40
1992	5	1.06	1.14	0.59	0.68	868	2407	893	2.80	41
1992	6	0.91	0.84	0.48	0.75	1683	6805	1798	2.65	42
1992	7	0.92	1.19	0.50	0.88	225	6045	2550	2.65	43
1992	8	0.98	1.18	0.56	1.02	190	4666	2134	2.79	44
1992	9	0.97	1.27	0.55	1.03	181	4608	2202	2.73	45
1992	10	0.97	1.32	0.52	1.01	121	4050	2267	2.73	46
1992	11	0.99	1.47	0.51	0.77	87	2579	1301	2.85	47
1992	12	1.02	1.17	0.60	0.73	79	2458	1424	2.75	48
1993	1	1.17	1.45	0.56	1.03	137	2006	1056	2.98	49
1993	2	1.10	1.49	0.55	1.08	106	3647	1812	2.89	50
1993	3	1.10	1.49	0.59	0.92	124	1532	853	2.50	51
1993	4	1.15	1.54	0.57	0.77	194	1266	641	2.45	52
1993	5	1.13	1.30	0.66	0.68	244	1952	967	2.74	53
1993	6	1.01	1.21	0.56	0.80	580	4034	1481	2.76	54
1993	7	1.01	1.28	0.53	0.89	79	4130	1775	2.70	55
1993	8	1.06	1.39	0.59	0.98	89	3968	2041	2.73	56
1993	9	1.06	1.41	0.60	1.07	130	2629	1519	2.95	57
1993	10	1.12	1.41	0.57	0.98	120	1417	801	2.12	58
1993	11	1.19	1.75	0.57	0.85	57	1189	632	2.31	59
1993	12	1.30	1.75	0.50	1.02	78	807	273	2.31	60
1994	1	1.13	1.54	1.02	1.07	42	908	666	2.91	61
1994	2	1.24	1.48	0.72	0.87	62	636	393	2.84	62
1994	3	1.32	1.65	0.73	0.89	57	328	207	2.17	63
1994	4	1.34	1.64	0.72	0.91	57	493	286	2.66	64
1994	5	1.25	1.47	0.73	0.84	37	626	356	2.88	65
1994	6	1.08	1.24	0.63	0.81	62	2427	1335	2.83	66
1994	7	1.03	1.10	0.62	0.94	78	3424	1884	2.65	67
1994	8	1.14	1.46	0.65	1.15	55	1667	1094	2.61	68
1994	9	1.09	1.32	0.66	0.95	69	1785	1178	2.52	69
1994	10	1.25	1.42	0.63	0.86	97	1158	752	2.31	70
1994	11	1.22	1.47	0.59	1.05	49	957	536	2.28	71
1994	12	1.25	1.55	0.63	1.16	60	893	559	2.60	72
1995	1	1.32	1.50	0.63	1.15	69	1201	848	2.62	73
1995	2	1.35	1.41	0.60	1.19	70	855	643	2.36	74
1995	3	1.36	1.42	0.58	1.07	76	1172	735	2.54	75
1995	4	1.36	1.64	0.78	1.10	65	523	350	2.50	76
1995	5	1.31	1.48	0.71	0.83	55	713	393	2.17	77
1995	6	1.04	1.42	0.49	0.81	64	2674	1229	2.27	78
1995	7	1.09	1.22	0.59	0.79	98	2315	1432	2.36	79
1995	8	1.13	1.34	0.62	1.04	85	1989	1336	2.32	80
1995	9	1.13	1.25	0.59	0.88	85	1952	1099	2.30	81
1995	10	1.17	1.42	0.57	1.14	101	1384	1009	2.27	82
1995	11	1.28	1.25	0.52	0.76	71	1028	653	2.12	83
1995	12	1.23	1.22	0.50	1.09	64	1629	888	2.10	84
1996	1	1.24	1.30	0.56	0.96	79	886	761	1.88	85
1996	2	1.32	1.33	0.55	1.11	74	1033	670	1.90	86
1996	3	1.25	1.31	0.59	1.01	59	1071	687	2.29	87
1996	4	1.24	1.39	0.67	0.96	48	649	405	2.46	88
1996	5	1.18	1.27	0.63	0.64	81	622	293	1.37	89

1996	6	0.96	1.10	0.46	0.63	94	3558	1437	1.73	90
1996	7	1.00	1.07	0.52	0.78	154	2987	1644	2.43	91
1996	8	0.97	1.10	0.50	0.89	151	3166	1869	1.99	92
1996	9	1.05	1.20	0.53	0.98	139	2306	1422	2.20	93
1996	10	1.05	1.17	0.56	0.90	121	2257	1470	1.95	94
1996	11	1.06	1.17	0.55	0.97	128	2077	1331	2.26	95
1996	12	1.11	1.19	0.53	1.09	137	2130	1273	2.33	96
1997	1	1.23	1.51	0.69	1.28	134	250	325	1.47	97
1997	2	1.14	1.24	0.55	0.96	149	1359	867	1.71	98
1997	3	1.24	1.35	0.57	1.17	119	1266	775	1.66	99
1997	4	1.10	1.48	0.55	0.75	140	1020	593	2.11	100
1997	5	1.17	1.26	0.60	0.65	129	529	185	1.95	101
1997	6	1.03	1.21	0.50	0.67	141	1775	818	1.97	102
1997	7	1.06	1.13	0.48	0.86	149	3319	1502	2.02	103
1997	8	1.00	1.07	0.49	0.96	149	3287	1776	2.16	104
1997	9	0.95	0.98	0.48	0.87	713	3093	1959	2.08	105
1997	10	1.00	0.95	0.49	0.88	715	2393	1469	2.08	106
1997	11	1.05	1.01	0.48	0.88	399	1616	1003	2.32	107
1997	12	1.04	1.06	0.50	1.04	377	1653	972	1.98	108
1998	1	1.16	1.31	0.58	1.28	548	935	541	2.11	109
1998	2	1.01	1.11	0.52	1.04	613	2070	1073	2.43	110
1998	3	1.03	1.30	0.52	1.22	523	2474	1242	2.57	111
1998	4	1.09	1.44	0.54	0.85	342	1497	823	2.61	112
1998	5	1.17	1.33	0.59	0.83	338	363	191	2.11	113
1998	6	1.07	1.30	0.52	0.98	458	2340	1154	2.12	114
1998	7	1.11	1.20	0.55	1.14	626	2642	1438	2.72	115
1998	8	1.12	1.13	0.53	1.15	562	2816	1713	2.92	116
1998	9	1.11	1.21	0.53	1.12	739	4041	1989	3.02	117
1998	10	1.15	1.34	0.52	1.25	562	2753	1581	3.11	118
1998	11	1.18	1.33	0.56	1.13	388	1603	890	3.02	119
1998	12	1.19	1.29	0.52	1.09	557	2321	1213	3.24	120
1999	1	1.18	1.37	0.57	1.36	703	1289	584	3.22	121
1999	2	1.21	1.56	0.65	1.46	366	1205	597	2.96	122
1999	3	1.31	1.62	0.71	1.21	318	581	244	2.99	123
1999	4	1.36	1.63	0.64	0.98	404	691	245	3.22	124
1999	5	1.23	1.30	0.63	0.86	759	736	246	2.89	125
1999	6	1.19	1.39	0.56	0.99	628	2938	1260	2.80	126
1999	7	1.12	1.13	0.57	1.07	800	3774	2011	2.83	127
1999	8	1.11	1.19	0.58	1.14	622	3455	2154	2.54	128
1999	9	1.17	1.24	0.60	1.36	628	3759	2115	3.07	129
1999	10	1.17	1.29	0.61	1.34	622	1967	1248	2.88	130
1999	11	1.18	1.38	0.58	1.24	333	1779	874	3.05	131
1999	12	1.19	1.14	0.65	1.32	747	1095	593	2.74	132
2000	1	1.27	1.45	0.65	1.28	544	1438	688	2.43	133
2000	2	1.12	1.12	0.57	1.18	1165	2539	1412	2.62	134
2000	3	1.17	1.28	0.59	1.11	1426	2024	1011	2.49	135
2000	4	1.29	1.66	0.58	1.24	735	437	210	2.60	136
2000	5	1.19	1.52	0.65	1.03	584	745	351	2.70	137
2000	6	1.06	1.11	0.57	0.77	786	3903	1923	2.57	138
2000	7	1.10	1.06	0.58	0.85	504	4309	2518	2.68	139

2000	8	1.14	1.25	0.59	1.14	683	3993	2594	2.75	140
2000	9	1.17	1.28	0.59	1.20	399	3663	2161	2.39	141
2000	10	1.18	1.31	0.57	1.10	874	2873	1633	2.60	142
2000	11	1.27	1.49	0.59	0.97	371	1225	566	2.85	143
2000	12	1.20	1.43	0.58	1.13	752	819	381	2.99	144
2001	1	1.14	1.06	0.56	1.07	1382	3049	1522	2.46	145
2001	2	1.09	1.42	0.61	1.35	1045	1360	685	2.74	146
2001	3	1.07	0.99	0.51	1.01	1653	3351	955	2.83	147
2001	4	1.29	1.19	0.54	0.90	1470	939	545	2.52	148
2001	5	1.20	1.36	0.59	1.08	720	986	467	2.25	149
2001	6	1.14	1.32	0.53	0.78	840	3026	1295	2.80	150
2001	7	1.14	1.12	0.52	0.88	823	4334	2360	2.12	151
2001	8	1.09	1.05	0.57	1.11	1004	3990	2342	2.90	152
2001	9	1.09	0.97	0.49	1.02	1205	4948	2570	2.83	153
2001	10	1.08	0.97	0.51	1.03	1151	3798	2399	2.86	154
2001	11	1.15	1.19	0.51	0.87	654	2684	1333	2.62	155
2001	12	1.11	1.17	0.50	0.94	898	1913	953	2.73	156
2002	1	1.19	1.15	0.52	1.11	1575	2305	1176	2.68	157
2002	2	1.11	1.11	0.53	1.09	2007	1389	651	2.58	158
2002	3	1.11	1.32	0.59	1.00	1419	1870	787	2.10	159
2002	4	1.10	1.14	0.54	0.80	2029	1266	367	2.76	160
2002	5	1.12	1.16	0.56	1.19	1583	973	298	2.62	161
2002	6	1.11	1.12	0.53	0.96	1821	2647	1219	2.67	162
2002	7	1.07	0.95	0.52	1.05	1612	5996	2610	2.76	163
2002	8	1.11	1.21	0.54	1.22	960	4265	2622	2.88	164
2002	9	1.13	1.01	0.52	1.22	1149	5042	2488	2.81	165
2002	10	1.16	1.15	0.57	1.38	1317	3083	2119	2.57	166
2002	11	1.24	1.30	0.57	1.32	547	2316	1127	2.85	167
2002	12	1.25	1.40	0.59	1.08	607	1848	1183	2.51	168
2003	1	1.19	1.32	0.59	1.36	997	1809	894	2.46	169
2003	2	1.14	1.36	0.61	1.53	1518	905	530	2.58	170
2003	3	1.06	1.10	0.57	0.99	1686	2637	1059	2.61	171
2003	4	1.19	1.07	0.56	1.04	2441	737	242	2.65	172
2003	5	1.24	1.10	0.59	1.27	1770	1323	507	2.85	173
2003	6	1.14	1.17	0.58	0.98	1727	2613	1414	2.73	174
2003	7	1.16	1.16	0.57	1.21	762	5823	3134	3.08	175
2003	8	1.13	1.04	0.59	1.13	567	4922	3028	2.92	176
2003	9	1.10	1.06	0.60	1.37	603	4747	3097	3.06	177
2003	10	1.10	0.98	0.61	1.35	949	4145	2576	2.91	178
2003	11	1.11	1.00	0.58	1.20	941	3289	2068	2.86	179
2003	12	1.18	1.17	0.62	1.22	1000	1819	971	3.13	180

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