The Gulf of Mexico Grouper/Tilefish Fishery After Introduction of an Individual Fishing Quota Program: The Impact on Ex-vessel Prices

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Introduction

Increased attention is being given to evaluating the impacts of catch shares on federally-managed fisheries. One impact often mentioned but backed up with only limited empirical evidence is the assertion that implementation of a catch share program can result in an increased ex-vessel price associated with an improved quality of the harvested product. Studies that have been conducted which examine whether implementation of a catch share program results in a higher price for the landed product, furthermore, appear to be primarily focused on fisheries for which the season was significantly truncated prior to establishment of an IFQ program, due to a depletion of the stock size (and often the 'derby' effect when 'hard' quotas are initiated), and, as a result of a rebuilding of the stock, extended thereafter. In one of the earliest studies to examine the influence of a catch share program on price, Herrmann (1996) empirically examined dockside price effects associated with the introduction of an IVQ (Individual Vessel Quota) system in the Canadian Pacific halibut fishery. The season length of this fishery had declined from 121 days in 1974 to only 10 days in 1990, the year before introduction of the IVQ program.[1] By 1994, the season had increased to 260 days. Based on a three structural equation system (U.S. import demand for Canadian Pacific halibut to the United States, the Canadian supply of Pacific halibut to the United States, and an ex-vessel price for British Columbian halibut) and three identity equations to clear the market, and employing annual data covering the 1974-94 period for analysis, Herrmann (1996) found that the IVQ program culminated in a substantial increase in the ex-vessel price (about 40%) relative to any increase that may have occurred in the absence of the IVQ program. It is suggested by the author that much of the increase is attributable to the extended fishing season.[2]

An IFQ program for the federal Alaska Sablefish fishery was implemented in 1995. Like the British Columbian halibut season, the length of the federal Alaska Sablefish fishery had been shortened over time, equaling only 14 days in 1994. After implementation of the program, season length gradually increased and in 2014 equaled 245 days. To examine the role of the IFQ program on the derived demand for Alaska region sablefish (and hence ex-vessel price), Warpinski et al. (2016) developed a model consisting of three behavioral equations and a market clearing identity. Japan is the dominant buyer of Alaska sablefish and, as such, the first behavioral equation represented the Japanese demand for Sablefish from the United States. The second behavioral equation was modeled in such a manner to measure U.S. export allocation to Japan which is largely determined by Alaska's landings (itself being a function of management quotas and the real export price). The derived Alaska Sablefish inverse ex-vessel price is given as a function of the real export price to Japan and average daily landings. These three equations were estimated using annual data covering the 1988-2014 period. Employing a simulation process in which actual season length was held at the 1994 season length, Warpinski et al. (2016) estimated that, in the absence of an expanded season, the Alaska Sablefish ex-vessel price would have been approximately 27% higher in 2014 relative to the observed price of $7.91/kg.

There are two common themes associated with these studies. First, the studies found a significant price increase associated with the introduction of the catch share program. Second, each of these fisheries can

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[1] As noted by Herrmann (1996) the British Columbia season in 1990 actually consisted of two four-day periods (in April and *June*) and a two-day period in September with vessels only allowed to fish in one of the four-day periods. Thus, any vessel was limited to only six days of fishing.

[2] This study has more recently been expanded by Herrmann and Criddle (forthcoming) to include the Alaskan portion of the halibut fishery which came under an IFQ program in 1995 after the fishing season was reduced from 96 days in 1976 to only two days in 1994. Using a set of six simultaneous demand and supply equations, the authors found results similar to those reported by Herrmann (1996); i.e., a large increase in ex-vessel price.

be characterized as having a (very) shortened season prior to the introduction of the IFQ/IVQ season and an expanded season thereafter. The authors of the respective studies, in general, indicate that the price increases can largely be explained by the expanded fishing seasons. As suggested by Wilen and Homans (1994) and cited in Herrmann (1996):

"Marketing losses occur in open-access or regulated open-access fisheries for several reasons. Foremost among these is poor-quality raw product associated with the race to catch fish (gear-damaged fish, undersized fish, lack of on-board handling). Additional factors include reduced-quality wholesale product associated with capacity bottlenecks, freezing deterioration, and inability to market when fewer substitutes are available. All of these translate into lower ex-vessel prices…"[3]

While many catch share programs are initiated only after a 'derby' has developed in the fishery, this does not appear to be the situation with respect to the grouper/tilefish fishery. With the exception of a few relatively short seasonal closures, the fishery was, for all intents and purposes, a year-round fishery prior to the IFQ program being introduced.[4] Thus, reasons cited by Wilen and Homans (1994) for lower ex-vessel prices in a regulated open-access fishery may not be valid when considering the grouper/tilefish fishery.[5]

The Models and Data

Previous studies that have empirically examined the influence of the introduction of an IFQ system on ex-vessel prices have traditionally done so using a set of structural equations (generally *ad hoc*) with relevant marketing clearing prices to estimate demand and supply functions for the species being examined. Given the large number of species in the grouper/tilefish complex in conjunction with the paucity of literature associated with the markets for these species (which may differ among species in the complex), an alternative method was employed to examine whether introduction of the grouper/tilefish IFQ program resulted in higher dockside prices. Specifically, a complete demand system was specified for purposes of analysis.

Estimation of a complete demand system involves a number of questions that must first be addressed. The first is the functional form to employ for analysis. The second is whether quantities or prices (or both) should be treated as endogenous (or both). The third is the selection of substitutes/complements to include in the model. The fourth is the type of time series data to employ in the analysis (e.g., monthly, quarterly, or annual) as well as the length of analysis.

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[3] While not explicitly mentioned by Wilen and Homans (1994), market gluts, even in the absence bottlenecks, can result in lower ex-vessel prices.

[4] A list of temporal closures can be found at: http://sero.nmfs.noaa.gov/sustainable_fisheries/acl_monitoring/commercial_gulf/reef_fish_historical/index.html. While the fishery was, for all intents and purposes, a year-round fishery prior to introduction of the IFQ program, there were a limited number of short temporal closures. For example, red grouper and the shallow-water grouper complex were closed briefly in 2004 and 2005. Tilefish and, to a lesser extent, the deep-water grouper, which are minor components of the grouper/tilefish 'fishery' experienced longer closures. While experiencing longer closures, evidence that a 'derby' developed for these components of the grouper/tilefish fishery is relatively weak. In fact, the amendment that created the grouper/tilefish IFQ program was done so, at least in part, to prevent a derby from developing.

[5] In support of this statement, recent analysis by Keithly and Wang (2017) found no appreciable changes in product form and market outlets when comparing dealer/processors activities both before and after introduction of the grouper/tilefish IFQ program.

With respect to the functional form, the Almost Ideal Demand System (AIDS) model (or some variant) has become the 'model of choice' when estimating a complete demand system due to its simplicity in both development and interpretation. It was originally developed by Deaton and Muellbauer (1980), with quantity being considered endogenous, while Moschini and Vissa (1992) and Eales and Unnevehr (1994) proposed the inverse version of it (i.e., price is considered endogenous while quantity is considered exogenous). The Inverse Almost Ideal Demand System (IAIDS) model possesses the same properties as the AIDS model initially proposed by Deaton and Muellbauer (1980) but is derived from the distance function rather than the cost function. The IAIDS model approach is generally considered to be appropriate when quantities are considered to be predetermined and prices are endogenous.

The primary purpose of this study, as noted in the Introduction, is to examine whether implementation of the grouper/tilefish IFQ program resulted in an increase in dockside prices. To examine this issue, we consider an IAIDS model where price is treated as endogenous and quantity is predetermined. While the majority of fishery-related demand studies consider quantities as predetermined and prices as endogenous or, sometimes, simultaneously determined with quantities (other than studies examining imports), this is not necessarily always the case. Based on the assumption that the ability to change effort, and hence catch, becomes more limiting the shorter the duration (e.g. in a month rather than a quarter or year) we also made the decision to analyze the effect of the grouper/tilefish IFQ program on dockside price using monthly data rather than quarterly or annual data. The period covered in the analysis was from 1997 through 2014.

The issue of which substitutes/complements to include in any demand model is always difficult and becomes particularly so in seafood products such as grouper in which marketing studies are extremely limited (or nonexistent) and the number of substitute products is potentially large. For purposes of the current analysis, seven species (groups of species) were included: (1) grouper imports, (2) snapper imports, (3) dolphin imports, (4) Gulf of Mexico harvested red grouper, (5) Gulf of Mexico harvested 'Other' groupers, (6) Gulf of Mexico harvested red snapper, and (7) Gulf of Mexico and South Atlantic harvested dolphin. The rationale for including grouper imports (both fresh and frozen) is obvious. Snapper and dolphin were considered to be the 'most' likely substitutes for grouper and were, hence, also included in the analysis. Both of these species have significant imports and hence imports of both of these species (fresh and frozen) were included as were the GOM harvest of red snapper and GOM&SA harvest of dolphin.[6]

[6] The list of species was determined, at least in part, with the assistance of NOAA personnel (Mike Travis). In the original version of the model, tilapia imports, rather than dolphin was considered to be an appropriate substitute. In general, analysis using tilapia is qualitatively the same as using dolphin. When tilapia was replaced with dolphin, an additional equation (i.e., Gulf and South Atlantic landings) was added to the system.

Given its relatively large landings, GOM harvested red grouper were treated separately in the complete demand system. Other grouper species (black, warsaw, yellowedge, and gag) were aggregated for purposes of analysis.[7][8]

Some modifications to the data were made prior to analysis. Imports for the three species (groups) were used as reported on a product weight. Monthly Gulf harvests of red grouper, 'other' groupers, and red snapper are reported on a whole weight and for purposes of analysis were first converted to gutted weight. Then the prices for these species given by NMFS Regional Office for the IFQ years (i.e., from 2010 through 2014 for grouper species and 2007 through 2014 for red snapper) were used in lieu of those prices one would derive from using the data on the NMFS website).

Summary statistics of the seven share equations included in the complete demand system are presented in Table 1. As indicated, imports dominate the shares with the three import categories representing about 80% of total expenditures which, by construction of a complete demand system, sum to one. GOM red grouper represents approximately seven percent of total expenditures while GOM 'Other' groupers represent about five percent of total expenditures in the system.

Table 1: Summary Statistics Related to Share Equations (1997-2014).

Variable	N	Mean	Std Dev	Min.	Max.
Grouper Imports (product weight)	216	0.1207	0.0406	0.0343	0.2763
Snapper Imports (product weight)	216	0.3424	0.0822	0.1231	0.5586
Dolphin Imports (product weight)	216	0.3437	0.1569	0.0390	0.7943
GOM Red Grouper (gutted weight)	216	0.0727	0.0340	0.0003	0.1808
GOM Red Snapper (gutted weight)	216	0.0596	0.0553	0.0001	0.3036
GOM&SA Dolphin (whole weight)	216	0.0098	0.0143	0.0003	0.0726
GOM Other Groupers (gutted weight)	216	0.0512	0.0330	0.0018	0.1504

Annual deflated prices (based on the 2014 Consumer Price Index) for the imported species (groups) used in the analysis are presented in Figure 1 while the deflated annual prices for the Gulf landings (GOM&SA in the case of dolphin) are presented in Figure 2.[9]

[7] Before aggregating across these species, the appropriate tests for aggregation were conducted (an Augmented Dickey-Fuller test was applied to all species indicating that prices were stationary which suggested that causality tests could be conducted). Results of these tests indicated a statistical similar pattern of price movements across these species which, based on the Composite Commodity Theorem, permits aggregation (see Asche, Brennes, and Wessells, 1999 for details).

[8] While not tested, there is little doubt that the price movements of the tilefish species follow the same pattern as the grouper species aggregated for purposes of analysis. Given that tilefish landings are relatively small in relation to the 'Other' grouper category, it is safe to say that results with the tilefish landings being included would not have appreciably changed. Furthermore, tilefish landings could not have been included as a separate equation in the system because of the longer seasonal closures (i.e., there would be no price data).

[9] While the prices in the graphs are presented on a deflated basis, the models, as discussed in the next section, are estimated using nominal price data. Of course, it should not matter whether the models are estimated using nominal or deflated prices given the structure of the complete demand system. Prices for the major tilefish species are given in the Appendix to this report. They follow a similar pattern to that of GOM red grouper and GOM 'Other' grouper.

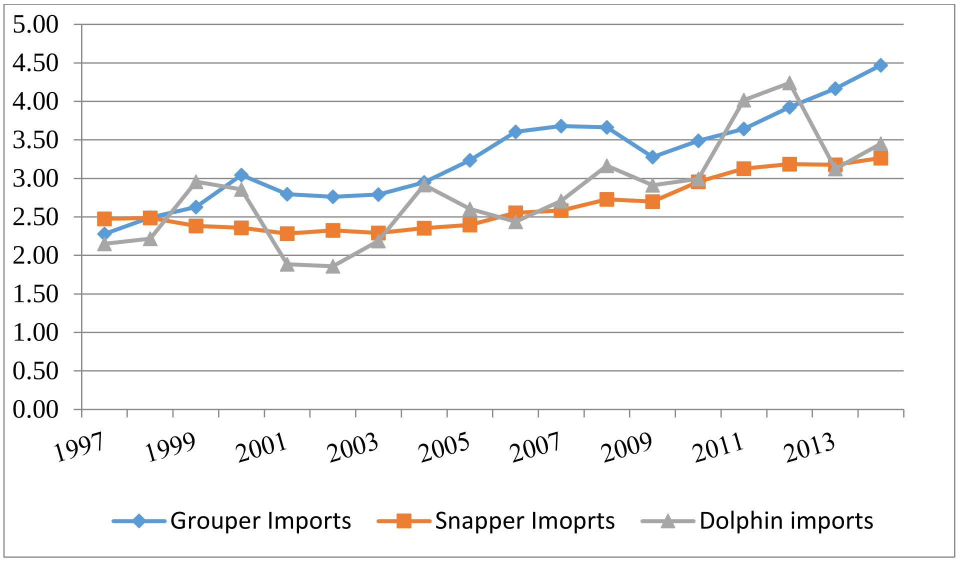

Figure 1: Annual Deflated Prices for Imported Species Used in Analysis (1997-2014).

As indicated from the information presented in Figure 1, deflated import prices for all three species (groups) showed significant increases in recent years (though the dolphin import price is very erratic). Overall, the annual deflated price for imported grouper advanced from an average of $3.49 per pound (product weight) during 2005-09 to $3.94 per pound (product weight) during 2010-14 or by almost 15%. The annual deflated snapper import price advanced from an average of $2.59 per product weight pound during 2005-09 to $3.27 per pound (product weight) during 2010-14, or by more than 20%. The annual deflated import price of dolphin between the two periods increased by almost 30%; from an average of $2.76 per pound to $3.56 per pound.[10]

[10] Perhaps more revealing, the deflated annual import grouper price increased from $3.28 per pound in 2009 to $4.47 per pound in 2014; or by about 35%. The deflated annual snapper import price advanced from $2.70 per pound in 2010 to $3.27 in 2014; or by about 20%.

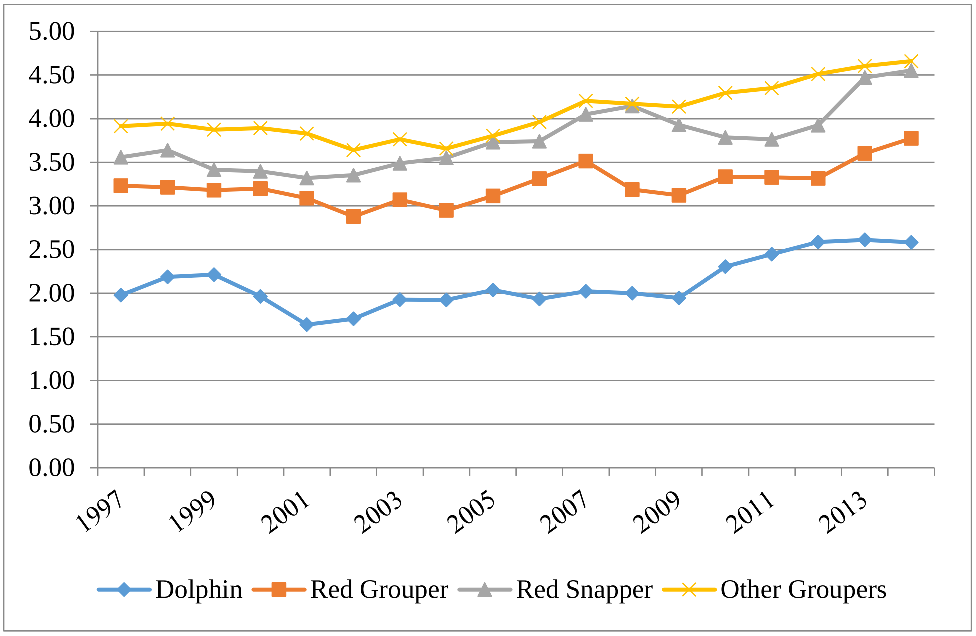

Figure 2: Annual Deflated Dockside Prices for GOM Species Used in Analysis (1997-2014).

The deflated annual dockside price of GOM harvested red grouper increased from an average of $3.25 per pound (gutted weight) during 2005-09 to $3.47 during 2010-14, or by about 7%. Hence, the import grouper price apparently increased more than the GOM harvest price of red grouper when comparing the five-year pre-IFQ period to the five-year post-IFQ period. The average annual deflated dockside price of GOM harvested 'Other' grouper increased from an average of $4.06 (gutted weight) during 2005-2009 to $4.48 during 2010-14; or by about 10%. The deflated price of GOM harvested red snapper (gutted weight) increased from an average of $3.92 during 2005-09 to $4.10 during 2010-14 which, in percentage terms, is equal to about 5%. This compares to the approximately 20% increase in the imported snapper price over the same period.[11] Finally, the deflated dockside price of GOM&SA dolphin increased from $1.99 per pound (whole weight) to $2.51 per pound, or by almost 25%.[12]

A consideration of the information in Figures 1 and 2 indicates a large increase in prices, in general, among all species. This strong increase likely reflects, at least in part, a recovering economy after a steep recession. Though there are no studies which examine the final outlet, the seafood products being considered in this study are likely largely consumed in the away-from-home market which is heavily influenced by the economy.[13]

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[11] GOM red snapper landings increased significantly over this period as a result of increased commercial quota.

[12] As indicated in Figure 2, the ex-vessel dolphin price is considerably lower than either the grouper or red snapper prices which is in contrast to that observed with respect to the imported prices (Figure 1). Part of the explanation for the lower domestic dolphin price relates to it being given on a whole weight basis while grouper and red snapper are given on a gutted weight basis.

[13] Recent analysis by Keithly and Wang (2017) suggests that more than a third of GOM grouper/tilefish sales by dealers are directed to the restaurant trade.

Models Used to Consider the Price Effects Associated With Implementation of the Grouper/Snapper IFQ Program

To examine the price effects, if any, associated with the introduction of the GOM grouper/tilefish IFQ program, two versions of the IADS model were evaluated. The first version was a static model. The second version was a habit formation model.

Static Model:

The general linear version of the static version of the IADS model used to evaluate the price effects associated with the GOM grouper/tilefish program can be written in equation form as:

$$w_{it} = \alpha_{it} + \sum_j \gamma_{ij} \ln q_{it} + \beta_{i0} \ln Q_t + \sum_s d_{is} D_{st} + \delta_i gdt + \gamma_i sdt + \varepsilon_t \quad (i=1\ldots,7,\ s=1\ldots,12,\ and\ t=1..,T)$$

where w_{it} is the budget (expenditure) share for the i-th product (i.e., grouper imports, snapper imports, dolphin imports, GOM red grouper, GOM 'Other' grouper, GOM red snapper, and GOM&SA dolphin), q_{it} is the quantity supplied of the i-th product at time t (imported grouper, imported snapper, imported dolphin, GOM red grouper, GOM red snapper, GOM 'Other' grouper, and GOM&SA dolphin), $\ln Q_t = \sum_k w_{kt} \ln q_{kt}$ is the Stone quantity index, D_{st} represents a vector of monthly dummy variables, gd_t is a discrete variable used to estimate the influence of the grouper/tilefish IFQ program on the respective shares (equal to 0 prior to January 2010 and 1 thereafter) and sd_t is a discrete variable used to estimate the influence of the red snapper IFQ program on the respective shares (equal to 0 prior to January 2007 and 1 thereafter).

To meet demand theory requirements, the following restrictions on the IADS model demand system of parameters are imposed:

Homogeneity and adding-up restrictions:

$$\sum_j \gamma_{ij} = 0 \qquad \sum_i \beta_{i0} = 0 \qquad \sum_s d_{is} = 0 \qquad \sum_i \delta_i = 0 \qquad \sum_i \gamma_i = 0$$

Symmetry restrictions:

$$\gamma_{ij} = \gamma_{ji}$$

The effect of the grouper/tilefish IFQ program on price can be evaluated by considering the parameter estimates associated with gd_t in each of the share equations. Specifically, one would anticipate a positive parameter estimate associated with this variable in the GOM Red grouper share equation and the GOM 'Other' Groupers share equation if the program culminated in an increased price for the various grouper species (groups of species).[14] Parameter estimates associated with the grouper/tilefish program (i.e., gd_t) and the GOM red snapper IFQ program (i.e., sd_t) are presented in the columns two and three of Table 2 with the first column merely being that of the respective shares. As one might expect based on economic theory, the discrete variable associated with the grouper/tilefish IFQ program had a negative (and statistically significant) impact on the grouper import share. However, the main parameters of interest are

[14] Given that quantities are assumed exogenous in the IAIDS model, an increased share related to the grouper/tilefish IFQ program must be the result of an increased price.

those associated with the GOM Red Grouper share equation and the GOM 'Other' Grouper share equation. Associated with the GOM red grouper share equation, the parameter estimate associated with the GOM grouper/tilefish IFQ program (*gd*) was found to be negative (though statistically insignificant) suggesting that the program had no effect on the dockside red grouper price. The parameter estimate associated with the GOM 'Other' grouper share equation, while positive, is also statistically insignificant.

Given possible collinearity between the discrete variables representing the grouper/tilefish IFQ program (*gd*) and the red snapper IFQ program (*sd*) and the emphasis of this study (i.e., the influence of the grouper/tilefish IFQ program on grouper dockside price), the static model was re-estimated with *sd* deleted from the model. Parameter estimates associated with the grouper/tilefish IFQ program with only the discrete variable representing the grouper/tilefish program in the system of equations are given in the last column of Table 2. As indicated, changes in parameter estimates tend to be very small suggesting that inclusion of the red snapper IFQ discrete variable in the system of equations does not significantly influence results.

In summary, based on the results associated with the static IAIDS model, the grouper/tilefish IFQ program does not appear to have influenced the dockside prices of grouper species. This is not unexpected given that, unlike other catch share program analyses related to the influence of the respective programs on dockside prices, a 'derby' fishery and related shortened season was not a reason for initiation of the grouper/tilefish IFQ program.[15]

[15] As noted, while tilefish were not included in the analysis, the relatively small harvests of these species suggest that inclusion of them would not have appreciably altered the results.

Table 2: Parameter Estimates Associated With the Discrete Variables to Examine the Influence of the Grouper/Tilefish IFQ Program (*gd*) and the Red Snapper IFQ Program (*sd*) in the Static Model.

	Grouper & Red Snapper IFQ Discrete Variables in Share Equations		Only Grouper IFQ Discrete Variable
	Grouper IFQ (*gd*)	Snapper IFQ (*sd*)	Grouper IFQ (*gd*)
Grouper Import Share	-0.0234	-0.008	-0.0223
	(-5.98)[a]	(-1.87)	(-5.73)
Snapper Import Share	-0.0151	-0.0014	-0.0154
	(-1.94)	(-0.17)	(-1.99)
Dolphin Import Share	0.00871	0.03802	0.0093
	-0.91	-3.61	-0.94
GOM Red Grouper Share	-0.0038	-0.0149	-0.0042
	(-1.14)	(-4.07)	(-1.23)
GOM Red Snapper Share	0.03284	-0.00797	0.0323
	-4.97	(-1.08)	-4.9
GOM ‘Other’ Grouper Share	0.0002	-0.01105	0.001
	-0.06	(-3.20)	-0.31
GOM&SA Dolphin Share	-0.0027	0.0011	-0.0026
	(-1.81)	-0.64	(-1.74)

[a] t-values given in parentheses

Uncompensated price flexibilities (evaluated at the means) associated with the static IADS model are presented in Table 3. All own-price flexibilities were found to be negative and less than one in absolute value, implying that the demand for each the different species (groups) included in the analysis is price inflexible. The own-price flexibilities, given along the main diagonal, range from -0.278 (grouper imports) to -0.725 for GOM red snapper. The fact that all own-price flexibilities associated with the domestically-harvested species (groups) were found to be statistically significant (and negative) indicates that changes in GOM landings of these species due to, say, a change in regulations will result in a change in their dockside prices, holding all other factors constant.[16]

Uncompensated cross-price flexibilities are given by the off-diagonals in Table 3. Most, but not all, are negative and statistically significant implying gross substitutes. While negative and statistically significant, most cross-price flexibilities are relatively small indicating that a change in the quantity supplied of one product will have only a relatively small impact on the price of another product. For example, a 10% increase in the quantity supplied of GOM red grouper was found to translate into a less than one percent reduction (-0.66%) in the GOM red snapper dockside price but a much larger reduction in the dockside price of 'Other' grouper (i.e., -1.38%). On the other hand, a 10% increase in grouper imports (at the mean) was found to result in a 1.1% reduction in the price of GOM red grouper and 1.5% reduction in the GOM 'Other' grouper price.

Table 3. Uncompensated Price Flexibilities Associated with the Static Model (including both *gd* and *sd* Discrete Variables in System.

	Grouper Imports	Snapper Imports	Dolphin Imports	GOM Red Grouper	GOM Red Snapper	GOM 'Other' Grouper	GOM&SA Dolphin
Grp. Imports	-0.278 (-10.69)	-0.45 (-12.09)	-0.287 (-14.59)	-0.064 (-5.81)	-0.035 (-6.31)	-0.05 (-4.31)	-0.002 (-0.20)
Snap. Imports	-0.154 (-13.02)	-0.592 (-21.05)	-0.261 (-17.63)	-0.02 (-3.03)	-0.031 (-7.90)	-0.054 (-8.48)	-0.02 (-4.19)
Dol. Imports	-0.033 (-2.65)	-0.08 (-2.52)	-0.526 (-27.41)	-0.002 (-0.27)	0.011 -2.18	0.018 -2.64	0.005 -1.22
GOM Red Grp.	-0.109 (-5.46)	-0.115 (-2.75)	-0.21 (-8.18)	-0.643 (-35.27)	-0.031 (-3.92)	-0.085 (-6.46)	0.005 -0.63
GOM Red Snp.	-0.12 (-6.69)	-0.332 (-6.86)	-0.27 (-6.14)	-0.066 (-5.40)	-0.725 (-38.07)	-0.046 (-5.21)	-0.019 (-5.28)
GOM Other Grouper	-0.15 (-5.14)	-0.461 (-8.64)	-0.161 (-5.41)	-0.138 (-7.36)	-0.045 (-5.23)	-0.436 (-18.00)	-0.039 (-2.76)
GOM&SA Dolphin	-0.008 (-0.06)	-0.654 (-3.21)	0.03 -0.3	0.051 -0.76	-0.085 (-3.18)	-0.182 (-2.41)	-0.188 (-2.06)

The estimated parameters associated with the suite of monthly dummy variables can be used to ascertain whether demand for any of the products included in the model varies by month or season. These parameter estimates are provided in Table 4. As evident, there appears to be little seasonality in demand

[16] While the dependent variables are shares, the quantity supplied is assumed to be predetermined as are total expenditures across products. Hence, a change in share resulting from a change in its own quantity must be the result of a change in price of that product.

for either the imported products or the domestic products. As one might hypothesize, there appears to be a small increase in demand (i.e., a higher price) for GOM red snapper in February associated with Lent. Somewhat unexpectedly though, demand for GOM red grouper appears to be relatively low in February and March; possibly related to the higher demand for red snapper (at least in February).[17] Finally, there appears to be no seasonal changes in demand for any of the imported products.

Table 4: Parameter Estimates and T-values (in parentheses) Associated With Monthly Discrete Variables.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.
Grouper Import Share	0.0011 (0.21)	-0.0073 (-1.39)	0.0026 (0.49)	0.0013 (0.24)	-0.0053 (-0.84)	-0.0069 (-1.11)	0.0005 (0.10)	-0.0020 (-0.35)	-0.0043 (-0.78)	-0.0040 (-0.73)	-0.0010 (-0.18)
Snapper Import Share	-0.0090 (-0.83)	-0.0072 (-0.67)	0.0105 (0.97)	0.0143 (1.33)	0.0184 (1.55)	0.0164 (1.41)	0.0220 (1.96)	0.0136 (1.21)	0.0062 (0.55)	0.0123 (1.10)	0.0051 (0.48)
Dolphin Import Share	0.0017 (0.12)	0.0092 (0.69)	-0.0078 (-0.58)	-0.0043 (-0.32)	-0.0055 (-0.40)	0.0051 (0.37)	0.0073 (0.54)	0.0117 (0.85)	0.0171 (1.25)	0.0042 (0.30)	0.0070 (0.53)
GOM Red Grouper Share	-0.0040 (-0.87)	-0.0102 (-2.22)	-0.0117 (-2.53)	-0.0037 (-0.81)	-0.0043 (-0.86)	-0.0051 (-1.05)	-0.005 (-1.01)	0.0025 (0.52)	-0.0072 (-1.52)	-0.0046 (-0.23)	-0.0001 (-0.03)
GOM Red Snapper Share	0.0077 (0.81)	0.0220 (2.36)	0.0091 (0.97)	-0.0028 (-0.30)	-0.0160 (-1.74)	-0.0130 (-1.41)	-0.017 (-1.82)	-0.0157 (-1.67)	0.0005 (0.05)	-0.0042 (-0.44)	-0.0092 (-0.98)
GOM&SA Dolphin Share	-0.0015 (-0.75)	-0.0002 (-0.10)	-0.0009 (-0.43)	-0.0052 (-2.40)	0.0098 (2.85)	0.0067 (2.01)	-0.004 (-1.36)	-0.0065 (-2.60)	-0.0057 (-2.57)	-0.0024 (-1.10)	-0.0012 (-0.58)

Habit Formation Model

Holt and Goodwin (1997) introduce the concept of dynamics to the IADS model. The issue of dynamics becomes important if, for example, consumption of a good depends on past consumption of that good. In a complete demand system, current consumption of a good depends not only on past consumption of that

[17] This does not imply that the ex-vessel price is $0.02 higher but only that the GOM red snapper share increases by approximately two percent in February as a result of an increase in the red snapper ex-vessel price. This is because the denominator in each of the share equations represents total expenditures across all seven products included in the system of equations.

good but also on the past consumption of all goods included in the system. Holt and Goodwin proposed handling dynamics in the IAIDS model using the general following form:

$$w_{it} = \alpha_{it}^{*} + \alpha_{i}^{**}\mu_{t-1} + \sum_{j} \gamma_{ij} \ln q_{jt} + \beta_{i0} \ln Q_t + \sum_{s} d_{is} D_{st} + \delta_i gd + \gamma_i sd + \varepsilon_t$$

where $\mu_{t-1} = \sum_{i} \ln q_{it-1}$ represents the lagged aggregated quantity (which sum to zero across all equations) and $\ln Q_t = \sum_{k} w_{kt} \ln q_{kt}$. This model, as indicated, is similar to the static model but adjusted for aggregate expenditures in the previous period. All other variables and their meanings are the same as those discussed with respect to the static model. As such, the primary parameter estimates of interest when considering whether the GOM grouper/tilefish program resulted in a change in grouper prices are again those associated with *gd*. These are presented in Table 5 which can be interpreted in a manner analogous with that of Table 2. As indicated, the parameter estimates associated with the GOM grouper/tilefish IFQ program in the Habit Formation model are very similar to those derived in the static model (see Table 2). Thus, building 'habit formation' into the model does not change the conclusion that introduction of the grouper/tilefish IFQ program has had no appreciable impact on the GOM dockside grouper prices.

Table 5: Parameter Estimates Associated With the Discrete Variables to Examine the Influence of the Grouper/Tilefish IFQ Program (*gd*) and the Red Snapper IFQ Program (*sd*) in the Habit Formation Model.

	Simple Habit (Grouper & Snapper IFQ Impacts)		Simple Habit (Only Grouper IFQ Impacts)
	Grouper IFQ	Snapper IFQ	Grouper IFQ
Grouper Imports Share	-0.0207 (-5.62)	-0.0068 (-1.71)	-0.0197 (-5.37)
Snapper Imports Share	-0.0120 (-1.62)	-0.0005 (-0.07)	-0.0134 (-1.81)
Dolphin Imports Share	0.0096 (-0.97)	0.0389 (-3.58)	0.0100 (-0.99)
Grouper Red Landings Share	-0.0065 (-2)	-0.0162 (-4.58)	-0.0065 (-1.9)
Snapper Red Landings Share	0.0306 (-4.58)	-0.0088 (-1.17)	0.0305 (-4.56)
Other Grouper Landings Share	0.0010 (-0.32)	-0.00982 (-2.77)	0.0024 (-0.75)

GOM&SA Dolphin Landings Share	-0.0031 (-1.99)	0.0009 -0.50	-0.0029 (-1.86)

[a] T-values are presented in the parentheses.

The estimated own and cross-price flexibilities derived from the habit formation model are presented in Table 6. With a few notable exceptions, the estimated flexibilities are similar to those derived from the static model and hence are not discussed here.

Table 6. Uncompensated Price Flexibilities Associated with the Habit Formation Model (including both *gd* and *sd* Discrete Variables in System.

	Grouper Imports	**Snapper Imports**	**Dolphin Imports**	**GOM Red Grouper**	**GOM Red Snapper**	**GOM Other Grouper**	**GOM&SA Dolphin**
Grouper Imports	-0.251 (-9.07)[a]	-0.422 (-10.84)	-0.293 (-14.31)	-0.124 (-8.56)	-0.085 (-7.08)	-0.088 (-6.07)	-0.012 (-1.16)
Snapper Imports	-0.139 (-10.62)	-0.606 (-19.22)	-0.252 (-16.12)	-0.049 (-5.28)	-0.051 (-6.35)	-0.068 (-7.37)	-0.028 (-4.77)
Dolphin Imports	-0.022 (-1.82)	-0.049 (-1.58)	-0.542 (-27.89)	-0.012 (-1.20)	0.000 (-0.02)	0.013 (1.72)	0.007 (1.55)
GOM Red Grouper	-0.173 (-7.35)	-0.165 (-3.41)	-0.190 (-6.82)	-0.533 (-20.93)	0.065 (3.69)	-0.024 (-1.41)	0.024 (2.26)
GOM Red Snapper	-0.184 (-6.72)	-0.357 (-5.43)	-0.265 (-5.33)	0.052 (2.23)	-0.636 (-18.65)	0.015 (0.81)	0.001 (0.09)
GOM Other Grouper	-0.209 (-6.20)	-0.487 (-7.63)	-0.148 (-4.59)	-0.055 (-2.28)	0.023 (1.06)	-0.396 (-11.97)	-0.021 (-1.27)
GOM&SA Dolphin	-0.103 (-0.79)	-0.889 (-3.92)	0.129 (1.19)	0.182 (2.14)	0.033 (0.50)	-0.092 (-1.00)	-0.173 (-1.83)

[a] T-values are given in parentheses

Conclusion and Discussion

The primary conclusion that is derived from the current analysis is that the GOM grouper/tilefish IFQ program has not resulted in any 'significant' increase in dockside prices for the grouper species. This is most likely the result of not having significant shortened fishing seasons prior to the introduction of the IFQ program for the major species in the grouper/tilefish complex.[18] However, though not resulting in an increase in price due to a higher quality product, monthly prices appear to have become more stabilized during the period of the grouper/tilefish IFQ program. This can be seen by examining some data for GOM red grouper which is given in Table 7. Average monthly red grouper harvests during the 2005-09 period, as indicated, ranged from a low of 191 thousand pounds (March) to 536 thousand pounds (June). On a percentage basis, the range was from 4.2% to 11.8%. Finally, dockside price ranged from a low of $2.63 per pound (gutted weight) to $3.04 per pound with a rather definite negative relationship between average monthly landings and the price per pound.

During the five-year period after the introduction of the grouper/tilefish IFQ program, percentage of landings by month fell in a much more narrow range (i.e., from 6.1% in August to 10.5% in December) and price fell in a much more narrow range (i.e., from $3.25 per pound in February to $3.47 in April).

To the extent that the apparently more stable monthly landings during the IFQ period is the result of the IFQ program, these more stable landings appear to have resulted in a more stable dockside price.

Table 7: Monthly GOM Red Grouper Harvests and Prices for the Five-Year Period Before and After Establishment of the IFQ Program.

	2005-09			2010-14		
	Avg. Pounds	% in Month	$/Pound	Avg. Pounds	% in Month	$/Pound
January	364,244	8.00%	$2.82	332,661	7.20%	$3.26
February	268,569	5.90%	$2.87	403,750	8.80%	$3.25
March	190,933	4.20%	$3.04	435,370	9.40%	$3.41
April	411,663	9.10%	$3.00	414,153	9.00%	$3.47
May	472,660	10.40%	$2.79	474,617	10.20%	$3.37
June	536,461	11.80%	$2.63	307,588	6.70%	$3.29
July	484,828	10.70%	$2.60	308,546	6.70%	$3.37
August	534,862	11.80%	$2.70	282,884	6.10%	$3.39
September	399,819	8.80%	$2.85	428,357	9.30%	$3.37
October	315,699	6.90%	$2.87	416,152	9.00%	$3.32
November	252,464	5.60%	$2.99	326,492	7.10%	$3.38
December	316,191	7.00%	$2.90	483,336	10.50%	$3.38

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[18] While the fishing seasons for tilefish were, as noted, significantly truncated in some years, annual tilefish harvests represent a very small proportion of total grouper/tilefish harvests.

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Appendix: Deflated Ex-vessel Tilefish Prices