HARVEST STRATEGIES FOR A TRANSBOUNDARY RESOURCE: GEORGES BANK HADDOCK

Eric M. Thunberg, National Marine Fisheries Service, Eric.Thunberg@NOAA.GOV
Charles M. Fulcher, National Marine Fisheries Service, Charles.Fulcher@NOAA.GOV
Jon K. T. Brodziak, National Marine Fisheries Service, Jon.Brodziak@NOAA.GOV

ABSTRACT

The eastern Georges Bank haddock resource is shared and managed by the U.S. and Canada through a transboundary resource sharing agreement. This agreement includes an annual process for joint stock assessment, setting of a TAC, and harvest shares for each country. The resource sharing agreement provides a mechanism for establishing bilateral action by both countries, but covers only part of the total haddock stock on Georges Bank. The resource sharing agreement does not apply to non-Georges Bank haddock stocks in the U.S. and Canada. Haddock is an important source of income for U.S. and Canadian fishermen and is a commodity that is traded between the two countries. Thus, management decisions taken under the transboundary sharing agreement have implications for domestic markets in the U.S. and Canada and through trade links between the two countries. This paper explores the implications of pursuing different harvest strategies between the U.S. and Canada within an institutional setting that requires bilateral control over a portion of potential haddock supplies, yet provides opportunities to take unilateral action that could affect international trade and prices received by domestic fishermen in both countries.

Keywords: Transboundary resource, Trade, Harvest Strategy

INTRODUCTION

Haddock is one of several groundfish species harvested on Georges Bank by U.S. and Canadian fishermen. Along with cod and yellowtail flounder, the eastern Georges Bank haddock resource is managed by the U.S. and Canada through a transboundary resource sharing agreement. This agreement includes an annual process for joint stock assessment, setting of TACs, and harvest shares. The resource sharing agreement consists of a three-tiered process that includes an assessment committee, a management guidance committee, and a policy setting level. The Transboundary Resource Assessment Committee (TRAC) is charged with the task of determining current stock status including biomass levels, fishing mortality rates, and estimating TACs for the coming calendar year. The TRAC recommendations are forwarded to the Transboundary Management Guidance Committee (TMGC) for consideration. The TMGC may accept the recommended TACs or may make adjustments to account for uncertainties in the assessments. The TMGC recommendations are presented to the Transboundary Resource Steering Committee (hereafter referred to as the Steering Committee) for final approval and adoption by each country. The Steering Committee is also responsible for setting policy for the sharing agreement which may include setting terms of reference for specific research issues and setting harvest strategies.

Although not a formal treaty or statutory obligation, the resource sharing agreement provides a mechanism for establishing bilateral action by both countries. However, the agreement covers only part of the total haddock resource on Georges Bank. The resource sharing agreement also does not apply to non-Georges Bank haddock stocks in the U.S. and Canada. Within this setting each country is bound by the sharing agreement to take bilateral action affecting a portion of the domestic supply of haddock in each country, but is free to pursue different management objectives affecting haddock supplies harvested from resources not subject to the agreement.

Even though regulatory approaches differ, with Canada operating under an ITQ system and the U.S. using days at sea controls, both countries have pursued common biological objectives for all haddock resources. However, under the auspices of the resource sharing agreement representatives of the Canadian processing industry approached the Steering Committee in 2004 to consider changing the harvest strategy for the Eastern Georges Bank haddock resource. This request was prompted by concerns over the potential market effects of the 2003 year class of haddock on Georges Bank, which was assessed at almost twice the size as the previous largest recorded year class in 1963 (Figure 1). Anticipated landings as such a large year class recruits into the fishery were believed to cause depressed prices. Processors also suggested that they needed more time to adjust production capacity and to build markets to accommodate the larger supply of raw material. To accomplish these objectives consideration of a constant harvest strategy was requested and the Steering Committee asked for an economic analysis of alternative harvest strategies for the Eastern Georges Bank resource area.

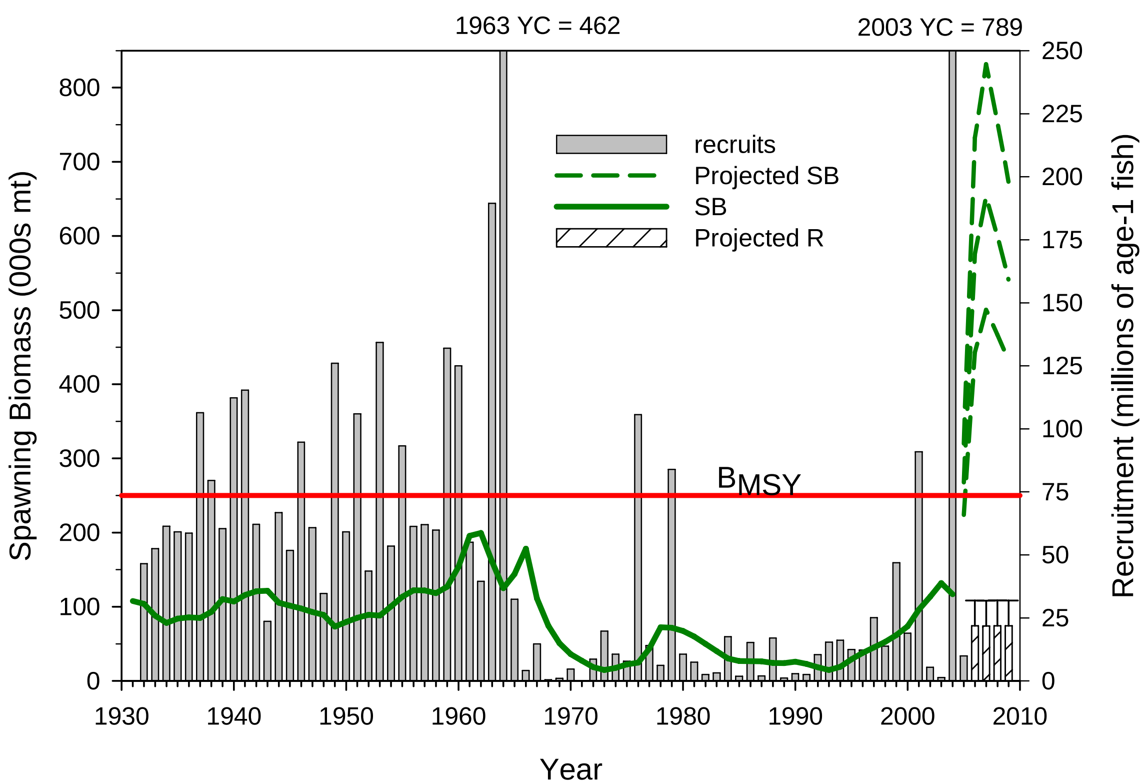

Figure 1. Observed and projected recruits and spawning biomass for Georges Bank haddock (1930 – 2010)

This paper provides an overview of the economic analysis conducted at the request of the Steering Committee. The first section provides a description of the market relationships between the U.S. and Canada. The second section describes the econometric model that was developed to evaluate market impacts. In that section, data sources are discussed and a brief description is presented of the methods used to project haddock supplies over a ten year time frame. Model results are presented in the third section followed by a concluding section that offers extensions to the analysis and potential means of improving economic yield for the shared groundfish resources.

THE U.S. CANADA HADDOCK MARKET

Modeling the U.S. and Canadian trade in groundfish products received considerable attention during the early to mid-1980s as U.S. harvesters argued that Canadian imports were driving down ex-vessel prices. Past studies of groundfish markets [1,2] developed a system of equations to reflect supply and demand relationships at different market levels including imports, but focused on undifferentiated processed groundfish.

The economic implications of a change in haddock harvest strategy will depend on how international markets adjust 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 [3,4]of the cod market suggest that linkages between North American (U.S. and Canada) and European 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.

The U.S. domestic market is the primary market for domestic landings and for imported haddock from Canada. In evaluating the economic effect of different harvest strategies for haddock, the market of most interest is a raw material market since at least 85% of all haddock imports from Canada are fresh whole haddock, and consumers in the Northeast and New England in particular prefer fresh fish. In effect, this market is a derived demand by U.S. processors for factor inputs. Within this context, it is important to determine the substitutability between domestic and imported whole haddock and the impact that market substitution has on ex-vessel prices. If U.S. processors substitute domestic landings for imported haddock, then an increase in U.S. landings would reduce the quantity demanded for Canadian imports. Ex-vessel prices in both the U.S. 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 [2]. 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 U.S. 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.

ECONOMETRIC MODEL OF THE U.S. – 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 U.S. ex-vessel price of haddock lagged one period, the ex-vessel price of cod, U.S. domestic haddock landings, and a time trend. The import price is expected to be negatively related to quantity demanded. 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. The lagged price is likely reflective of an underlying adjustment process 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.

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. In our time series, 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 decrease.

U.S. 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 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 U.S., 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. 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 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.

Data

The system of equations described above was estimated using monthly data obtained from several sources (available from the authors upon request) 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. Data on monthly U.S. landings in live weight and value were obtained from Northeast region dealer 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 U.S. Census Bureau. All price data were expressed in nominal terms converted to U.S. dollars. Also, since both U.S. 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.

Biological Projections

Three alternative constant 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. In each case, fishing mortality rates were not permitted to exceed the reference fishing mortality rate of $F_{Ref}=0.26$. To reflect the current harvest strategy and form a basis for comparison, a fourth projection was conducted by setting constant fishing mortality equal to $F_{Ref}=0.26$.

Projected landings streams for the period 2005 to 2014 for each of these harvest strategies were provided per guidance from the TRAC 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 (reflecting recent environmental conditions). These conditions are assumed to prevail at least over the medium term. The projection time period was selected to bring the entire 2003 year class into the 9+ age class. 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.

Procedures for Estimating Economic Effects of Different Harvest Strategies

The econometric model of the 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 variables 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 1).

Since the proposed change in harvest strategy would only affect landed haddock from the resource sharing area, all other landings were treated as exogenous. Projected landings from both the Gulf of Maine and Canadian non-Georges Bank landings were not available so quantities from these resources were held constant at their recent three-year average (Table 2). Landings from the Western portion of the Georges Bank resource were projected using the same methods used for the Eastern resource area.

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 market model includes 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.

Table 1. 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

Table 2. 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

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 [5]. 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).

RESULTS

Econometric Model

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 3). The signs of all variables were consistent with prior 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 U.S. 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 these relationships are estimated with considerably more error, perhaps due to some form of unaccounted for specification or measurement error. Model performance (a detailed discussion is available from the authors upon request) 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 supplies of haddock may lie outside the range of observed data. However, even though the 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 ordinal rankings of alternative harvest strategies.

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 U.S. processor demand for imported whole fish from Canada is very responsive to the raw material price. By contrast, the substitution elasticity for U.S. 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.

The price equations for the U.S. 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 U.S. 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 U.S. (-0.06) suggesting that a proportional increase in U.S. 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 U.S. ex-vessel demand suggests that the availability of imports has a price dampening effect on prices received by U.S. harvesters.

Table 3. Results of Estimated U.S. – 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* (0.442)	-3.244* (0.716)	1.154* (0.107)	0.030 (0.072)
Import Price	-11.642* (1.328)	3.515* (0.666)		
Haddock Price t-1 (US)	1.325* (0.586)		0.161* (0.059)	
Haddock Price t-1 (CA)				0.319* (0.051)
Ex-vessel Cod Price (US)	2.120* (0.417)		0.162* (0.031)	
Landings (US)	-0.276* (0.085)		-0.060* (0.007)	
Landings (CA)		1.220* (0.088)		-0.251* (0.034)
Landings t-1 (CA)		0.113* (0.048)		
Import Quantity			-0.088* (0.013)	0.173* (0.035)
Alternative Processed Products Price		-0.411* (0.165)		0.314* (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.

Projected Landings, Import Sales, and Ex-Vessel Revenue

Of the constant harvest strategies only the harvest level of 30,000 mt was sustainable for the entire projection period (Table 3). A 40,000 mt constant harvest would be sustainable for six years beginning in 2007 while the 50,000 mt constant harvest strategy would only be maintained for three years. Cumulative projected landings were 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 3). 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 3. Summary of Median 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

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 4). Further, both cumulative import quantities and value of sales for these two harvest strategies are virtually identical. 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. At a discount rate of 7%, 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. Note that a sensitivity test using discount rates ranging from 3% to 9% had no affect on the ordinal ranking of the harvest alternatives in terms of import sales or estimated revenues to U.S. and Canadian harvesters.

Table 4. Predicted Median Import Quantities and 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 5). 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.

Variability in Projected Yield

The 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 2). In Figure 2 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

Table 5. Predicted Median 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
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

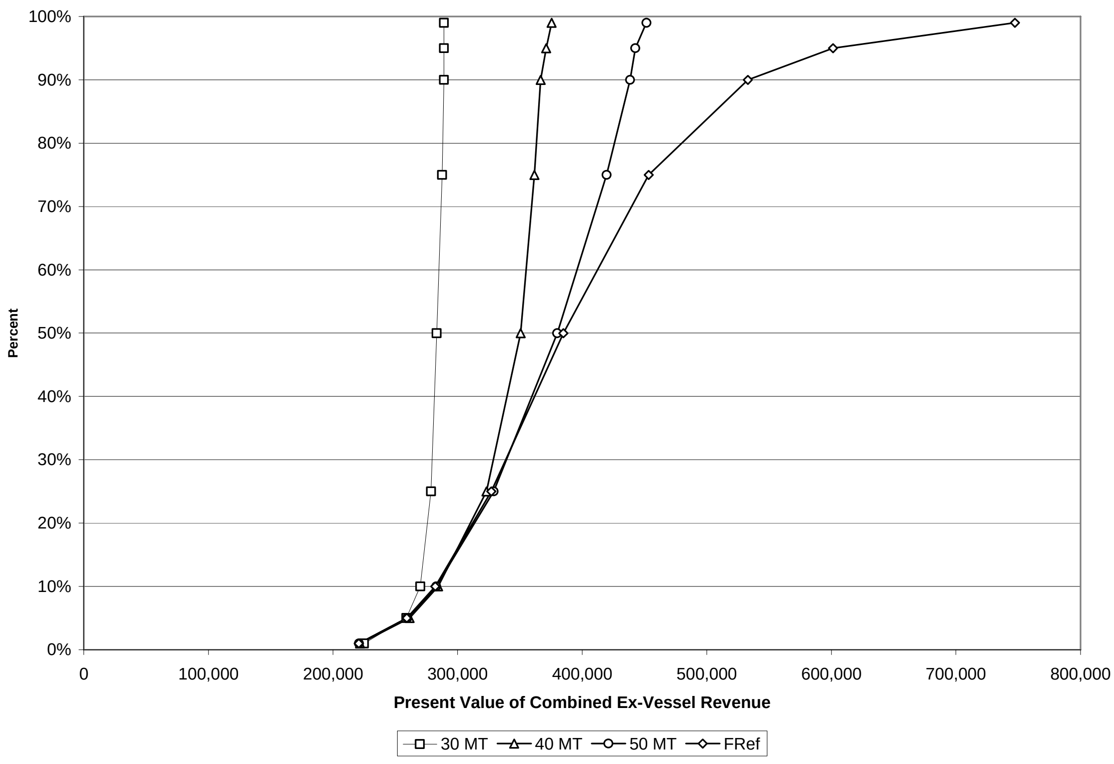

Figure 2. Cumulative probability distribution for combined present value of U.S. and Canadian ex-vessel revenue ($1,000 U.S.)

the median values reported in the above tables 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 2 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 constant TAC. This is also true of the 30,000 and 40,000 mt constant harvest strategies. 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.

CONCLUSIONS AND EXTENSIONS

The findings of this study demonstrate that haddock markets create interdependencies between the U.S. and Canada. Changes in management strategy will affect haddock trade and prices received by fishermen in both countries. Of the harvest strategies considered herein, harvesting at a constant F_{Ref} produced the highest present value of ex-vessel revenues in both the U.S. and in Canada and produced the highest present value of import sales of haddock from Canada to the U.S. This finding was robust with respect to the choice of discount rate. Taking uncertainty over projected landings into account also favored the constant F_{Ref} strategy as it more readily takes advantage of future recruitment events. This finding is tempered by a number of caveats noted throughout that bear repeating.

First, as with any fitted statistical model, predictions will be more reliable when applied to conditions that are within the range of observed data. Given the size of the 2003 haddock year class landings are 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 U.S. 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 amounts 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.

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, closures 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. share of the Eastern Georges Bank TAC haddock will not be taken. Given the comparatively low cod TAC, bycatch rates of cod in the haddock fishery may make allowable levels of constant catch or constant F_{Ref} harvest strategies difficult to achieve.

Extensions

Throughout the development of the modeling exercise several avenues for extension of the analysis were identified. First, a price premium is known to be paid for larger haddock. 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. Further exploration of this issue is warranted but should be regarded as largely speculative due to lack of reliable data.

Second, while still remaining within the statutory limits of the Sustainable Fisheries Act, the possibility still exists, at least in the U.S., to pursue a harvest strategy on haddock resources not subject to the resource sharing agreement that could have an impact on import markets as well as ex-vessel prices. The modeling framework developed for this study could be used to explore the implications of such unilateral action taken by either the U.S. or Canada. Note that within the context of regulatory requirements such action would be limited to suppressing haddock supplies through some form of management or coordinated industry action.

In a recent study by Soboil and Sutinen [5] the authors point out potential gains from coordinated management of shared groundfish resources on Georges Bank. Presumably being able to take advantage of these potential gains is one of the reasons for the resource sharing agreement in the first place. However, in its current form the sharing agreement would not be able to take full advantage of an arrangement like that suggested by Soboil and Sutinen because of the single species nature of the sharing agreement. That is, the resource sharing agreement does not make it possible to adjust the sharing formula for individual species to maximize economic return to both countries. For example, the Canadian share of the Georges Bank yellowtail flounder TAC has not been taken in recent years. Likewise, the U.S. share of the haddock TAC has not been taken. Economic yield may be improved if it were possible to transfer some of the Canadian yellowtail flounder quota to the U.S. and vice versa for haddock. Movement toward such transfers would provide opportunities to enhance the economic value from the use of Georges Bank groundfish and would be a true sharing arrangement for transboundary resources.

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