APPENDICES

Limited Access General Category (LAGC) IFQ Fishery Program Review

2010 - 2015

Approved by the New England Fishery Management Council as complete and final on June 15, 2017

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APPENDIX A – ANNUAL IFQ QUOTA LEASE MODEL (COUNCIL STAFF)

Dr. Demet Haksever, Council Staff

Lease prices by vessels

Since there were more IFQ holders that leased-out their quota than the number of active vessels, the number of transactions that reported a price greater than 1 was higher compared to lease-in transactions. For analytical purposes, such as estimating leasing costs, only those unit values greater than $1 were assumed to be reflect reliable estimates of leasing prices.

Table 1. Number of vessels that leased (in) quota by lease-price data group

Number of vessels	Lease price per lb. of scallops leased			
FY	Zero or NA	$0.1-$1	>$1	Grand Total
2010	16	26	31	73
2011	16	26	32	74
2012	14	11	52	77
2013	9	10	62	81
2014	23	14	58	95
2015	19	16	58	93
Grand Total	**97**	**103**	**293**	**493**

Table 2. Average lease-in prices by lease price data group including leasing to the same affiliations

FY	Zero/NA	$0.1-$1	>$1
2010	0.00	0.43	1.57
2011	0.00	0.69	1.77
2012	0.00	0.68	2.47
2013	0.00	0.48	2.89
2014	0.00	0.35	3.42
2015	0.00	0.42	3.46

Note: averages are obtained by dividing sum of lease value with the sum of lease lbs.

Table 3. Number of vessels that leased (out) quota by lease-price data group

Number of vessels	Lease price per lb. of scallops leased			
FY	Zero or NA	$0.1-$1	>$1	Grand Total
2010	51	34	75	160
2011	52	28	87	167
2012	37	11	125	173
2013	43	10	139	192
2014	52	17	131	200
2015	43	13	114	170
Grand Total	**278**	**113**	**671**	**1,062**

Table 4. Average lease-out prices by lease-price data group including leasing to the same affiliations

FY	Zero/NA	$0.1-$1	>$1
2010	0.00	0.73	1.74
2011	0.00	0.88	2.16
2012	0.00	0.41	2.89
2013	0.00	0.45	3.27
2014	0.00	0.28	3.96
2015	0.00	0.51	4.09

Note: averages are obtained by dividing sum of lease value with the sum of lease lbs.

The differences in price when all transactions are included versus when only those transactions that took place between different owners with (and those with a price of higher than $1 are included) could be seen in Figure 1. As expected, the lease-in prices for transactions involving two different owners were higher than prices when all leasing transactions were included.

Figure 1. Lease-in prices per lb. of quota leased

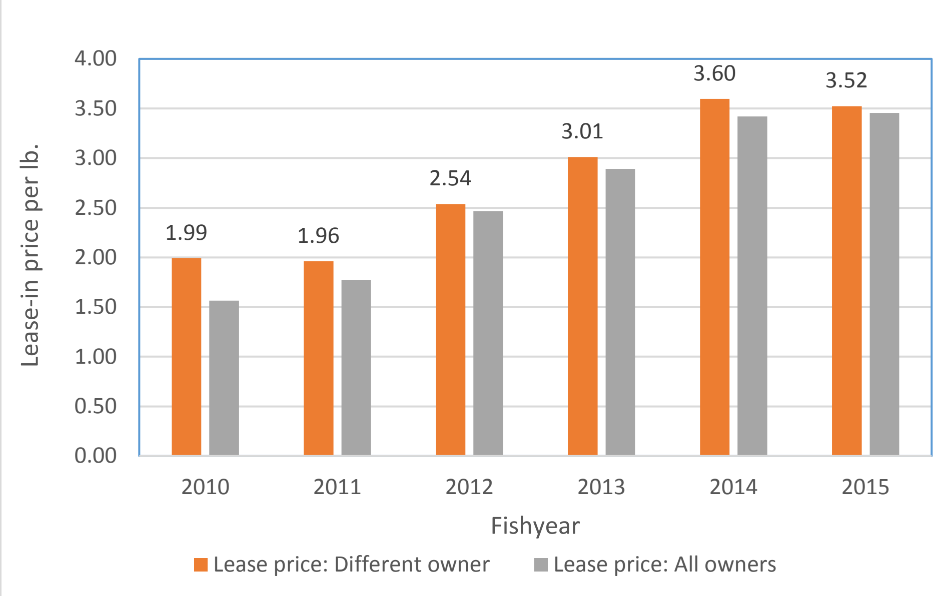

Table 5. Leasing-in from same affiliation and lease-in prices (2010-2015)

Lease price	Number of vessels	Number of vessels as % of total	Average leasing price
ZERO or NA	89	74%	NA
$0.1-$1	7	6%	0.50
>$1	25	20%	2.77
Grand Total	**121**	**100%**	**NA**

Note: Number of transactions could be higher if each vessel was involved in more one lease transactions annually.

Table 6. Leasing-in from a different owner or affiliation and lease prices (2010-2015)

Lease price	Number of vessels	Number of vessels as % of total	Average leasing price
ZERO or NA	73	16%	NA
$0.1-$1	86	19%	0.51
>$1	297	65%	2.90
Grand Total	**456**	**100%**	**NA**

Note: Number of transactions could be higher if each vessel was involved in more one lease transactions annually.

Table 7. Leasing-out same affiliation and lease-in prices (2010-2015)

Lease price	Number of vessels	Number of vessels as % of total	Average leasing price
ZERO or NA	89	74%	NA
$0.1-$1	7	6%	0.50
>$1	25	20%	2.77
Grand Total	**121**	**100%**	**NA**

Note: Number of transactions could be higher if each vessel was involved in more one lease transactions annually.

Table 8. Leasing – out different owner or affiliation and lease prices (2010-2015)

Lease price	Number of vessels	Number of vessels as % of total	Average leasing price
ZERO or NA	344	32%	NA
$0.1-$1	95	9%	0.58
>$1	624	59%	3.15
Grand Total	**1063**	**100%**	**NA**

Note: Number of transactions could be higher if each vessel was involved in more one lease transactions annually.

Table 9. Estimation of lease-out prices (by MRI)

Nonlinear GMM Summary of Residual Errors

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq
lnleasepr	7	546	22.5968	0.0414	0.2034	0.7058	0.7025

Nonlinear GMM Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
intc	-1.64363	0.3511	-4.68	<.0001
netprice	0.233027	0.0118	19.78	<.0001
owngrp	0.113312	0.0419	2.70	0.0071
affgrp	0.583337	0.0303	19.27	<.0001
pctactallo	-4.32643	0.4869	-8.88	<.0001
numves	0.026664	0.00344	7.76	<.0001
trans	-0.03161	0.00644	-4.91	<.0001

Netprice: ex-vessel price per lb. net of trip costs per lb. of scallops
owngrp: if leased out to different affiliation=1, if leased out to same afflation=0
affgrp: individual owner=1, permit bank=0
pctactallo= total ifq allocation for the active owners as a % of total ifq allocation
numves= number of vessels that were net leasers (lease-in)
trans= Number of lease-out transactions by each individual owner

Figure 2. Actual and estimated annual lease-out price (different owners)

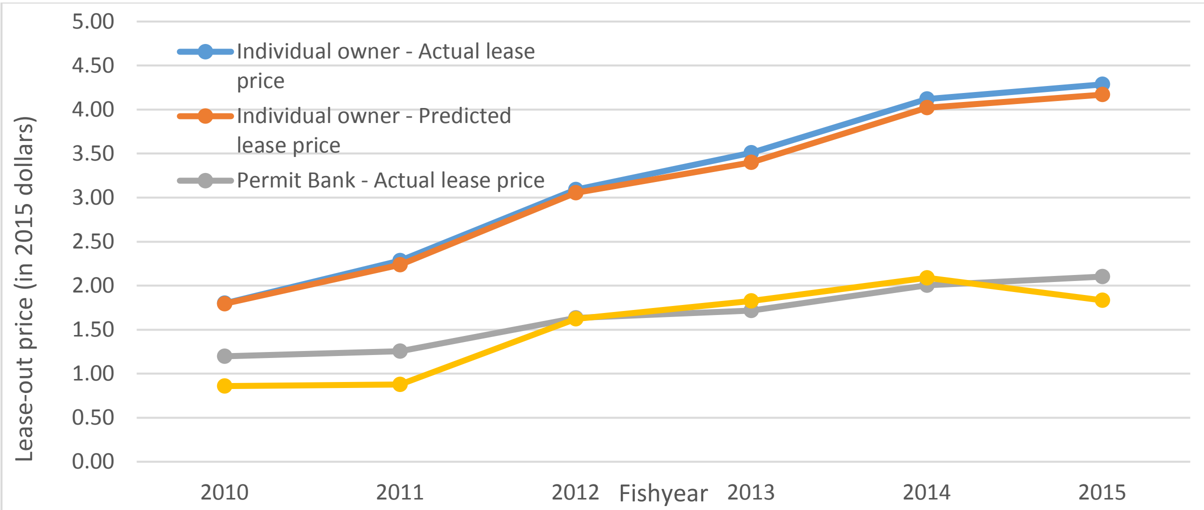

Table 10. Actual and predicted lease price for leasing out a different or same affiliation

Fishyear	Lease-out owner type	Actual lease price	Predicted lease price	Number of individual IFQ owners
2012	Different owner	3.09	3.05	95.00
	Same owner	2.97	2.77	9.00
2012 Total		**3.08**	**3.03**	**104.00**
2013	Different owner	3.51	3.40	87.00
	Same owner	2.91	3.07	10.00
2013 Total		**3.45**	**3.37**	**97.00**
2014	Different owner	4.12	4.02	74.00
	Same owner	3.70	3.65	10.00
2014 Total		**4.07**	**3.98**	**84.00**
2015	Different owner	4.29	4.17	67.00
	Same owner	3.87	3.78	16.00
2015 Total		**4.21**	**4.09**	**83.00**

APPENDIX B – ESTIMATION OF TRIP COSTS

Dr. Demet Haksever, Council Staff

Data for variable costs, i.e., trip expenses include food, fuel, oil, ice, water and supplies and damage costs. Trip costs for limited access and LAGC- IFQ vessels are obtained from the observer cost data for 1999-2015. The trip costs per day-at-sea (ffiwospda) were estimated as a function of vessel crew size (CREW), vessel horse power (HP), vessel length (LEN) fuel prices (FUELP), and dummy variables for limited access general category (LGC) and small dredge (SMD) vessels to identify important variables that affect trip expenses. This cost equation was assumed to take a double-logarithm form and estimated with data obtained from observer database. The empirical equation presented in **Table 11** estimated more than 80% of the variation in trip costs and has proper statistical properties using the observer data from 1994 to 2015 fishing years (1709 observations) for the limited access and limited access general category vessels.

Table 11. Estimation of total trip costs per DAS used for the limited access and limited access general category vessels

Nonlinear GMM Summary of Residual Errors								
Equation	**DF Model**	**DF Error**	**SSE**	**MSE**	**Root MSE**	**R-Square**	**Adj R-Sq**	**Durbin Watson**
lnffiwospda	7	1702	166.7	0.0979	0.3130	0.8105	0.8098	1.4501

Nonlinear GMM Parameter Estimates				
Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**
intc	1.158278	0.2884	4.02	<.0001
len	0.797279	0.0788	10.11	<.0001
hp	0.119528	0.0365	3.28	0.0011
crew	0.590184	0.0672	8.79	<.0001
fuelp	0.80674	0.0286	28.25	<.0001
LGC	-0.63291	0.0620	-10.21	<.0001
SMD	-0.15493	0.0336	-4.61	<.0001

APPENDIX C – ESTIMATION OF FIXED COSTS

Dr. Demet Haksever, Council staff

The fixed costs include those expenses that are not usually related to the level of fishing activity or output. These are insurance, maintenance, license, repairs, office expenses, professional fees, dues, taxes, utility, interest, communication costs, upgrade costs, association fees and dock expenses. Because of the composition of the sample data in terms the vessel characteristics is not the same as the composition of the fleet, average sample values do not necessarily equal to the average costs for the scallop fleet as whole.

Fixed cost estimates are updated using the 2011-2012 cost survey data collected by the SSB of NEFSC. This data set contained 932 vessels operating in different fisheries. Only 134 of these vessels had a scallop permit however.

Permit category	2011	2012	Total
LA	28	15	43
FT	21	14	35
PT	7	1	8
LAGC	55	36	91
IFQ	24	15	39
B or C	31	21	52
Total	83	51	134

The model shown in **Table 12** is based on the fixed cost survey data for vessels that have a scallop limited access and limit access IFQ permit and estimates basic fixed costs as a function of horse power*length (HPLEN), total revenue from fishing (TOTREV) and a dummy variable for IFQ (IFQ) vessels. Fixed costs were estimated by using the 54 observations for vessels with a positive entry for each of the component of basic fixed costs including insurance, maintenance and repairs as well as a positive value for horse power and length. The results show these three variables (HPLEN, total revenue and IFQ dummy variable) explain about 71% of the variation in fixed costs with statistically significant coefficients. These estimates will be updated using the 2015 cost survey data when it becomes available.

Table 12. Estimation of basic fixed costs

Nonlinear GMM Summary of Residual Errors								
Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq	Durbin Watson
lnFC	4	50	8.8455	0.1769	0.4206	0.7245	0.7080	2.5636

Nonlinear GMM Parameter Estimates				
Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**
INTERCEPT	4.399791	1.4354	3.07	0.0035
HPLEN	0.279186	0.1254	2.23	0.0305
LAGC	-0.3737	0.1744	-2.14	0.0371
TOTREV	0.36226	0.0929	3.90	0.0003

Table 13. Actual and estimated fixed costs, vessel size and average total revenue (Cost survey data sample)

Data	LA	LA+LAGC	LAGC
FC – Estimated/per vessel	$348,563.92	$303,881.58	$112,358.60
FC – Actual values/per vessel	$440,125.18	$274,801.38	$120,056.34
Horse Power	991.79	725.17	467.21
Length	85.94	80.83	63.35
Total Revenue	$1,821,149	$1,607,972.50	$530,954.07
Number of vessels	14	12	28

APPENDIX D – EX-VESSEL PRICE ANALYSIS OF THE IFQ FISHERY

Northeast Fishery Science Center, SSB

Over the first six years of the IFQ fishery (2010-2015), average annual scallop *ex-vessel* prices exceeded those of the Limited Access fishery in all years by a range of $0.29-$0.72 per pound. In contrast, the General Category and IFQ-qualifying fleet fishing under TACs only received higher prices in two years from 2004-2009. To better understand the scallop price premium received by IFQ vessels, a hedonic model of *ex-vessel* prices was estimated using micro-level data in order to control for many of the other determinants of prices.

To construct the dataset used to estimate the model, all purchases of scallops from vessels for fishing years 2004-2015 were extracted from NMFS dealer databases. The sale date, species, market category, quantity, and value were added directly into the model, with prices normalized to 2016 Q1 using the GDP Implicit Price Deflator. VTR serial numbers were used to determine fishing location, trip length, and gear fished for each scallop sale. The permit number of the vessel was used to extract the category of scallop permit(s) held by that vessel. Some vessels possess multiple scallop permits in a fishing year, and to account for this, the trip limits in place for the various permit categories were used as cutoff points in assigning a vessel sale to a permit category.[1] Dummy variables for the day-of-the-week, month, and fishing year of each scallop sale were included. Additionally, the aggregate daily quantity of scallops landed across all ports was captured both directly and indirectly. Interaction terms for permit category and scallop size, as well as permit category and trip length, were included to better capture differences across various components of the scallop fishery. The final dataset contains 204,655 sales transactions representing 98.4% of all scallop meat sales over the 12 year period.

Five model specifications were run. The preferred linear model includes an Instrumental Variables (IV) estimator in which the one-day lag of daily quantities is used as an instrument for daily quantities, as it was thought that daily scallop quantities are potentially determined simultaneously with prices. Permit category results are relative to the Limited Access (LA) fleet, and for other dummy variables, bases were set to the category with the most observations (e.g. 11-20 count scallops for size; New Jersey for state of landing). The preferred model fits well with an R^2 of .865 and diagnostics reject under-identification. While the results are extensive, those of primary interest are the IFQ fleet receiving a $0.09 premium relative to the LA fleet, while the General Category fleet receives a $0.03 premium and the transition period fleet receives a $0.13 discount. This residual IFQ premium may be attributed in part to unobservable production characteristics common to the IFQ fleet, such as improved handling of scallops, or may be attributed to the buyer side of the equation.

From the preferred model results, the discrete effects of permit category and scallop size were calculated. That is, after prices have been predicted for all sales transactions, the permit category (or size) categorical variable was set to a particular value and any corresponding interaction terms were modified as appropriate. The predicted price of the base case (LA for permit category; 11-20 count for size) was subtracted and averages were computed after grouping by fishing year. Figure 3 illustrates predicted prices for selected permit categories over their active time period.[2] The GC fleet is predicted to receive very similar prices to LA vessels during 2004-2007, the Transition fleet receives lower prices than the LA fleet during 2008-2009,

[1] While this is an imperfect way to classify trips, model results are quite robust to moderate changes in this cutoff.
[2] Standard errors for each group are computed using the delta method

and the IFQ fleet receives a premium in all fishing years from 2010-2015. The predicted IFQ premium ranges from $0.18 (1.5%) in 2013 to $0.32 (3.4%) in 2010. In terms of size effects, all permit categories receive higher prices for larger scallops than smaller scallops. IFQ vessels receive higher prices than Transition vessels for all size categories and receive higher prices than LA vessels for all size categories other than unclassified. Size effects across the scallop fishery as a whole have been increasing (Figure 4). U10 scallops have received large premiums during 2014-2015, and 31+ count scallops have received sizable discounts during these years.

The IFQ and LA fleets operate very differently, and there are a number of reasons why a premium for IFQ vessels exist. IFQ vessels have landed a greater percentage of U10 scallops than LA vessels, and the premium for U10 scallops has increased sharply in recent years. IFQs are transferable while DAS and access area trips are not; states with higher ex-vessel prices have seen an increase in landings under transferable quotas. Additionally, generally shorter trips by the IFQ fleet yield a fresher product than the LA fleet; permit category and trip length are interacted in the model, however a lack of long IFQ trips is a barrier to completely conditioning out the effect of trip length. In terms of increased *ex-vessel* prices for the IFQ period relative to the transition period, derby-style fishing during the transition period was apparent in the model variable distributions, with a lack of observations in late fall and winter.

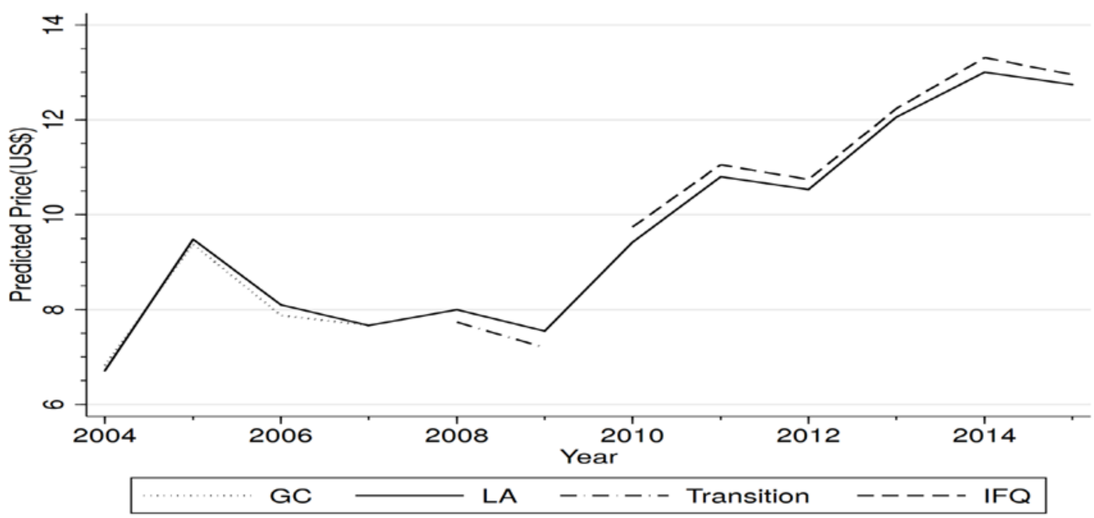

Figure 3: Predicted Prices over time by Scallop Permit Category.

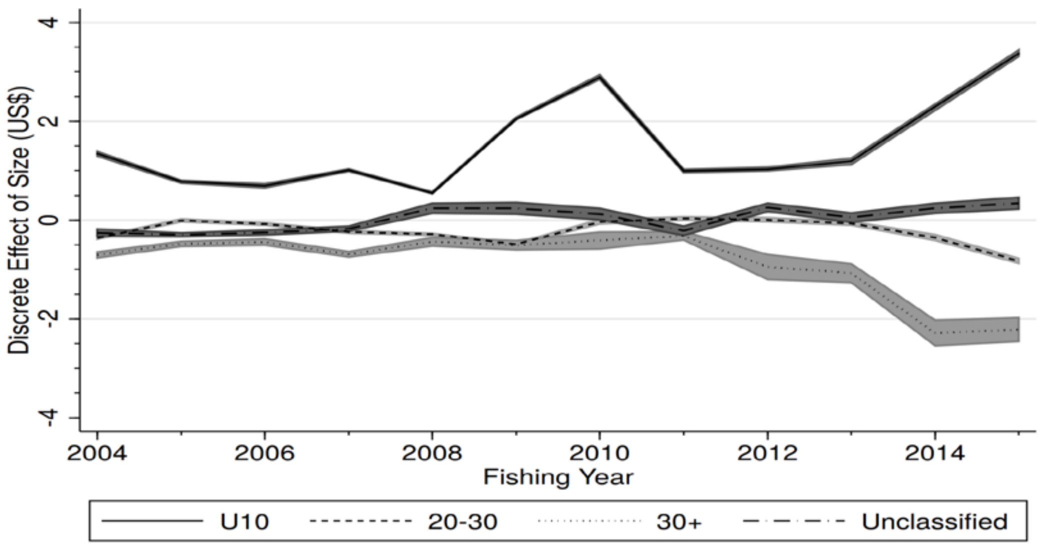

Figure 4: Discrete premia (lines) and 95% confidence intervals (ranges) relative to the 11-20 market **category over time.**

APPENDIX E – AN EMPIRICAL ANALYSIS OF INDIVIDUAL FISHING QUOTA MARKET TRADING

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Running Title: Individual fishing quota market trading

An empirical analysis of individual fishing quota market trading

Abstract

In the study, we investigate determinants of IFQ lease price and permanent transfer share in the General Category Scallop fishery of the Northeastern United States. A unique micro data set on individual IFQ transactions and related vessel and stock information for the 6-year time period, fishing year 2010-2015, was used to estimate models of quota markets and individual transactions. We find that IFQ lease price is generally affected by factors influencing profitability of the fishery as well as the competitiveness of the leasing market. Results of the analysis also suggest that the price for IFQ transfers captures the capitalized profits in the fishery over time with adjustment for relevant risks. Overall, the IFQ market performance is in general agreement with economic theory.

1. Introduction

Over the past four decades, individual transferable quota (ITQ) or similar programs have been increasingly incorporated into fisheries management around the world. The number of empirical studies of the effectiveness of these programs has also been growing (Weninger, 1998; Shotton, 2001; Newell et al., 2005; Chu, 2009; Walden et al., 2012). Costello et al. (2008) investigated 121 fisheries managed using catch shares by 2003 and found that catch share program could improve economic efficiency, reduce over-capitalization, and halt the depletion of fish stocks. Economic efficiency gains associated with ITQ programs have been reported in a number of studies, such as fisheries in Iceland (Arnason, 2005) and Denmark (Andersen et al., 2010), and the Gulf of Mexico red snapper fishery (Solís et al., 2015). Based on their assessment of all major United States federal catch share fisheries and associated shared stock fisheries in British Columbia, Grimm et al. (2012) find that catch shares result in improvements in resource conservation, economic returns, and social performance, relative to industry performance under traditional management.[3]

[3] Multiple studies also examine issues and concerns about ITQ management, such as its undesirable distributional impacts on fishing communities (Anderson, 1991; Gauvin et al., 1994; Matulich et al., 1996; McCay et al., 1998; McCay, 2004; Brandt, 2005; Anderson et al., 2008; Yandle and Dewees, 2008; Carothers, 2013) and its effectiveness in stock conservation (Chu, 2009; Acheson et al., 2015; Bromley, 2015; Kahui et al., 2016).

In the Northeast United States, the Limited Access General Category (LAGC) Scallop Individual Fishing Quota (IFQ) program was implemented in 2010. The Program established quota shares (QS) that, when multiplied by the annual catch limit (ACL) for the IFQ fishery, determines the quota pounds (QP) of scallop meats that may be harvested in a given year by any one entity holding QS. The IFQ program allows trading of both QS and QP. The former is the permanent share while the latter is a short term leasing arrangement for a single year. Economic theory predicts that, on average, the price for QS (i.e., a permanent transfer of the IFQ share) is equal to the capitalized profits in the fishery over time, whereas the price for QP (i.e., an IFQ lease) reflects the marginal net return in the fishery. The objective of this study is to evaluate general economic performance of the QS and QP transactions in the General Category Scallop IFQ program and to test whether the market prices are consistent with economic theory.

A clear understanding of the quota market is crucial under ITQ management. According to Arnason (1990), under certain conditions (e.g., perfectly competitive markets), the fishery manager only needs to monitor the quota market price and to adjust the total quota (TAC) until the current total quota market value is maximized, which is the "minimum information management" scheme to achieve socially optimal condition for the fishery. There are at least three functions of an efficient QP market: to allocate QP to those who value it most, to encourage efficient use and discipline inefficient use of QP, and to provide information for business planning and policy decisions (Holland, 2016; Newell et al., 2007).

In spite of the importance of information on IFQ markets, there has been a lack of systematic studies of ITQ trading using empirical data, due to the fact that price information on catch share transfers is often limited or unavailable in most catch share programs (Holland et al., 2015). Newell et al. (2005) examine the ITQ fisheries in New Zealand Using a 15-year panel dataset from New Zealand that covers 33 species and more than 150 markets for fishing quotas, Newell et al. (2005) assessed trends in market activity, price dispersion, and the fundamentals determining quota prices. They found that market activity was sufficiently high in the economically important markets and that price dispersion had decreased. They also found evidence of economically rational behavior through the relationship between quota leases and sale prices and between fishing output and input prices, ecological variability, and market interest rates. Market design and imperfections may be important in these new markets; Anderson (2004) illustrates how trading limitations can lead to very different final outcomes using a laboratory experiment. Lee (2012) finds that institutional limitations lead to bargaining power in the Northeast US Multispecies Days-at-Sea market. Ropicki and Larkin (2014) find that informational differences, proxied by social network indicators, had similar effects in the Gulf of Mexico Red Snapper quota market. Holland (2016) illustrates the market imperfections in the Pacific Groundfish market.

The General Category Scallop IFQ program provides a unique opportunity to investigate new IFQ markets using empirical data. The fishery targets a single species, and thus, its quota market does not involve the many complexities associated with IFQs for multispecies fisheries. We compile a micro data set with information on individual transactions as well as relevant vessels and fishing quota allocations. We estimate models of quota markets and individual transactions, following the general framework of Newell et al. (2005) and the Lee (2012).

2. Background

The study period covers fishing years 2010-2015, i.e., March 1, 2010 through February 28, 2016. During this period, the scallop IFQ lease market was quite active, with 1,852 lease (QP) transactions. In contrast, there were only 169 permanent IFQ share (QS) transfers. There were approximately 330 permits in the General Category scallop fishery, and over 70% percent participated lease trade.[4]

The Atlantic sea scallop fishery is managed by the New England Fishery Management Council (NEFMC). Limited Access (LA) was introduced in 1994; permit-holders that did not qualify into the LA fishery could fish under a General Category (GC) permit, which remained an open-access fishery with a 400 pound trip limit (NEFMC, 1993). Amendment 11 created the Limited Access-General Category (LAGC) fishery and further divided it into the IFQ, Northern Gulf of Maine, and Incidental fisheries. The goal of Amendment 11 was to control fishing capacity and scallop mortality in the LAGC fishery. The NEFMC also adopted a vision for the LAGC fleet to "maintain the diverse nature and flexibility within this component of the scallop fleet" (NEFMC, 2007. p8).

The LA and IFQ fleets are affected by spatial closures to protect scallop habitat, groundfish habitat, and groundfish. A rotational access system also affects the LA and IFQ fleet. In this system, areas of the ocean with an abundance of juvenile scallops are closed to allow those scallops to grow larger. Regulations for the IFQ fleet include a possession limit, currently 600 lbs, and a fleet-level aggregate limit on trips into scallop rotational access areas. The aggregate limit was reached three times during the study period, Delmarva (in 2010), Hudson Canyon (2011), and Mid-Atlantic Access Area (2015). The life-history characteristics of sea scallops are favorable for spatial management: scallops grow quickly, adults have low levels of natural mortality, and scallops are relatively immobile after settling on the ocean floor (Hart and Rago, 2006). Due to the importance of the rotational management system, finely detailed biomass data is collected to inform managers (See NEFSC, 2014 and NEFMC, 2015 for examples) and used to project future biomass using the Scallop Area Management Simulator (SAMS).

A few institutional limitations and peculiarities of the market are worth describing. During the 2010 and 2011 fishing years, entities that made permanent transfers of QS were required to transfer their entire QS allocation prior to use of IFQ, and vessels that utilized any IFQ could not subsequently transfer IFQ later in the fishing year. Beginning in 2012, permanent transfers of QS that were less than an entity's QS allocation were allowed. In addition, vessels cannot be allocated more than 2% of the sub-ACL and individuals cannot have an ownership interest of more than 5% of the sub-ACL (73 Federal Register 20092-20093). These ownership caps were desired by fishery managers to limit consolidation. There are also two "permit banks" that own QS and lease quota. The Cape Cod Fisheries Trust works with the Cape Cod Community Development Partnership to lease QP to local fishermen at below market rates. A similar permit bank is operated by the State of Maine. IFQ trades occur through word of mouth and are often facilitated through brokers; no centralized market exists. Fishing right holders are required to report lease and transfer information to the Greater Atlantic Fisheries Regional Office (GARFO), including buyer and seller permit numbers, QS transferred or QP leased, and the price that was paid. Finally, the "Confirmation of Permit History" (CPH) program can be utilized by right-holders. The catch history of a fishing vessel and therefore QS in the IFQ scallop program can be separated from the fishing vessel itself. Rights holders can then transfer this to a new vessel, sell this right, or lease out the corresponding of QP on an annual basis.

The total value of leases increased from, on average, \$74 thousand per month in 2010 to \$350 thousand per month in 2015. Corresponding total lease quantity grew from 37 thousand to 90 thousand

[4] There are an additional 40 fishing vessels that are dual permitted in the Limited Access fishery (managed under Days-at-Sea) and the IFQ fishery. These vessels are not allowed to transfer or lease their QS or QP.

pounds per month (Figure 1).[5] The actual monthly lease quantity was even greater than those depicted in the figure, as over 30% of the lease quantity were excluded due to missing value information in the lease trade records (e.g., when quota was transferred between two vessels with the same owner). Significant seasonal variation existed in the lease market, and the number of lease transactions fluctuated between 10-60 per month. About half of the transactions involved CPH sellers. Spatial variation in lease trade was also evident, and most buyers and sellers were in Massachusetts and New Jersey.

Scallop price was rising from approximately \$9/lb to \$13/lb in the study period. A similar trend was also present in IFQ lease price, increasing from about \$2/lb in 2010 to over \$4/lb in 2015 (Figure 2). Changes in the IFQ transfer price generally followed the same pattern as the lease price (Figure 3; Pearson correlation coefficient between lease and transfer prices = 0.58 ($p<0.01$), excluding the two low-transfer-price outliers in 2012 and 2015). Transfer prices for QS have been around \$40/lb in recent years (Figure 3).

3. Method

One approach to examine general economic performance of IFQ market is to investigate the determinants of quota price movement using regressions (Newell et al., 2005). As shown by Newell et al., quota price may be affected by multiple factors including returns from fisheries, cost of fishing, resource conditions, and general economic climate. For our analysis, we develop two types of models: a macro-model of aggregate IFQ lease market and a micro-model of individual quota lease transactions.

The general specification of the macro-model of IFQ lease price (y) is:

$$y_t = \beta_0 + \mathbf{s}_t'\boldsymbol{\beta}_1 + \mathbf{r}_t'\boldsymbol{\beta}_2 + \mathbf{c}_t'\boldsymbol{\beta}_3 + \mathbf{b}_t'\boldsymbol{\beta}_4 + \mathbf{m}_t'\boldsymbol{\beta}_5 + \mathbf{e}_t'\boldsymbol{\beta}_6 + \mathbf{t}_t'\boldsymbol{\beta}_7 + \varepsilon_t \quad (1)$$

where βs are coefficients to be estimated and ε is an error term. At time t, **s** is the vector of scallop price and revenue, **r** is the vector of price and revenue of other species, **c** is the vector of fishing cost, **b** is the vector of scallop resource availability (quota allocation and stock), **m** is the vector of market competitiveness and permit type, **e** is the vector of macroeconomic condition, and **t** is the vector of seasonal effects and time trend. Different versions of Equation (1) (e.g., with lagged variables) are estimated using monthly data and autoregressive error model corrected for 1^{st}-3rd order autocorrelation (Yule-Walker estimates).

Following Lee (2012), the general specification of the micro-model of IFQ lease price (y) is:

$$y_i = \gamma_0 + \mathbf{x}_i'\boldsymbol{\gamma}_1 + \mathbf{g}_i'\boldsymbol{\gamma}_2 + \mathbf{h}_i'\boldsymbol{\gamma}_3 + u_i \quad (2)$$

where γs are coefficients to be estimated and u is an error term. For transaction i, **x** is the vector including the same set of independent variables in Equation (1), **g** is the vector of the characteristics of buyer, and **h** is the vector of the characteristics of seller. We employ White estimator to calculate heteroscedasticity consistent standard errors (Greene 2012).

4. Data

Primary data sources for the study include separate data files on approved IFQ lease transactions, IFQ permanent transfers, vessel logbook (fishing trip records), scallop fishing quota base allocation,

[5] The annual quantity accounted for about 42% of the total quantity of all lease transactions (including those with missing lease value information) in fishing year 2010, and around 65% in fishing years 2013-2015.

vessel permits data, and scallop biomass data from the National Marine Fisheries Service (NMFS). For convenience of data compilation, we identify buyer and seller in an IFQ trade using their fishing permit numbers. Note that about 84% of the permit numbers were associated with the same hull number during the study period. Thus, IFQ trade among permits captures the general pattern of trade among vessels, and in turn, vessel owners.

Fishing histories and other characteristics of buyer and seller of an IFQ trade (e.g., catch quantities, revenues, and costs) are constructed through merging data on IFQ transactions, logbook, and other files by permit number. For aggregate market variables, trip-level information is merged by permit number for each month and fishing year. Prices and values are converted to real 2015 dollars using the Producer Price Index for unprocessed and prepared seafood.

The data sets for regression analyses exclude IFQ transactions without price information. We also exclude observations with prices that are likely to be data errors or non-response answers: lease transactions with prices between $1.01/lb -$10/lb and transfers with prices between $1.01/lb -$100/lb are used in the analysis. Tables 1-2 present definition and descriptive statistics of variables in the macro-model of lease market. Tables 3 and 4 summarize similar information for the micro-model of lease transactions.

Vessel trip costs were estimated using a regression model for scallop dredge developed using NMFS Sea Sampling data and corresponding logbook information (Jin et al., 2016). In the model, trip cost is a function of vessel size (i.e., tonnage) and trip duration (days absent). Since relevant trip-level data are available for vessels involved in IFQ transactions, trip costs for those vessels can be easily calculated.

5. Results

We develop IFQ lease market and transfer market models using Equations (1) and (2) and project data sets each includes a large set of variables on prices and revenues of scallop and other species, fishing costs, scallop resource availability, as well as market and vessel permit information. Separate stepwise regressions were used to analyze the effects of these variables on IFQ lease price and transfer share. The result of a stepwise regression is an ordinary least-squares estimation of a linear multivariate model including only variables significant at or above the 15% level, which helps to identify key factors affecting the dependent variable in each case.

5.1. IFQ Lease Market

Table 5 reports the results from Yule-Walker estimations of two separate macro-models for monthly mean IFQ lease price in Equation (1) using the data set with selected variables described in Tables 1 and 2. The table includes results for statistically significant explanatory variables and constant terms. The models fit the data well with R-squares around 0.85. Most of the variables are significant at the 1% level and all are at the 10% level. The estimation results from both models suggest that the lease price is positively related to scallop price, which is consistent with economic theory and the findings of Newell et al. (2005). Lease prices are also inversely related to the number of permit-bank sellers that were active, which is consistent with the missions of these organizations to offer quota at below-market prices to encourage fishing activity in their communities. IFQ lease price is expected to be higher if the total scallop revenue in the previous month was high, and lower if the percent of scallop quota fished is high (Model II).

The percent quota fished describes the cumulative scallop harvest by month over a fishing year of all IFQ market participants relative to their total quota allocation. As the percent quota fished increases, the overall remaining quota declines, and the fishing year is closer to the end. The percentage of the quota fished was found to be inversely related to QP prices. There are two possible explanations for this findingThis is consistent with the theory of real-options, in which the "option value" component will declined to zero as the expiration date approached (Anderson, 1987). Alternatively, this could reflect within-season decreases in the value of exercising the real-option; Valcu and Weninger (2013) show that this can occur in an IFQ fishery if there are large stock effects in production or heterogenous-in-value stock. Both of these phenomena are likely in the IFQ fishery: the life history of scallops can result in patches of high density scallop beds (Hart and Chute, 2004) and large scallops receive high prices relative to smaller scallops (Ardini and Lee, 2016).

Other results indicates that positive relationships exist between IFQ lease price and variation of fishing costs across vessels (std of trip cost), macroeconomic condition (GDP), and trade in September (Model I). Note that a larger variation in fishing costs across vessels reflects an increased heterogeneity in vessel operational efficiency, which may lead to elevated market activities. Low-cost vessels are likely offer higher price, according to classical bidding models (Wilson 1977).[6]

Table 6 reports the results the White estimator for IFQ lease price in equation (2) using the data set on individual lease transactions (Tables 3 and 4). As in the macro-models of IFQ leases, the lease price is, on average, positively related to scallop price, GDP, and trade in September, and negatively related to percent of scallop quota fished. Furthermore, the micro-model results suggest that IFQ lease price is expected to be lower if the number of sellers in a month is large, the seller is part of a permit bank or a frequent seller, the buyer has large quota base allocation, and the buyer's vessel is large. Buyers with large quota allocations are less eager to acquire additional fishing quota, and they may be well informed about the state of the fishery and have an informational advantage. Buyer and seller locations (states) also affect the lease price. Lease quantity also positively influences lease price; this may be related to search costs for buyers.

5.2. Relationship between IFQ Lease and Transfer Prices

As noted in the introduction, according to economic theory, the price for IFQ transfer (QS) is equal to the capitalized profits in the fishery over time, whereas the IFQ lease price reflects the marginal net return in the fishery. Under dynamic quota arbitrage, assuming stable (competitive) market, the relationship between transfer price (P_T) and lease price (P_L) may be expressed as (Newell et al. 2005):

$$P_T = \frac{P_L}{\delta} \quad \text{or} \quad \frac{P_L}{P_T} = \delta \tag{3}$$

where δ is the discount rate perceived by scallop IFQ traders.

Figure 4 shows that the general movement of the lease to transfer price ratio follows that of the rate of 10-year Treasury note (Pearson correlation coefficient = 0.48 (p<0.01), excluding the two outliers in 2012 and 2015). The mean T-note rate and mean price ratio are 2.4% and 9.9%, respectively. On

[6] We also investigated the effects of vessel net revenues on the IFQ lease price, and the results were not statistically significant. This could be related to the fact that vessels in the General Category Scallop IFQ fishery catch both scallop and other species. The share of scallop landings fluctuates in a year between 60% (typically in May or June) and 30% (typically in November). Vessel owners maximize the total net revenue across different species.

average, the price ratio is 4.3 times the T-note rate. Fishing, and investing in a newly-created property right associated with fishing, is far riskier than investing in US Treasury securities. In particular, there is uncertainty about future stock levels, volatility in costs of fishing, and concerns about the the quality of the newly established property right (Arnason 2005; Scott 1996 and 1999). Thus, the IFQ trader's discount rate is significantly higher,

6. Conclusions

This study has investigated determinants of IFQ lease (QP) price and permanent transfer shares (QS) in the General Category Scallop fishery of the Northeastern United States. Detailed data on individual IFQ transactions and related vessel and stock information for the 6-year time period, fishing year 2010-2015, were used to estimate models of quota market and individual transactions.

The estimation results suggest that IFQ lease price is generally affected by factors influencing profitability of the fishery as well as the competitiveness of the leasing market. Specifically, lease price is positively associated with scallop price, general economic condition, and wider variation of fishing costs across vessels. Lease price is negatively associated resource availability, permit-bank sellers, and the presence of large number of sellers. Significant seasonal and spatial effects on lease price are also identified. Generally, for an IFQ market to function well, we need a large number of boats and active trading activities.

The number of permanent IFQ transfers is small due to ownership caps, high costs to obtain QS, and the convenience of a robust leasing market. Although QS trade is infrequent, changes in mean transfer price seem related to the movements in mean lease price. The results imply that, on average, the price for IFQ transfers reflects the capitalized profits from fishing over time, adjusted for risks associated with the scallop fishery. Overall, the scallop IFQ market performance has been consistent with economic theory.

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Table 1: Lease Market Model Variable Description

Variable	Unit	Description
Dependent Variables		
Mean lease price	2015$/lb	monthly average lease price
Independent variables		
Scallop price	2015$/lb	monthly average scallop price
Std of trip cost	10^3 2015$	standard deviation of trip cost across permits by month
Lagged total scallop revenue	10^3 2015$	total scallop revenue in previous month
Number of permit-bank seller		number of permit-bank sellers by month
Percent quota fished		percent of TAC fished by month in a fishing year
GDP	10^12 2009$	US quarterly real GDP
September		monthly dummy
Fishing year 2013		yearly dummy
Fishing year 2014		yearly dummy
Fishing year		time trend

Table 2. Lease Market Data Descriptive Statistics

Variable	Mean	Std Dev	Minimum	Maximum
Dependent variable				
Mean lease price	3.15	0.81	1.85	4.93
Independent variables				
Scallop price	12.06	1.27	8.07	14.58
Std of trip cost	6.11	1.53	3.55	12.59
Lagged total scallop revenue	2.11	1.18	0.72	6.16
Number of permit-bank sellers	3.40	3.93	0	20
Percent quota fished	0.61	0.31	0.04	1.17
GDP	15.56	0.55	14.60	16.51
September	0.08	0.28	0	1
Fishing year 2013	0.17	0.38	0	1
Fishing year 2014	0.17	0.38	0	1
Fishing year	2012.50	1.72	2010	2015

Table 3. Micro Model Variable Description

Variable	Unit	Description
Dependent Variables		
Lease price	2015$/lb	lease price
Independent variables		
Lease quantity	10^4 lb	lease quantity
Scallop price	2015$/lb	monthly average scallop price
Percent quota fished		percent of TAC fished by month in a fishing year
Number of sellers		number of sellers by month
Permit bank seller		seller is in permit bank
Frequent seller		Seller sold more than 20 times in the study period
GDP	10^12 2009$	US real GDP
Buyer vessel gross ton	10^2 ton	buyer vessel gross tons
Buyer quota allocation	10^6 lb	buyer base allocation
RI buyer		state dummy
DE buyer		state dummy
MA buyer		state dummy
ME buyer		state dummy
NC seller		state dummy
NY seller		state dummy
RI seller		state dummy
August		monthly dummy
September		monthly dummy
Fishing year 2010		yearly dummy
Fishing year 2011		yearly dummy

Table 4. Lease Transaction Data Descriptive Statistics

Variable	Mean	Std Dev	Minimum	Maximum
Dependent variable				
Lease price	3.03	1.25	1.02	8.66
Independent variables				
Lease quantity	0.40	0.44	0.00	3.58
Scallop price	12.14	1.14	8.07	14.58
Percent quota fished	0.59	0.30	0.04	1.17
Number of sellers by month	25.82	9.60	4	49
Permit bank seller	0.18	0.38	0	1
Frequent seller	0.24	0.43	0	1
GDP	15.61	0.52	14.60	16.51
Buyer vessel gross ton	0.53	0.38	0.05	1.37
Buyer quota allocation	0.01	0.01	-0.01	0.05
RI buyer	0.01	0.08	0	1
DE buyer	0.01	0.07	0	1
MA buyer	0.58	0.49	0	1
ME buyer	0.03	0.17	0	1
NC seller	0.03	0.18	0	1
NY seller	0.03	0.17	0	1
RI seller	0.01	0.10	0	1
August	0.09	0.29	0	1
September	0.08	0.27	0	1
Fishing year 2010	0.10	0.29	0	1
Fishing year 2011	0.19	0.39	0	1

Table 5. Model of IFQ Market: Monthly Mean IFQ Lease Price

	Model I		Model II	
Variable	**Coefficient**	**Std Error**	**Coefficient**	**Std Error**
Scallop price	0.176***	0.056	0.231***	0.062
Std of trip cost	0.124***	0.027	-	-
Lagged total scallop revenue	-	-	0.098*	0.049
Number of permit-bank seller	-0.029***	0.011	-0.047***	0.012
Percent quota fished	-	-	-0.404**	0.168
GDP	0.847***	0.163	-	-
September	0.210*	0.125	-	-
Fishing year 2013	-	-	-	-
Fishing year 2014	0.522***	0.171	-	-
Fishing year	-	-	0.253***	0.051
Intercept	-12.917***	2.231	-507.759***	101.755
# Of observations	72		71	
R-squared	0.86		0.84	

*, **, and *** denote significance at 10, 5, 1% significance levels, respectively.

Table 6. Model of Individual Transactions: IFQ Lease Price

Variable	Coefficient	Std Error
Intercept	-6.491***	1.266
Lease quantity	0.134***	0.051
Scallop price	0.134***	0.040
Percent quota fished	-0.419***	0.112
Number of sellers	-0.005**	0.003
Permit bank seller	-1.445***	0.060
Frequent seller	-0.355***	0.056
GDP	0.578***	0.094
Buyer vessel gross ton	-0.131**	0.065
Buyer quota allocation	-13.309***	2.552
RI buyer	-1.031***	0.357
DE buyer	-0.513***	0.195
MA buyer	-0.124**	0.052
ME buyer	-0.271*	0.153
NC seller	0.316***	0.084
NY seller	0.622***	0.115
RI seller	1.151**	0.478
August	0.262***	0.074
September	0.326***	0.090
Fishing year 2010	-0.956***	0.105
Fishing year 2011	-0.744***	0.072
# of observations	1,189	
R-squared	0.62	

*, **, and *** denote significance at 10, 5, 1% significance levels, respectively.

Figure 1. Monthly Total IFQ Lease Quantity and Value

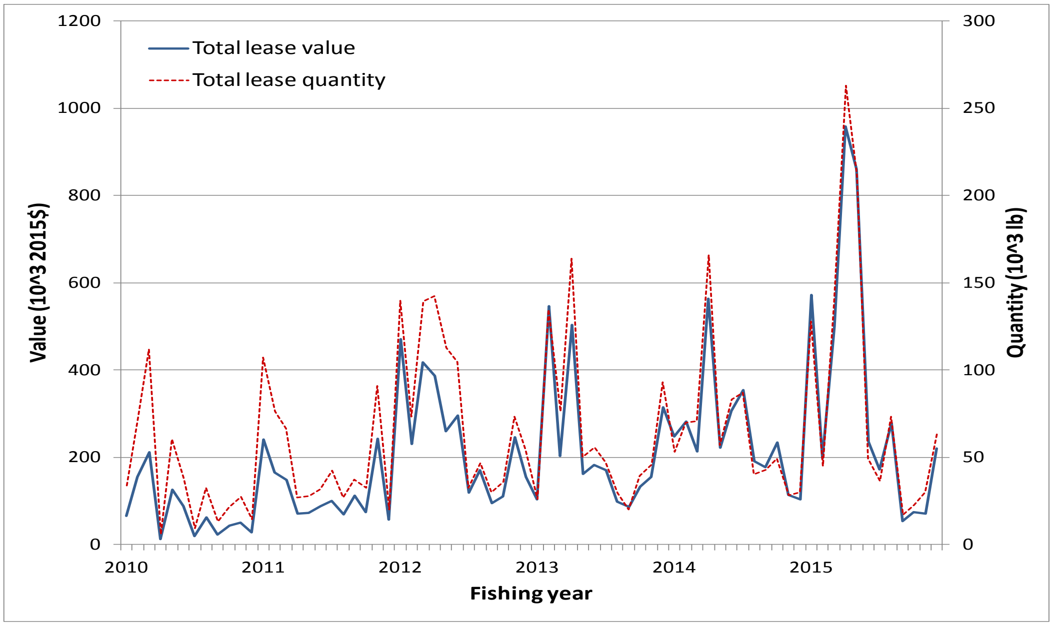


Figure 2. Monthly Mean IFQ lease Price and Scallop Price

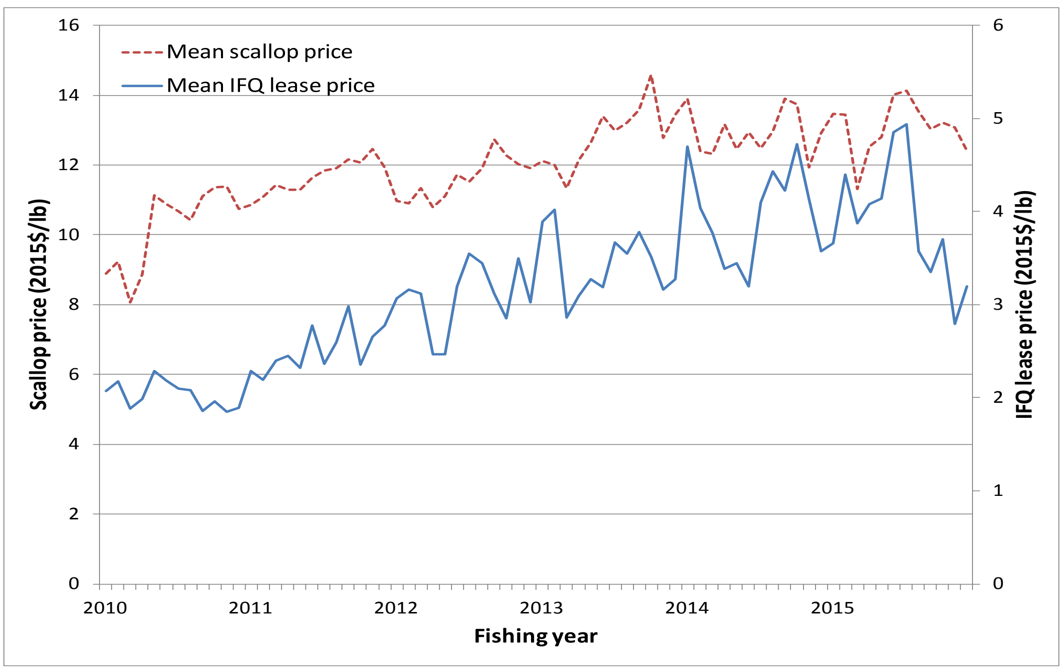


Figure 3. Monthly Mean IFQ Lease and Transfer Prices

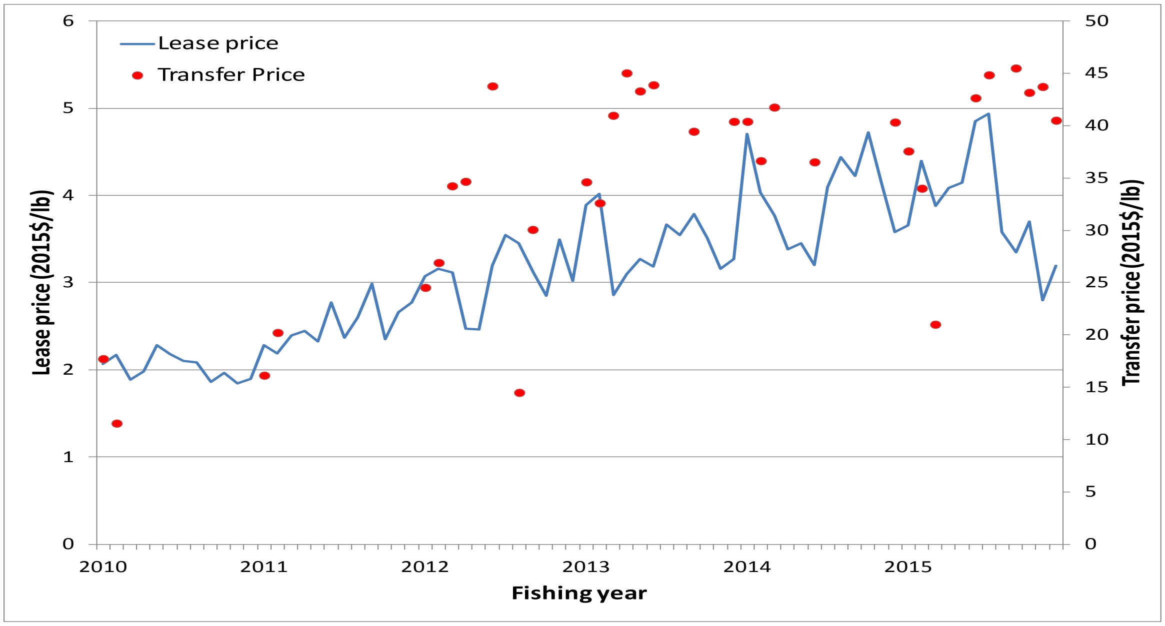
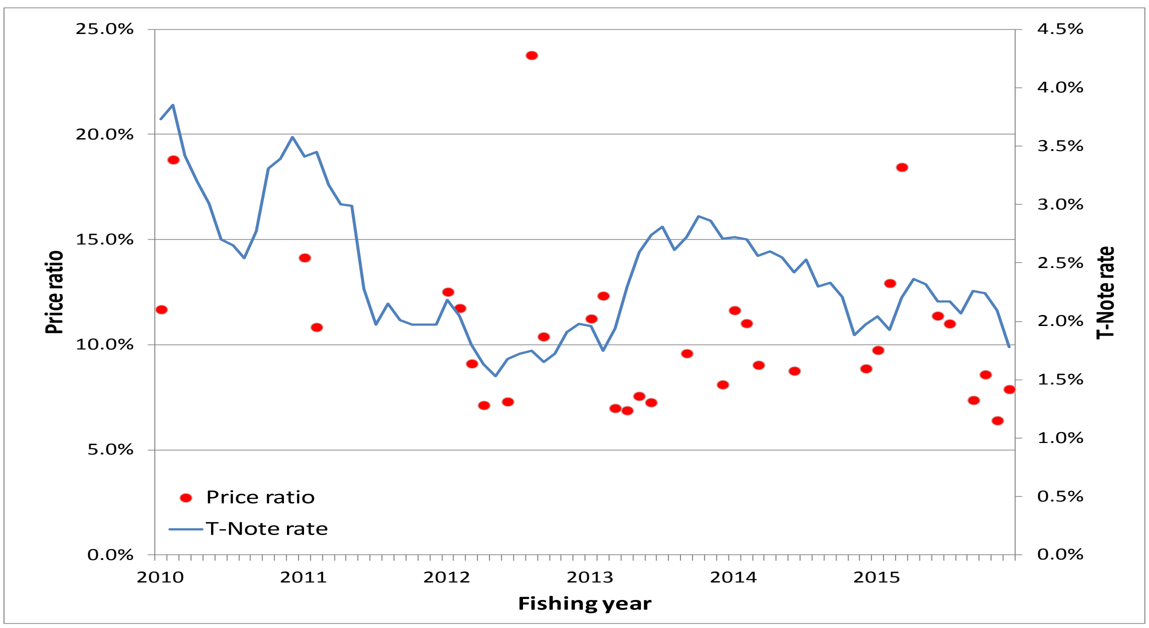


Figure 4. Monthly Lease-Transfer Price Ratio vs. T-Note Rate



APPENDIX F – GENERAL CATEGORY PERMIT HOLDERS THAT DID NOT QUALIFY FOR AN IFQ PERMIT

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Intro and Methods

To qualify for an IFQ permit, a General Category scallop vessel had to have 1,000 pounds of scallop meat landings during any fishing year over the qualification period (3/1/2000 to 11/1/2004). This section focuses on those vessels that did not meet the IFQ criteria, but did land scallops during the qualification period and continued to remain active in any fishery during the IFQ period (3/1/2010 - 2/29/2016). The purpose is shed some light on how reliance across species groups differed among these vessels during the two time periods as well as examining how many vessels may have qualified for an IFQ permit had the qualification criterion been lower. For purposes of analysis reliance was measured by the percent of total revenue earned from designated species groups. The species groups were assembled according to the FMPs of the New England and Mid Atlantic Fishery Management Councils. Species that are not explicitly managed by an FMP in either Council were combined into an "other" group.

Non-qualifiers were identified by first extracting all dealer purchases of sea scallops from NFMS dealer data for scallop fishing years 2000-2004. The vessel permit number of the seller to the dealer was then matched to permit data, so that only sales by General Category vessels were kept. Annual scallop sales (by fishing year) were then summed by vessel. Any vessel that landed scallops but had less than 1,000 pounds of scallop landings in all of the qualifying years was identified as a non-qualifier. Dealer data for each of these non-qualifying vessels were summarized by species group and fishing year for the IFQ period 3/1/2010 to 2/29/2016. Any vessel that did not report landings of any species during the entire IFQ period was deemed to be inactive and was eliminated from further consideration. This left a total of 180 non-qualifying vessels that had landed scallops during the qualifying period and were active in at least one year during the IFQ period.

Results and Discussion

Trends among actual non-qualifiers

As noted above, there were 180 non-qualifying vessels identified. Of these 180 vessels, 97 (54%) actively fished for scallops in only one fishing year during the qualification period, while just 11 vessels (6%) actively fished for scallops in all five years (Table 1). This suggests that most non-qualifiers were generally not engaged in the scallop fishery throughout the qualification period.

Table 14: Number of active fishing years (>0 lbs. scallop landings) by non-qualifying general category vessels during qualification period (fishing years 2000-2004)

# Active fishing years	# Vessels
1	97
2	44
3	17
4	11
5	11
Total	*180*

As Table 1 demonstrates only a handful of non-qualifying vessels were active in every year during the qualifying years, meaning that there were a substantial number of vessels moving in and out of the fishery over time. In FY2000, 62 of the 180 non-qualifiers landed scallops (Table 2). Of these 62 vessels, 30 exited the fishery and did not land scallops during FY2001. In FY2001, 67 non-qualifying vessels landed scallops (a net increase of 5 vessels). These 67 vessels were comprised of 35 vessels that entered the fishery in 2001 (they did not land any scallops during FY2000) and 30 vessels that landed scallops in both FY2000 and FY2001. FY2002 saw the largest net decrease in active vessels (-13), the largest number of exiting vessels (-41), the lowest number of entering vessels (28), and the lowest number of vessels that remained from the previous FY (26). This was followed by an increase in active vessels in FY2003 from 54 to 77, with the largest number of entering vessels (46) and the smallest number of exiting vessels (-23) occurring in that FY.

Table 15: Number of active, non-qualifying vessels by fishing year during qualification period

	FY2000	FY2001	FY2002	FY2003	FY2004
Active, non-qualifying scallop vessels	62	67	54	77	75
Entry (# vessels active after being inactive in previous FY)	N/A	35	28	46	37
Exit (# vessels inactive after being active in previous FY)	N/A	-30	-41	-23	-39
Remain **(# of vessels that fished in the current year and previous FY)**		32	26	31	38
Year to year Net Change	*N/A*	*5*	*-13*	*23*	*-2*

In terms of fishery participation, the 180 non-qualifying vessels were active in a wide variety of fisheries during the qualification period, and continued to do so during the IFQ period. The percent of total revenue by species group among non-qualifiers during the qualification period and during the IFQ period is shown in Table 3. Sea scallop revenue comprised a small percentage of total revenue during both periods. Across the designated species groups, sea scallop revenue was the smallest revenue component to the 180 non-qualifiers. Groundfish comprised the greatest percentage of revenue during both periods, though the percentage decreased during the IFQ period. Table 3 would suggest that failing to qualify for an IFQ permit did not force these vessels to dramatically alter their fishing choices. It appears that the far larger impact to the non-qualifying General Category vessels as a whole arose from changing conditions and management in the groundfish fishery. Still, of these 180 non-qualifying vessels, a majority (99) did not participate in the scallop fishery during the IFQ period.

Table 16: Percentage of revenue generated by species group among non-qualifying vessels (N=180) during qualification (3/1/2000 to 11/1/2004) and IFQ periods (3/1/2010 to 2/29/2016)

Species Group	Percentage of revenue generated by non-qualifiers during qualification period	Percentage of revenue generated by non-qualifiers during IFQ period
Sea Scallop	0.1%	1.2%
American Lobster	1.9%	4.9%
Groundfish	33.8%	23.7%
Monkfish	7.1%	4.5%
Scup/Fluke/Black Sea Bass	7.5%	13.5%
Squid	14.3%	17.8%
Surf Clam/Ocean Quahog	20.5%	15.8%
Whiting	6.9%	7.4%
Other	7.9%	11.3%
Total	*100.0%*	*100.0%*

Non-qualifiers under hypothetical landing requirements

The potential effect that a more liberal poundage qualification might have had on the number of non-qualifiers was evaluated by selecting the "best" year among the 180 non-qualifiers. The resulting distribution of non-qualifiers' best years is illustrated in Figure 1. The distribution illustrates that many of the 180 non-qualifiers still would not have been eligible for an IFQ permit if the landings criteria was lowered. For example, if the criteria were 500 lbs., there would have been 139 non-qualifiers (41 fewer). The species breakdown of these 41 vessels that came closest to qualifying is shown in Table 4. In comparison to Table 3, the percentage of revenue that came from sea scallops during the qualification period is slightly higher; though still less than 1%. Somewhat surprisingly, the percentage of revenue from sea scallops during the IFQ period was lower among these 41 vessels than the entire group of non-qualifiers. This sub-group of vessels also was heavily reliant on groundfish during the qualification period, collecting 52.5% of total revenue from this species group. During the IFQ period, this percentage dropped to 33.4%.

Figure 5: Number of General Category vessels that would fail to qualify for an IFQ permit under hypothetical landings criteria during qualification period

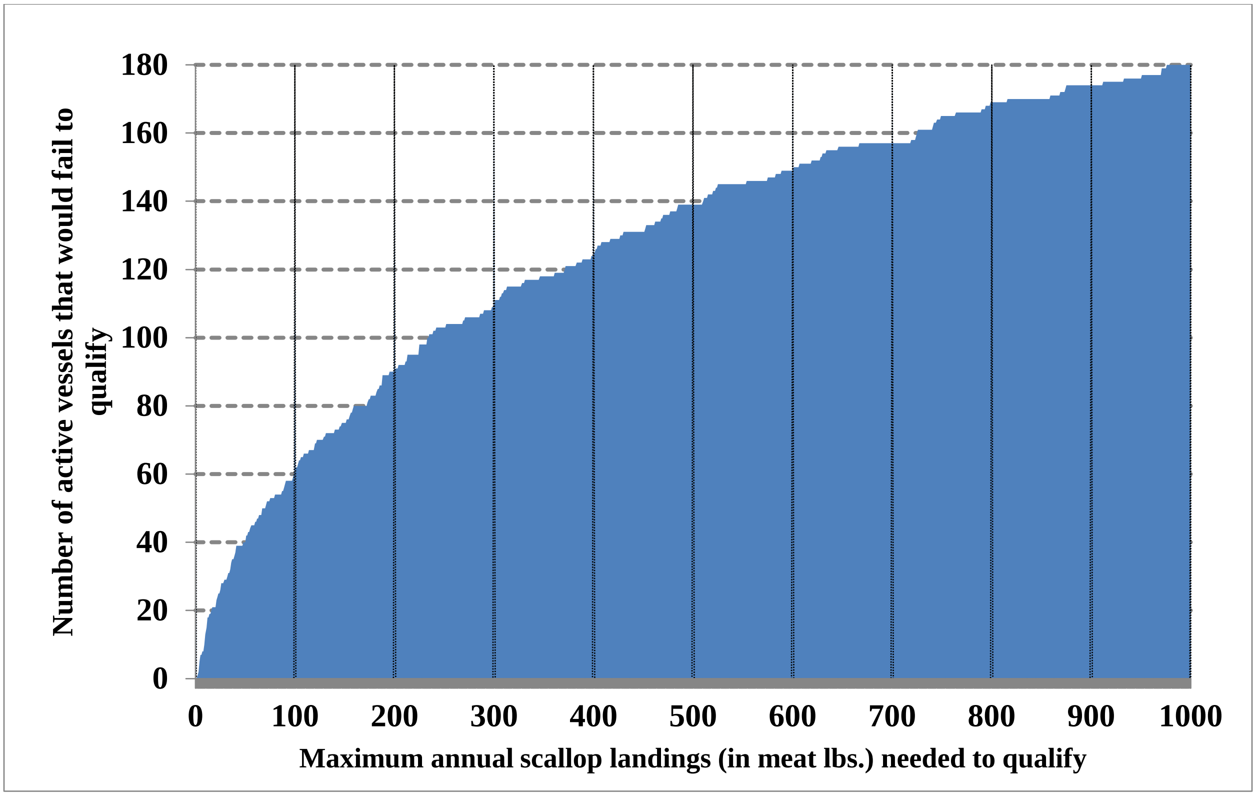


Table 17: Percentage of revenue generated by species group among non-qualifying vessels that would have qualified under a 500 lb. landing criteria (N=41) during qualification (3/1/2000 to 11/1/2004) and IFQ periods (3/1/2010 to 2/29/2016)

Species Group	Percentage of revenue generated by select non-qualifiers during qualification period	Percentage of revenue generated by select non-qualifiers during IFQ period
Sea Scallop	0.3%	0.4%
American Lobster	2.7%	6.3%
Groundfish	52.5%	33.4%
Monkfish	8.9%	5.5%

Scup/Fluke/Black Sea Bass	5.0%	11.2%
Squid	10.2%	9.2%
Surf Clam/Ocean Quahog	5.6%	10.4%
Whiting	7.2%	13.5%
Other	7.6%	10.1%
Total	*100.0%*	*100.0%*

APPENDIX G – MEASURING SPECIES DIVERSITY AMONG IFQ VESSELS USING THE HERFINDAHL INDEX

Greg Ardini, Northeast Fishery Science Center, SSB

Intro and Methods

The Herfindahl Index is a metric that is commonly used to measure concentration in a market place. In this more generally utilized form, the calculation of the index involves squaring the share each firm holds in a market. For the purposes of this section, the Herfindahl Index is used to measure the concentration of revenue by IFQ vessels among various species groups, such that the proportion of revenue from each species group is squared (Equation 1). The species-related revenue used to calculate the index was retrieved from NMFS dealer data. The grouping by species is shown in Table 1.

The Herfindahl Index was calculated for scallop fishing years 2004-2015 for all vessels that had an IFQ permit for at least one fishing year during 2010-2015. Calculations were made for all fishing years in which a vessel was active, resulting in a Herfindahl measurement of 3,090 vessel/fishing year combinations. To highlight those vessels most dependent on scallops, the dataset was then filtered to only include those vessel/fishing year combinations that had a majority of their total revenue from scallops, resulting in 1,636 combinations. For the purposes of comparison, the Herfindahl indices were then replotted for this subset.

$$\text{Equation 1:} \quad H = \sum_{i=1}^{N} s_i^2$$

Where s_i = the share of a vessel's total revenue from species group i; N=total number of species groups. For example: a vessel collecting 80% of revenue from scallops and 20% from lobster; $H = (.8)^2 + (.2)^2 = .68$

Table 18: Species grouping used in calculating the Herfindahl Indices

Species Group Name	Species Included in Group (if not identified in the group name)
Atlantic Scallop	
Black Sea Bass and Fluke	
Bluefish (Mid-Atlantic)	
Bluefish and Scup (New England)	
Butterfish, Whiting, Red Hake	
Halibut (New England)	
Atlantic Herring	
Highly Migratory Species	Tunas, Sharks, Swordfish
Illex Squid	
Lobster	
Loligo Squid	
Mackerel	
Menhaden	
Mid-Atlantic Groundfish	Cod, Wolffish, American Plaice, Witch Flounder, Unspecified Hake, Haddock, Pollock, Redfish, Halibut
Monkfish (Mid-Atlantic)	

New England Groundfish	Cod, Winter Flounder, Witch Flounder, Yellowtail Flounder, Haddock, American Plaice, Pollock, Whiting, Redfish, Monkfish
Ocean Pout (New England)	
Ocean Quahog	
Offshore Hake	
Scup (Mid-Atlantic)	
Shrimp	
Skates	
Spiny Dogfish	
Surf Clam	
Tilefish	
Unspecified Hake (New England)	
White Hake	
Windowpane Flounder (New England)	
Windowpane Flounder and Ocean Pout (Mid-Atlantic)	
Winter Flounder (Mid-Atlantic)	
Wolffish (New England)	
Yellowtail Flounder (Mid-Atlantic)	
Other Species	

Secondly, the full set of 3,090 vessel/fishing year combinations were grouped into two different time periods to illustrate changes in reliance on scallops over time. The first time period (FYs 2004-2009) covers when these vessels were fishing under a General Category (GC) permit and when they were fishing under an IFQ permit with a fleet-wide TAC. The second period (FYs 2010-2015) covers when these vessels were fishing under a true IFQ permit. This method is a more simplified approach in which all non-scallop revenue is aggregated at the vessel level. Conversely, the number of species groups a vessel lands aside from scallops will change its Herfindahl Index (Equation 1).

Results and Discussion

Herfindahl Index Trends

A plot of the Herfindahl indices for the 3,090 active vessel/FY combinations is shown in Figure 1. Over time, there is an upward trend, indicating a less diverse catch portfolio across active vessels. FY2015 had an especially pronounced spike in indices. In recent years, the median (the horizontal line within the box) is higher than the mean (the diamond in the box) indicating a distribution shifted towards the maximum Herfindahl value of 1. The box extends from the 25th percentile to the 75th percentile for each fishing year, while the line outside the box covers all observations that are within 1.5*IQR[7] of the 25th or the 75th percentiles. The 75th percentile is very close to 1.0 in every fishing year, but some vessels do have a Herfindahl around 0.2 in every fishing year as well. It is important to mention that some vessels that had a high index in a given fishing year may not necessarily derive most of their revenue from sea scallops. These vessels may very well mainly rely on another species group from Table 1.

Figure 2 shows the inverse of the Herfindahl indices presented in Figure 1. The inverse Herfindahl index represents the number of species groups that would comprise aggregate revenue if revenue shares were equal across all species (e.g. a vessel with a Herfindahl index of

[7] IQR refers to Interquartile Range and is the distance between the 25th and 75th percentiles.

.5 could attain all of their revenue from 2 species groups equally). The fact that the vast majority of data points in Figure 2 lie below 2.0 is an indication there tends to be a relatively small number of species groups that comprise most of the revenue generated by IFQ qualifiers. Circles in the figure are considered outliers (beyond 1.5*IQR from the 25^{th} or 75^{th} percentiles) and roughly correspond to inverse values >3.0 in most fishing years. Therefore a vessel that could generate revenue from 3 species groups equally would be considered rare.

In comparison to Figure 1, Figure 3 shows the Herfindahl indices for the subset of 1,636 vessel/FY combinations in which scallops were the top revenue-earning species group. Compared to Figure 1, the indices tend to be higher. This is not a huge surprise, considering all of these vessels qualified for an IFQ permit and scallop prices are higher than most other species. There also appears to be a slight upward trend in Herfindahl indices in Figure 3, though not nearly as pronounced as in Figure 1. The indices in Figure 3 did start at a higher point than those in Figure 1, leaving less room for an upward trend across vessels. For all fishing years in Figure 3, the median is higher than the mean indicating a distribution shifted towards the maximum Herfindahl value of 1. In fact, the median in all fishing years is not far from 1. This means that among vessels that earn more revenue from scallops than any other species group in a given fishing year, at least half of these vessels earn all, or nearly all, of their revenue from scallops.

Figure 4 shows the inverse of the Herfindahl indices presented in Figure 3. Again, the inverse Herfindahl index represents the number of species groups that would comprise aggregate revenue if revenue shares were equal across all species. In comparison to Figure 2, the distribution is even closer to 1 (where all revenue is generated by one species group). Figure 4 shows that IFQ qualifiers that earn more revenue from scallops than any other species group generally do not have secondary groups that come close to rivaling the importance of scallops. This is evidenced by the fact the in most fishing years, a value above 2.0 is considered an outlier.

Figure 6: Herfindahl indices by vessels holding an IFQ permit in at least one fishing year from 2010-2015, includes all active vessel/fishing year combinations

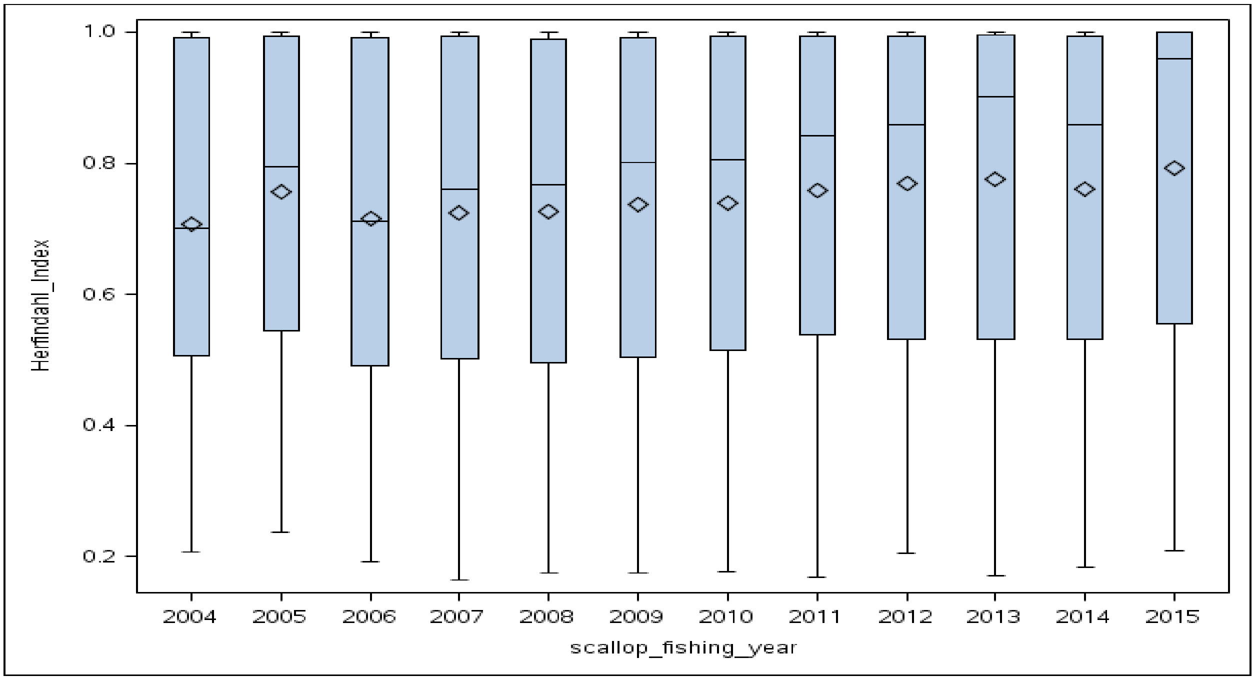


Figure 7: Inverse of the Herfindahl indices (Figure 1) by vessels holding an IFQ permit in at least one fishing year from 2010-2015, includes all active vessel/fishing year combinations

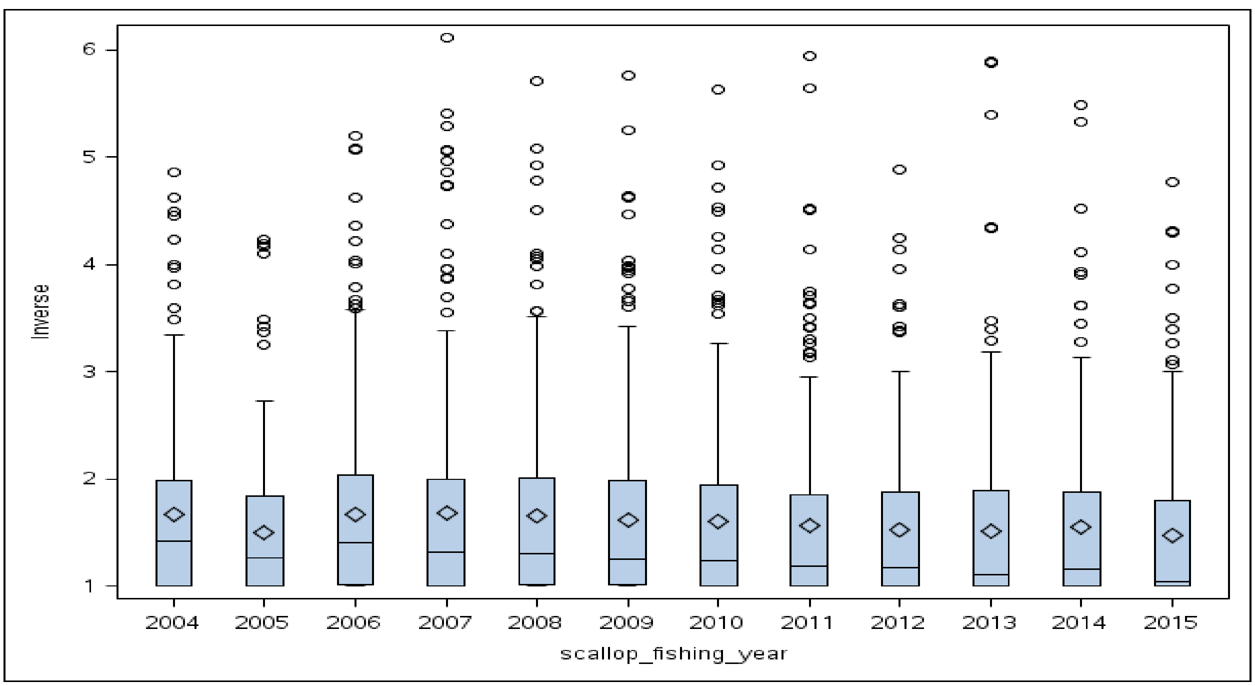


Figure 8: Herfindahl indices by vessels holding an IFQ permit in at least one fishing year from 2010-2015, includes all active vessel/fishing year combinations in which scallops were top revenue earning species group

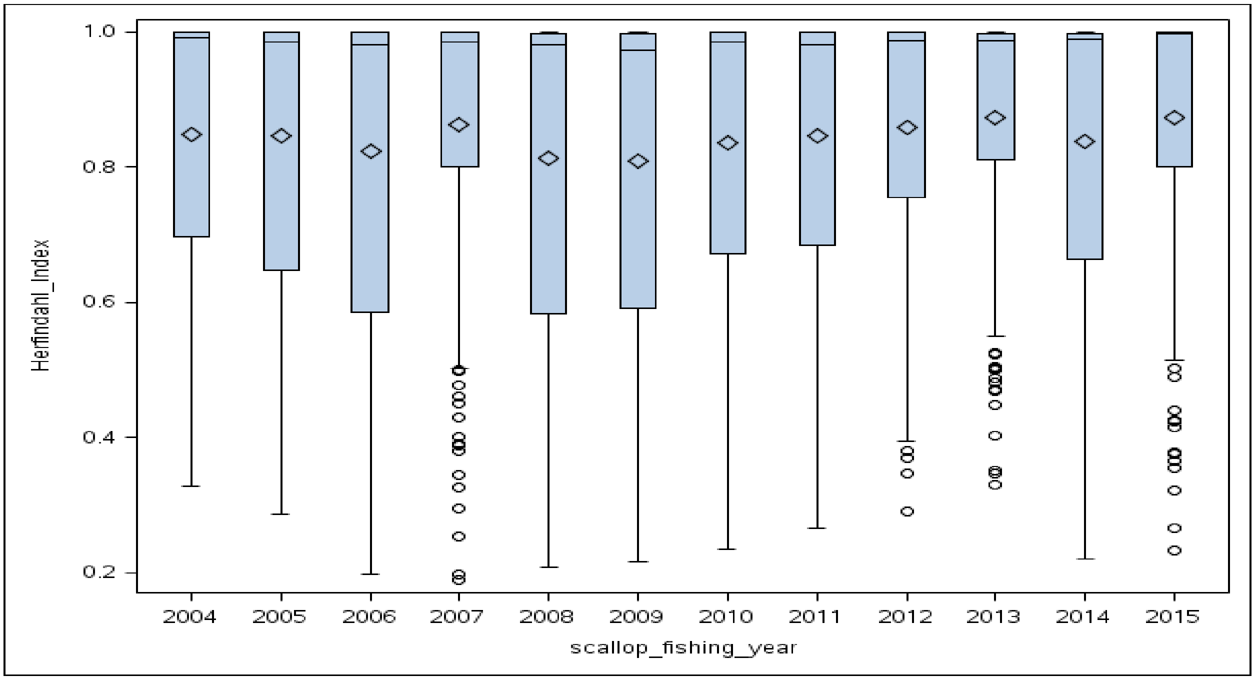
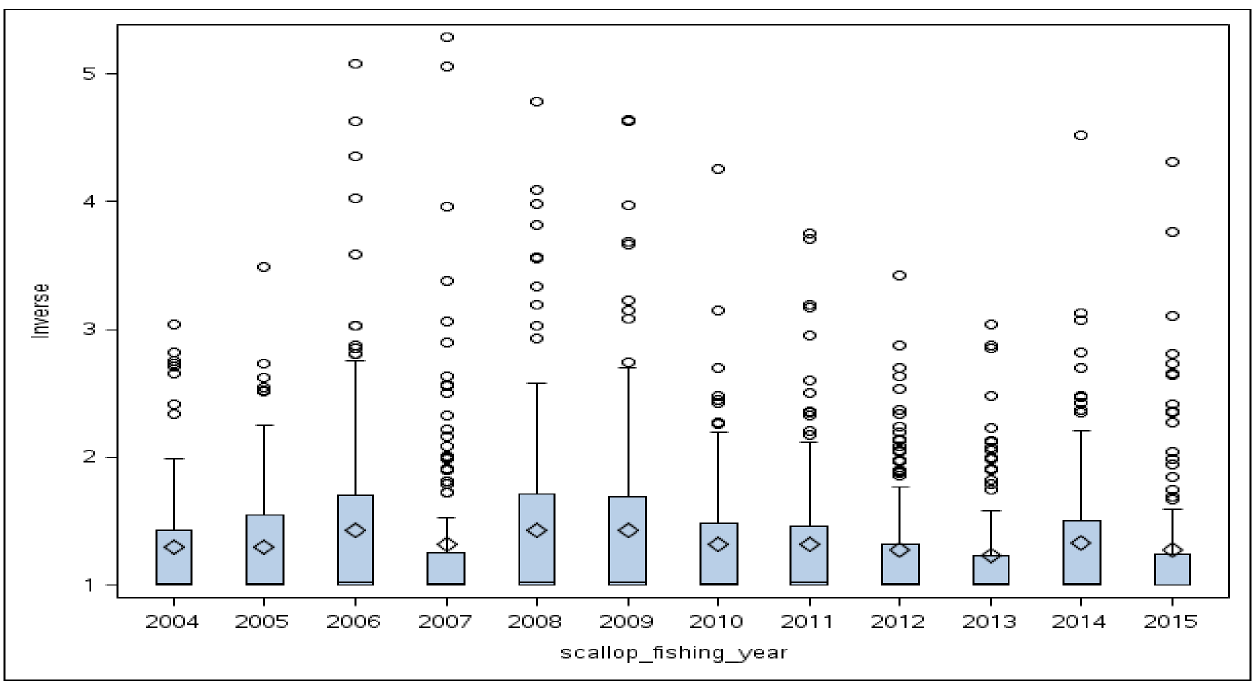


Figure 9: Inverse of the Herfindahl indices (Figure 3) by vessels holding an IFQ permit in at least one fishing year from 2010-2015, includes all active vessel/fishing year combinations in which scallops were top revenue earning species group



IFQ Revenue Trends

Table 2 gives the breakdown of scallop landings revenue relative to overall landings revenue. A few interesting trends stand out. First, the absolute number and percentage of vessels deriving 0% of their landings revenue from scallops sharply increase during the IFQ period vs. the six years prior. This could be an indication that a fair number of vessels that qualified for an IFQ permit leased out their entire quota. Second, there is a decline in vessels collecting less than half of their landings revenue from scallops during the IFQ period. It may be that vessels that were not among the most reliant on scallops prior to IFQs were the ones that started leasing out their quota when the IFQ fishery started. Third, the percentage of vessels receiving over half of their revenue from scallops increased during the IFQ period. As a counter to vessels less reliant on scallops, these vessels may have been the ones that were more likely to lease in quota. The increased price for scallops in more recent fishing years also would result in some vessels being more reliant on scallops.

Table 19: Reliance on revenue from scallops among vessels holding an IFQ permit in at least one fishing year from 2010-2015

% Revenue from scallops	**Fishing Years**	
	2004-2009	2010-2015
0%	25 (8%)	60 (20%)
0% - <25%	88 (28%)	62 (21%)
25% - <50%	40 (13%)	18 (6%)
50% - <75%	32 (10%)	39 (13%)
75% - <100	113 (36%)	107 (36%)
Total	*315*	*297*

Table 20: Percentage of revenue generated by species group among non-qualifying vessels (N=180) during qualification (3/1/2000 to 11/1/2004) and IFQ periods (3/1/2010 to 2/29/2016)

Species Group	Percentage of revenue generated by non-qualifiers during qualification period	Percentage of revenue generated by non-qualifiers during IFQ period
Sea Scallop	0.1%	1.2%
American Lobster	1.9%	4.9%
Groundfish	33.8%	23.7%
Monkfish	7.1%	4.5%
Scup/Fluke/Black Sea Bass	7.5%	13.5%
Squid	14.3%	17.8%
Surf Clam/Ocean Quahog	20.5%	15.8%
Whiting	6.9%	7.4%
Other	7.9%	11.3%
Total	*100.0%*	*100.0%*

Non-qualifiers under hypothetical landing requirements

The potential effect that a more liberal poundage qualification might have had on the number of non-qualifiers was evaluated by selecting the “best” year among the 180 non-qualifiers. The resulting distribution of non-qualifiers’ best years is illustrated in Figure 1. The distribution illustrates that many of the 180 non-qualifiers still would not have been eligible for an IFQ permit if the landings criteria was lowered. For example, if the criteria were 500 lbs., there would have been 139 non-qualifiers (41 fewer). The species breakdown of these 41 vessels that came closest to qualifying is shown in Table 4. In comparison to Table 3, the percentage of revenue that came from sea scallops during the qualification period is slightly higher; though still less than 1%. Somewhat surprisingly, the percentage of revenue from sea scallops during the IFQ period was lower among these 41 vessels than the entire group of non-qualifiers. This sub-group of vessels also was heavily reliant on groundfish during the qualification period, collecting 52.5% of total revenue from this species group. During the IFQ period, this percentage dropped to 33.4%.

Figure 10: Number of General Category vessels that would fail to qualify for an IFQ permit under hypothetical landings criteria during qualification period

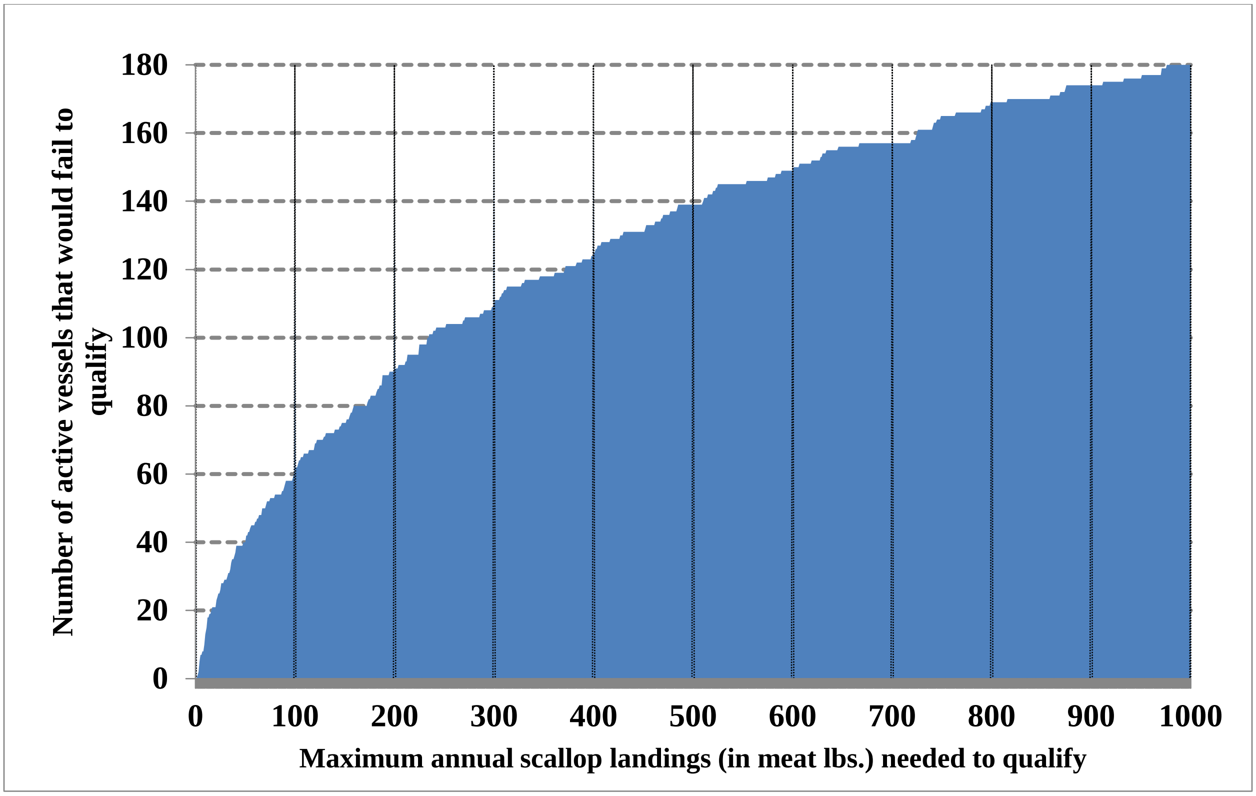


Table 21: Percentage of revenue generated by species group among non-qualifying vessels that would have qualified under a 500 lb. landing criteria (N=41) during qualification (3/1/2000 to 11/1/2004) and IFQ periods (3/1/2010 to 2/29/2016)

Species Group	Percentage of revenue generated by select non-qualifiers during qualification period	Percentage of revenue generated by select non-qualifiers during IFQ period
Sea Scallop	0.3%	0.4%
American Lobster	2.7%	6.3%
Groundfish	52.5%	33.4%

Monkfish	8.9%	5.5%
Scup/Fluke/Black Sea Bass	5.0%	11.2%
Squid	10.2%	9.2%
Surf Clam/Ocean Quahog	5.6%	10.4%
Whiting	7.2%	13.5%
Other	7.6%	10.1%
Total	*100.0%*	*100.0%*

APPENDIX H – GEOGRAPHICAL DIVERSITY

Dr. Min Yang Lee, Northeast Fishery Science Center, SSB

Important Findings

- Since 2010, the IFQ fishery landed in ports that are less similar to the all ports, but there is not particular trend in the IFQ fishery in relation to the LA fishery.
- The LAGC-IFQ fleet is using areas of the ocean that are similar to areas of the ocean used by the entire fishery.
- The overlap between the LAGC-IFQ and LA fleets decreased for 2 years, indicating the two fleets were using different areas of the ocean. However, from 2012-2015, the overlap indices have been increasing, indicating that the fleets have been using increasingly similar areas of the ocean.

1. Introduction and Motivation

The location, dispersion, and concentration of economic activity are frequently studied phenomena in regional science and economics[8]. This section describes the geography of the LAGC-IFQ scallop fishery using three methods. The first method characterizes the concentration of the IFQ scallop fishery across ports using relative and absolute indexes. The second uses similar techniques to characterize the concentration of the IFQ scallop fishery across the ocean, also using relative and absolute indices. The final method examines the amount of overlap between the IFQ and Limited Access fisheries.

2. Methods

We use a Generalized Theil index of disproportionality (Bickenbach and Bode, 2008) to characterize various geographic trends (dispersion and concentration) in the LAGC-IFQ scallop fishery. We also construct the Czekanowski (1909) overlap index applied to fishing locations for the LAGC-IFQ and LA fisheries. Where relevant, we also compute index values for the GC fleet to illustrate changes over time. The general form of the Theil index of concentration (*T*) for industry *i* in time period *t* is written as:

$$T_{it} = \sum_{r=1}^{R} w_{rt} \frac{\frac{X_{irt}}{\Pi_{irt}}}{\sum_r w_{rt} \frac{X_{irt}}{\Pi_{irt}}} \ln\left(\frac{\frac{X_{irt}}{\Pi_{irt}}}{\sum_r w_{rt} \frac{X_{irt}}{\Pi_{irt}}} \right) \tag{1}$$

where X_{ir} is the measure of economic activity of industry *i* in region *r* and time *t* . For all analysis, X_{ir} is nominal dollars of value in the LAGC-IFQ scallop fishery in region *r* and Fishing Year *t*. Π_{irt} is a reference distribution of activity that formalizes the null hypothesis of "no concentration" for industry *i*. The regional weights, w_{rt}, reflect the importance of each spatial unit and are selected so that $\sum_r w_{rt} = 1$. For all metrics, the regional weights, w_{rt}, are set to X_{ir};

[8] See Holmes and Stevens (2004), Combes and Overman (2004), and Fujita et al. (2004) for an overviews of concentration and specialization in North America, Europe, and East Asia respectively.

this weighting system maintains that each dollar of value is equally important in the aggregation. The $\frac{\mathrm{X_{irt}}}{\Pi_{irt}}$ term is referred to as a region-specific proportionality factor (RSPF).

The VTR data are used as the source for commercial landings (pounds) and port. For many earlier years in the VTR database, smaller, less-frequented ports were aggregated at the data entry step. We have corrected these aggregation problems by examining original images. The dealer data are used to construct the prices needed to compute value. We classify landings and value as either in or out of the IFQ fishery. We use the permit data to determine category (or categories) of scallop permit held by a vessel on the landing date. Trips taken by vessels holding a single category of permit are easily classified. Trips taken by vessels holding both LA and LAGC-IFQ scallop permit categories are classified into or out of the IFQ fishery based on reported landings. The scallop IFQ fishery allows for increased possession when an observer is onboard, therefore, we apply a weight cutoff of 700lbs before August 1, 2011 and 900 lbs after that date for these trips.

2.1 Dispersion and Concentration in landing ports

The spatial unit *i*, is the 2013 U.S. Census County Subdivision[9]. Aggregating to this spatial unit is likely to reduce or eliminate the effects of any remaining coding errors and combines nearby ports into a single unit. Most studies that examine relative disproportionality use a higher-level aggregate, such as sectoral or total employment, in region *r* as the reference (Brullhart and Traeger 2005; Cutrini 2010; Bickenbach et al. 2010). We follow this convention and use two references that implicitly benchmark the dispersion of the GC and LAGC-IFQ fisheries against two aggregates: the first is all fishing (R1), the second is all scallop fishing (RS). We also construct an absolute index that uses the uniform distribution ($\Pi_r = 1$) as the reference.

2.2 Dispersion and Concentration of Ocean Use (Fleet-wide).

The spatial units in this analysis are 0.5x0.5 km^2 grid cells. The basic data used in the previous section is supplemented with latitude and longitude from VTR. We used the method described in DePiper (2014) to convert these points into areas. We then aggregate to the fishing year to construct a map of fishing for the GC, LAGC-IFQ, and aggregate fishery. We use one reference, all scallop fishing (RS), to construct the relative dispersion index. We also construct an absolute index that uses the uniform distribution as the reference.

2.3 Overlap in ocean use between the IFQ fleet and the LA fleet

The spatial units in this analysis are 0.5x0.5 km^2 grid cells. We use the same data that is described in the previous section (mapped VTR data, aggregated to the GC, LAGC-IFQ, or aggregate fishery for each fishing year). For each spatial unit *r*, the share of fleet *i*'s activity in that cell is computed as:

$$s_{ir} = \frac{X_{ir}}{\sum_{r=1}^{N} X_{ir}} \tag{2}$$

[9] The Census county subdivisions correspond roughly to a "town": they are minor civil divisions (MCDs) for states that have governmental or administrative units that are smaller than a county and Census County Divisions (CCDs) for states that do not.

The Czekanowski Overlap index[10] (1909) is then constructed as:

$$Cz(i,j) = \sum_{r=1}^{N} \min(s_{ir}, s_{jr}) \qquad (3)$$

3. Results

3.2 Dispersion and Concentration of Ocean Use

The Relative Theil Index benchmarks the GC and LAGC-IFQ fleets against the entire scallop fishery. The Relative index indicates a relatively stable pattern of similarity of ocean use between the fleets through the time series. This indicates that GC and later LAGC-IFQ fleet is using areas of the ocean that are similar to areas of the ocean used by the entire fishery.

The Absolute Theil Index illustrates a general decrease from 2000 through 2008, indicating that the GC fleet was becoming more diffuse or spread out in the ocean. There was a increase in this index from 2008 through 2011, followed by a moderate decrease from this peak from 2012-2015.

3.3 Overlap in ocean use between the IFQ fleet and the LA fleet

The Czekanowski overlap index illustrates general increases in overlap of ocean use between the GC and LA fleets from 2000-2008. The pattern is not monotone; there are decreases in overlap in 2002, 2005-2006, and 2009. After 2010, the overlap between the LAGC-IFQ and LA fleets decreased for 2 years, indicating the two fleets were using different areas of the ocean. However, from 2012-2015, the overlap indices have been increasing, indicating that the fleets have been using increasingly similar areas of the ocean. We suspect that recent changes in this index are driven by changes in resource condition in “inshore” areas (that can be profitably used by the LAGC-IFQ fleet) and use of access areas.

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[10] See also Bray and Curtis (1957) and Finger and Kreinin (1979)

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Figure 3.1 The R1 (Relative to All fishing), RS (Relative to All Scallop fishing) and Absolute Theil Indices of Geographic Disproportionality for the General Category (GC) and LAGC-IFQ fisheries calculated across ports.

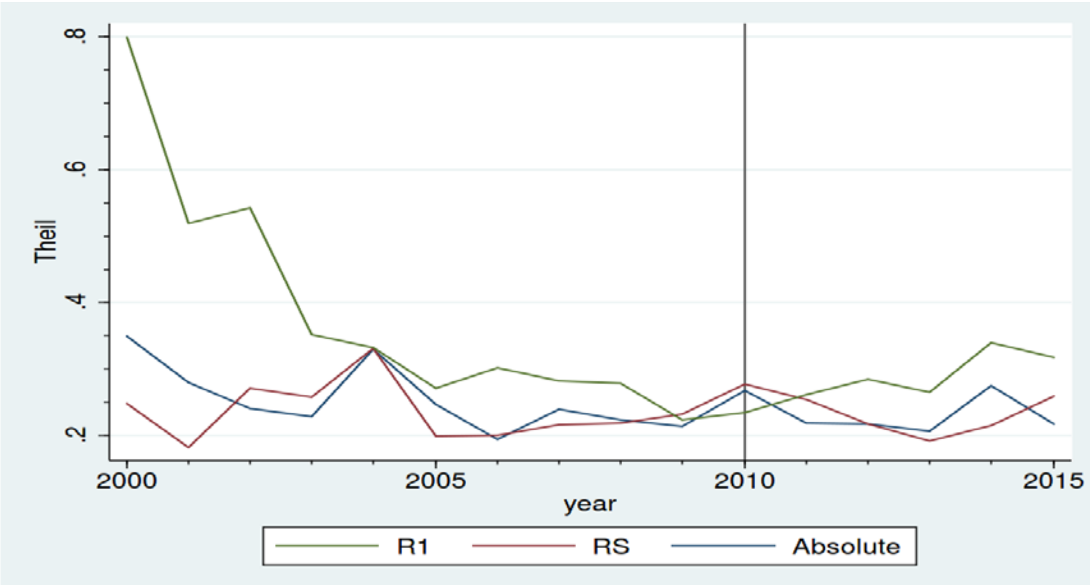


Figure 3.2 The RS (Relative to All Scallop fishing) and Absolute Theil Indices of Geographic Disproportionality for the General Category (GC) and LAGC-IFQ fisheries calculated across fishing locations.

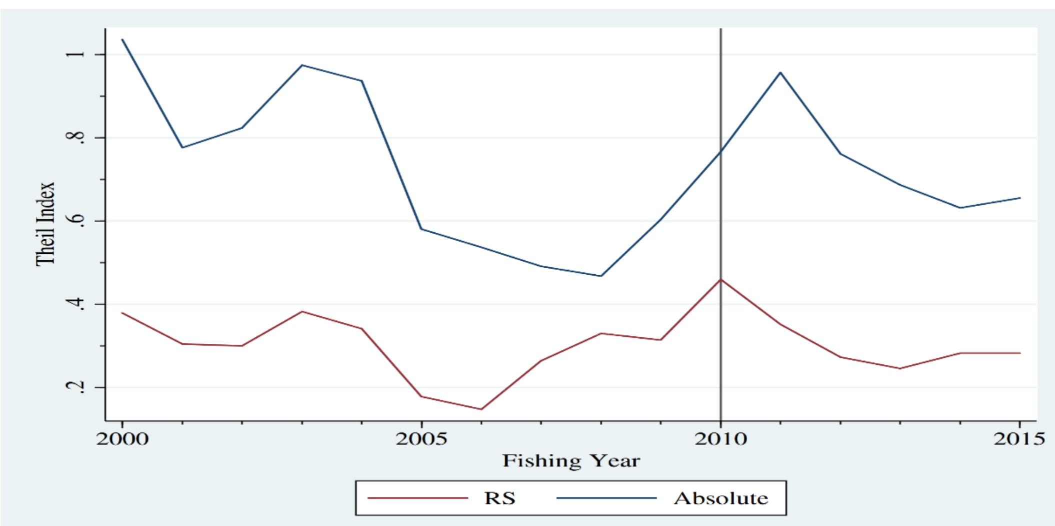
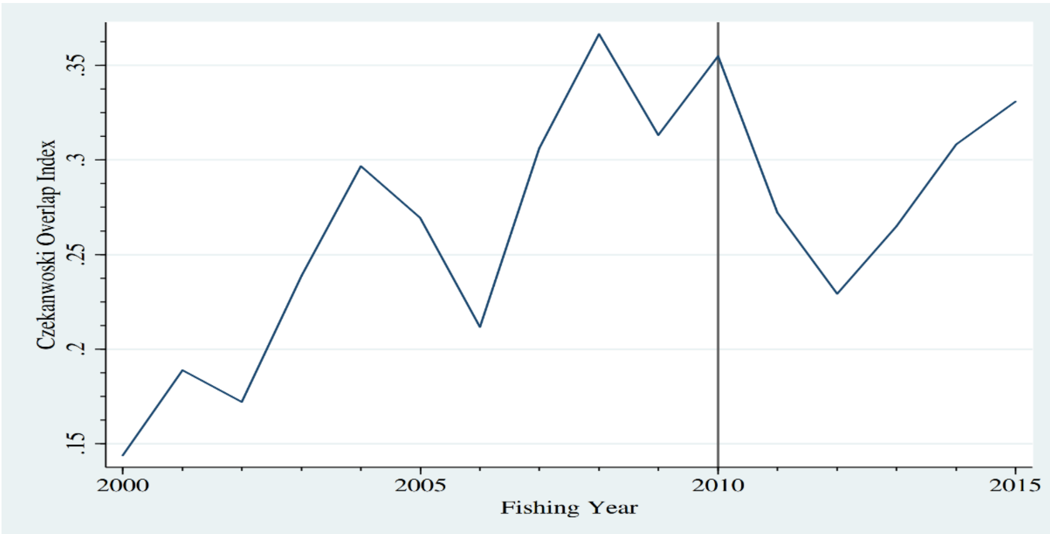


Figure 3.3 The Czekanowski Overlap Index between the LAGC-IFQ fleet and the LA fishery. Overlap between the GC and LA fishery prior to 2010 is also presented.



APPENDIX I – CREW SURVEY COMPONENT OF THE LAGC IFQ REVIEW

Dr. Matt Cutler, Northeast Fishery Science Center, SSB

Executive Summary

The Crew Survey component of the LAGC IFQ review utilizes the Survey on the Socio-Economic Aspects of Commercial Fishing Crew in New England and Mid-Atlantic conducted by the NEFSC Social Sciences Branch (SSB) from 2012 to 2013. Due to small sample sizes, this report utilizes a two-group t test approach to compare mean responses of crew members working on IFQ vessels versus those on non-IFQ vessels. This report also analyses differences in means between IFQ, non-IFQ, and crew members who worked on vessels that fished primarily for multispecies (groundfish) and lobster. Several subject areas were covered by the survey items analyzed. These included views about the management process, the fishery management plan, fishing area access, rules and regulations, environmental stewardship attitudes and behaviors, and finally job satisfaction and overall health and wellbeing. The main findings from this report are summarized by the bulleted statements below. These findings focus specifically on differences between crew members on IFQ vessels and crew on non-IFQ vessels. Please refer back to the main report for a description of the differences between these two groups and crew members on vessels fishing primarily for groundfish and lobster.

- Crew members of IFQ vessels were more likely than those on non-IFQ vessels to report that they did not trust managing authorities to make the right decisions when it came to regulating fisheries.
- Crew members of IFQ vessels were more likely than those on non-IFQ vessels to report that their captains were able to fish where he wanted to.
- Crew members of IFQ vessels were more likely than those on non-IFQ vessels to report that overall levels of bycatch and discards were high in their primary fisheries. IFQ vessel crew members were also more likely than non-IFQ crew to report that regulations had increased levels of bycatch and discards in their primary fishery.
- There were no significant differences between IFQ and non-IFQ crew members on any of the items assessing job satisfaction or overall health and wellbeing. Both groups of crew members generally expressed satisfaction with their earnings, time away from home, and the adventure of the job. Both groups also generally expressed that they felt connected to other fishermen and that they were proud to be fishermen.

1. Introduction and research methodology

This report provides an assessment of the social aspects of performance of the limited access general category (LAGC) individual fishing quota (IFQ) fishery for the five years following the program's implementation in fishing year 2010. Specifically, this section of the report analyzes survey data of commercial fishing crew members sampled from the population throughout ports in New England and the Mid-Atlantic regions. Data came from the Survey on the Socio-Economic Aspects of Commercial Fishing Crew in New England and Mid-Atlantic (hereafter referred to as the Crew Survey) conducted by the Social Sciences Branch (SSB) of the National Oceanic and Atmospheric Administration (NOAA) Fisheries Northeast Fisheries Science Center (NEFSC). This survey was in part intended to gather information about both the socio-demographic characteristics of crew members and their perceptions of and attitudes towards the management of their primary fisheries. This approach is unique because few studies have systematically investigated attitudes and perceptions of commercial fishing crew. This is especially true within the context of evaluating the performance of specific fisheries management programs and IFQ programs in particular.

Past survey efforts in the New England region have considered the behavioral changes of fishermen in response to imposed limitations on fishing effort. After a trap limit was imposed on the Maine lobster fishery, Acheson and colleagues (2001) conducted a survey of approximately half of the lobster license holders in the state of Maine in order to investigate the potential correlates of behavior in the aftermath of the new set of rules regarding the number of traps to be used. They found a variety of factors in play in determining fishermen's decisions to either increase or decrease the amount of traps used, leading Acheson to conclude that, "one of the most important problems facing fisheries management is determining under what circumstances fishermen will generate rules to conserve fisheries," (Acheson 2001). In 2011, Acheson and Gardner also conducted a follow-up survey in order to investigate the potential reasons for the relative failures of the groundfish management regime. Regarding the views of fishermen towards the goals of regulations and the science underlying the management regime, the authors found that, "[f]rom the fishermen's perspective, the goal of management should be to protect fish in vulnerable parts of their life cycle, (i.e., to protect small fish, gravid fish, and essential spawning and nursery grounds) by enacting mesh size regulations, closures, or both," that "fishermen do not believe that scientists know how many fish there are," and that fishermen "distrust the methods scientists use to collect fish population data," (Acheson and Gardner 2011). These are important insights from the industry regarding specific beliefs about what management should focus on and how well managers and fisheries scientists communicate their work and reasoning for choosing their methodologies. This all underscores the need for further survey research to this end and this research is in part an attempt to add depth to our understanding of the attitudes and beliefs that may also impact the relative successes or failures of the scallop IFQ program in particular.

In addition to particular management actions, prior survey efforts have assessed social capital and general attitudes towards management among commercial fishermen in the Northeast. Holland and colleagues conducted a survey of Northeast Multispecies (groundfish) permit holders to "develop a baseline of social capital in the groundfish fishery and to document attitudes toward the current management system based on days at sea and the new system based on sector allocations," (Holland et al 2010). While social capital was not the focus of the present study, their results regarding the views of groundfish permit holders about management provide a useful reference point for comparison. They found general dissatisfaction among groundfish permit holders with their fishery and the management system governing it, as well as mistrust in the science underlying the decisions made by those in management (Holland et al 2010). Other attempts to collect survey data of commercial fishermen looked at resilience in the face of changing management. In a 2007 survey of commercial fishermen in Northern Australia, Marshall and Marshall found that those who actively developed new fishing methods or had the business management skills requisite to adaptation were more likely to score highly on their measure of resilience to policy changes (Marshall and Marshall 2007). These results are suggestive of a potentially fruitful aspect worthy of investigation within the LAGC scallop IFQ fishery in the Northeast. The IFQ management system may have impacted the ability of scallop fishermen to adapt to changes in the fishery or other aspects of its management. While a number of indicators of performance are included in this overall report, there is room for further investigation into whether and the extent to which scallop fishermen taking part in the IFQ program have felt able to adapt and manage their businesses or employment circumstances as the fishery changes. This component of the review was not able to assess resiliency, per se, but some of the findings discussed in the following sections are noteworthy for a variety of other important reasons related to the impact and performance of the IFQ program since its inception several years ago. Moreover, this component of the review establishes a baseline of survey findings, which can not only inform managers and stakeholders, but also future survey research efforts aimed at assessing views and attitudes among both scallop fishermen and those in other fisheries as well.

1.2 Methods

1.2.1 *Sample*

The Crew Survey began in the fall of 2012 and lasted approximately one year. Given the lack of a registry or population database to draw a crew sample from, the Crew Survey was conducted mainly through in-person interviews using an intercept method at the docks of sampled ports. Ports from Maine to North Carolina were randomly sampled based on a stratified sampling design that took into consideration seasonally-based fishing activity and geographic diversity in the region's fisheries (Henry and Olson 2014). A sample size of 1,330 was calculated from an estimated crew population of 30,000[11]. Crew members were interviewed using an intercept method with interviewers approaching crew on the docks and entering survey responses into Nook tablet computers. The final number of completed surveys was 359, with 42 incompletes and 654 refusals (Henry and Olson 2014). A variety of factors contributed to the difficulty SSB had in obtaining a higher response rate, including scheduling problems related to the arrival and departure times being at odd/random hours and outright refusals to participate. The ports with the largest number of respondents were (in descending order) New Bedford, MA (n = 58), Gloucester, MA (n = 48), Cape May, Newport News, VA (n = 29), NJ (n = 27), Point Judith, RI (n = 27), Chatham, MA (n = 17), Rockland, ME (n = 14), Portland, ME (n = 14), Montauk, NY (n = 14), and Wanchese, NC (n = 14), and Portsmouth, NH (n = 11).

1.2.2 *Dependent Variables*

The dependent variables utilized in this research were originally conceived as indicators of five primary components of performance—financial viability, distributional outcomes, stewardship, governance, and well-being (Henry and Olson 2014). The survey items which comprised each of these measures were presented to respondents as statements about personal experiences and beliefs fishermen may have had regarding the process of fisheries management, regulations and rules, job satisfaction, and beliefs about the environment. Respondents were asked to respond to each statement by selecting one of five categories on a Likert-type scale ranging from "strongly disagree" to "strongly agree." Items related to governance included views about the fairness and inclusivity of the management process to fishermen ("Management Process"), the efficacy of the fisheries management plan for respondents' primary fisheries ("Fisheries Management Plan"), and the effect of regulations on fishing practices ("Rules and Regulations"). Items related to well-being included questions about satisfaction with earnings, time away from home, and whether or not respondents' would advise youth to enter the fishing industry in any capacity ("Satisfaction and Well-being"). Finally, items comprising the environmental stewardship measure included views about fishermen's responsibility to participate in management, effort to not harm the

[11] The crew population size was estimated based on SSB work with IMPLAN (Minnesota IMPLAN Group, 2008 IMPLAN System (data and software), 1725 Tower West Suite 140, Stillwater, MN 55082 www.implan.com). Information used to estimate this number came from fishing employment data from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages and the Bureau of Economic Analysis' Regional Economic Information System data which includes self-employment.

fishery, whether overfishing is possible, and the importance of the environment to respondents ("Environmental Stewardship"). Descriptions of these items are displayed throughout Tables 1-5.

1.2.3 *Analytical Strategy*

There has been a dearth of survey research looking at both the direct and multiplicative effects of demographic and fishery-related characteristics of individual fishermen on their attitudes and perceptions about management regimes. Additionally, few studies to date have utilized the measures of social and economic performance developed by Clay and colleagues (2014) in a systematic, quantitative method to assess the views of commercial fishermen about the fisheries management process. This is especially timely and useful given the growing need to develop long-term data collection efforts in the social sciences directed at fisheries and their participants (Henry and Olson 2014). The present study intends to address these gaps in the extant literature by contributing a unique quantitative analysis of recent survey data on commercial fishing crew members.

Statistical analyses were aimed at exploring potential differences in views about management between IFQ scallop program participants and non-participant scallop fishers among respondents to the Crew Survey, as well as those in other fisheries. This involved a series of two-sample *t* tests comparing means of IFQ scallop crew to non-IFQ scallop crew (hereafter referred to as IFQ crew and non-IFQ crew), groundfish crew, and lobster crew on responses to the dependent variables. Groundfish and lobster crew were utilized as comparison groups because they were the second- and third-largest sub-populations of primary fisheries represented in the sample. This approach was preferred due to the extremely limited response rates to many of the chosen dependent variables in this study. Sub-sample sizes on each outcome variable of interest were simply not large enough to provide for a robust and reliable multivariate analysis involving other independent predictors and controls. Future research efforts will need to utilize larger samples of crew members in order to tease out the possibility of spurious, confounding, mediating, moderating, or any other "third-variable" effects which may emerge from the inclusion of the socio-demographic or –cultural characteristics of individual crew members.

2. Results

2.1 *Management Process*

The majority of scallop-fishing respondents either agreed or strongly agreed that fishermen have a responsibility to participate in the management process. This sentiment was shared with no significant differences in means across all major fisheries represented in the sample and by both IFQ and non-IFQ crew. Just over half of scallop fishers either agreed or strongly agreed that people in charge of the management process were not fair. IFQ and non-IFQ crew did not report significantly different views on fairness of management (Table 2), but both reported significantly less often than groundfish crew that management was unfair (Appendix A). The majority (77%) of scallop fishers either disagreed or strongly disagreed with the notion that they felt integrated into the management process. The difference in means of IFQ and non-IFQ crew was not significant, but both groups were significantly less likely to feel integrated into the management process than lobster boat crew members (Appendix A). Finally, majorities across all fisheries and both IFQ and non-IFQ participants expressed disagreement with the notion that managers were serious about involving fishermen in the process.

A slight majority (55%) of all scallop fishing respondents expressed either agreement or strong agreement towards the statement that they did not trust management, but a substantial portion (32%) also remained neutral to the question of distrust of management. IFQ scallop crew significantly differed from non-IFQ crew on this item. According to the results from the two-sample *t* test, crew respondents in the IFQ scallop fishery were significantly more likely to express agreement that they did not trust management than their non-IFQ counterparts (Table 2). This difference is depicted graphically in Figure 1. Non-IFQ scallop crew members also expressed significantly less distrust of management than their groundfish crew counterparts (Appendix A).

There were no significant differences in mean responses between IFQ, non-IFQ, and crew members in the groundfish or lobster fisheries on a host of items related to the management process. Generally across all fisheries, respondents most often felt that they did not believe the information presented, that they had no opportunity to correct inaccurate information, that they did not have the opportunity to add new information to the process, and that opinions of fishermen were not taken seriously by managing authorities. On the other hand, views were more varied regarding the ability of fishermen to appeal unfair decisions by management. Roughly 46% and 47% of scallop and other fishers, respectively, disagreed that they had the right to appeal, whereas about 54% and 53% of scallop and others, respectively, were neutral, agreed, or strongly agreed with this notion.

2.2 *Fishery Management Plan*

Scallop fishers overall were fairly split on the issue of whether the goals of their FMP were being met. Approximately 47% of scallop crew either agreed or strongly agreed that their FMP was meeting its goals, as compared to roughly 37% who either disagreed or strongly disagreed. There was no significant difference between IFQ and non-IFQ scallop program participants. IFQ participants did differ significantly from groundfish crew, however, such that IFQ crew expressed slightly more agreement with the notion that their FMP's goals were being met than crew members in the groundfish fishery (Appendix B). Interestingly, those in the non-IFQ scallop fisheries did not differ from groundfish crew on this item.

Slightly more than half of all scallop-fishing respondents either agreed or strongly agreed that their FMP helped to protect the number of fish. While IFQ and non-IFQ scallop crew did not differ significantly, both groups did differ from groundfish crew on this matter. Mean responses for both IFQ and non-IFQ scallop crew were significantly higher than groundfish crew, suggesting that members of scallop fisheries were generally more likely than those in the groundfish fishery to believe their FMPs had helped to protect fish (Appendix B). Finally among the items assessing views about the FMP specifically, there were no significant differences by fishery or scallop permit types with respect to agreement with the notion that management can change quickly as conditions of the fishery change. Generally speaking, slightly under half of all crew either agreed or strongly agreed that management can change quickly in reaction to the changing conditions of the fishery.

2.3 *Fishing area access*

In general, about 65% of scallop crew members either disagreed or strongly disagreed that they were able to fish where they wanted to. Some of this effect was driven by non-IFQ scallop crew members as demonstrated by the two sample *t* test comparing means of IFQ and non-IFQ crew members. As presented in Table 7, the mean response of IFQ scallop crew was significantly higher than non-IFQ scallop crew. This effect is depicted graphically in Figure 2. While they differed from each other, both IFQ and non-IFQ scallop crew members were significantly much less likely to agree that they could fish where they wanted to than members of crew in the lobster fishery (Appendix B). Similar to views about being able to fish where they wanted, scallop fishers also generally disagreed (78%) with the notion that they were able to fish when they wanted to. Feelings of not being able to fish when desired held across IFQ and non-IFQ participants. Again, both IFQ and non-IFQ scallop crew differed significantly from lobster crew on this issue, such that they were less likely than lobster crew to agree that they could fish when they wanted (Appendix B). Finally, scallop crew members were generally divided on the issue of whether management should allow new fishermen into their fisheries. About 43% of all scallop fishers either disagreed or strongly disagreed with the notion that management should maximize the number of fishermen, whereas about 38% either agreed or strongly agreed with this sentiment. IFQ and non-IFQ scallop crew members did not differ significantly in their responses to this item.

With respect to broader access to fishing areas, respondents in the scallop fishery generally reported less agreement with the notion that fishing areas should be off-limits to users other than fishermen. Approximately 73% of scallop crew either disagreed or strongly disagreed that fishing areas should be off-limits to other users. IFQ and non-IFQ scallop crew did not differ significantly in their relative mean responses to this item, but both groups differed significantly from members of the groundfish and lobster fisheries. In each of the two-sample *t* tests, the mean responses of IFQ and non-IFQ scallop crew were significantly lower than both lobster and groundfish crew, meaning that, regardless of IFQ status, scallop crew were less likely to agree that fishing areas should be off-limits to other users than crew in the lobster and groundfish fisheries (Appendix B).

2.4 *Rules and Regulations*

A variety of interesting findings emerged from the analyses of items related to compliance with rules and regulations. In terms of how easy it has been finding information about rules and regulations, those in the scallop fishery did not differ much from those in other fisheries in how they viewed the ease with which they could find information. Most respondents across all fisheries either agreed or strongly agreed that it was easy to find information. On the other hand, about 65% of scallop fishers agreed that the rules governing their primary fishery have been easy to comply with, whereas only about 48% of those in all other fisheries reported the same. While the mean responses of IFQ and non-IFQ scallop crew did not differ significantly, there was a difference in how the two groups of scallop crew compared to the means of groundfish crew. IFQ scallop crew were significantly more likely than groundfish crew to agree that the rules had been easy to comply with, whereas non-IFQ scallop crew did not differ significantly from groundfish crew on this issue (Appendix C).

While scallop fishers generally felt the rules were easy to comply with, they more often reported that the rules and regulations of their primary fishery were too restrictive. Approximately, 76% of scallop crew members either agreed or strongly agreed that the rules of their primary fishery were too restrictive. IFQ and non-IFQ scallop fishers did not differ significantly in their respective views about the restrictiveness of the rules and regulations, but the IFQ program participants did express significantly different views from those in the lobster fishery. IFQ scallop crew members were more likely than lobster crew to view the rules and regulations as restrictive, whereas non-IFQ scallop crew did not differ significantly from lobster crew on this issue (Appendix C). The restrictiveness of rules and regulations appears to have been more salient to those participating in the IFQ program than to those in other major fisheries.

There were a few interesting differences by fishery on survey items related to the fairness of primary fishery rules and regulations. Just under half (47%) of respondents representing all fisheries reported that they agreed or strongly agreed that the regulations in their primary fisheries were unfair. Non-IFQ scallop crew members were slightly less likely than groundfish crew to agree that their regulations were unfair (Appendix C). With respect to the fairness of fines, roughly half of both scallop (54%) and those in other fisheries (49%) either disagreed or strongly disagreed with the notion that the fines were fair in their primary fisheries. Views about the fairness of fines did not differ significantly between IFQ and non-IFQ participants.

In addition to issues related to compliance and fairness, respondents were asked to assess the effect that regulations had on levels of bycatch, discarding, and highgrading in their primary fisheries. While the majorities of respondents reported that the effect of regulations produced no significant change in these levels, there were significant differences among IFQ and non-IFQ crew and fishery in terms of respondents' likelihood of reporting that bycatch levels had either decreased or increased. The mean responses of IFQ and non-IFQ scallop crew differed significantly such that IFQ crew more often reported that regulations had increased levels of bycatch (Table 8). This difference is depicted graphically in Figure 3. In similar fashion, IFQ scallop crew expressed significantly different views from their non-IFQ counterparts about the effect of regulations on levels of discards. IFQ scallop crew members were significantly more likely than non-IFQ crew to report that regulations had increased levels of discards (Table 8). This effect is shown in Figure 4. With respect to comparisons to other fisheries, non-IFQ scallop crew were significantly more likely to report that regulations had decreased levels of discards than crew-member respondents in the lobster fishery, while IFQ scallop crew were significantly less likely than groundfish crew members to report that regulations had decreased levels of discards.(Appendix C). Finally, in contrast to views about the effect of regulations on discards and bycatch, the vast majorities of respondents across all fisheries reported that regulations did not change levels of highgrading in their primary fisheries and no significant differences emerged by fishery in the bivariate analyses.

2.5 *Environmental Stewardship*

A number of interesting findings emerged through the analysis of survey items focused on assessing respondents' attitudes about environmental stewardship. Overwhelming majorities across all fisheries either agreed or strongly agreed that they made an effort to not harm their fisheries. There were no significant differences according to comparison of means tests between members of different fisheries or scallop IFQ and non-IFQ programs. Similar to self-reported efforts to not harm fisheries, respondents across all fisheries generally disagreed with the notion that the ocean is too large to overfish, although the majorities in this instance were not quite as large. There were no significant differences in mean responses by fishery or scallop IFQ and non-IFQ program crew in bivariate analyses. Finally among items related to environmental attitudes, respondents were asked whether they agree that the environment was important to them within the context that it was how they made their living. The overwhelming majority of respondents across all fisheries either agreed or strongly agreed that the environment was important to them because it was how they made their living. Much like the previous two items, the mean responses were not significantly different by fishery or scallop IFQ or non-IFQ program.

In addition to assessing attitudes about environmental stewardship, the Crew Survey also featured items which focused on some of the common fishing practices relating to stewardship, namely bycatch, discarding, and highgrading. Unlike the attitudinal items, however, these were not assessed on a five-point, likert-type "agreement" scale. Instead, respondents were asked whether overall levels of bycatch, discards, and highgrading were "low," "medium," or "high" in their primary fisheries. Majorities of respondents reported that levels were low for all three of these practices in their primary fisheries, but there were a number of interesting differences by fishery and scallop program. First, as presented in Table 9, IFQ scallop crew members reported higher levels of both bycatch and discards than those in non-IFQ scallop fisheries. IFQ scallop crew members also expressed higher levels of each than members of the lobster fishery (Appendix D). Interestingly, while IFQ scallop crew did not differ significantly from those in the groundfish fishery, non-IFQ scallop crew differed significantly such that they were reported lower levels of bycatch and discards than groundfish crew (Appendix D). Finally among these items, respondents' views about highgrading were virtually identical across all fisheries. Roughly 81% of scallop fishers and 79% of those fishing in all other fisheries reported low levels of highgrading in their primary fisheries. No significant differences emerged when comparing mean responses of those fishing on scallop IFQ or non-IFQ vessels or between scallop fishers and members of other fisheries either.

2.6 *Satisfaction and well-being*

Sharp differences emerged in the comparison of satisfaction with earnings between scallop fishers and members of all other fisheries. About 72% of scallop fishing respondents were either somewhat or extremely satisfied with their earnings from fishing, whereas only 44% those in all other fisheries represented felt the same way. Means tests provided greater clarity about the differences in satisfaction with earnings between members of specific fisheries. While IFQ and non-IFQ scallop crew members did not differ significantly in their relative satisfaction with their earning, both groups were significantly more likely to feel satisfied than those in the groundfish fishery (Appendix E). Similarly to satisfaction with earnings, respondents in the scallop fishery much more often reported satisfaction with their time away from home while fishing than those in all other fisheries represented in the sample. Both IFQ and non-IFQ scallop crew were more likely than groundfish crew respondents to be satisfied with their time away (Appendix E). Finally among items assessing respondents' satisfaction with aspects of fishing as a job, individuals across all fisheries generally felt satisfied with the adventure of the job. No differences emerged from means comparisons by IFQ/non-IFQ scallop participants.

Several other items were assessed in addition to measures of satisfaction in order to explore the various aspects of respondents' well-being as crew members. Among these were whether respondents; 1) would advise the young to enter commercial fishing; 2) felt like fishing was just a job to them; 3) considered fishing part-time; 4) considered leaving fishing altogether; 5) were proud to be commercial fishermen; 6) felt connected to other fishermen; 7) felt like leaders in their primary fisheries; and 8) felt like leaders in their local communities. With respect to encouraging younger generations, roughly 56% of scallop fishers said they would advise youth to enter fishing, compared with only about 38% of those in other fisheries. This difference was driven mostly by the disparities between groundfish crew and both IFQ and non-IFQ scallop crew groups (Appendix E). While the majorities of respondents in all fisheries either disagreed or strongly disagreed that fishing was just a job to them, *t* test results revealed that IFQ scallop crew were significantly less likely than lobster crew members to view fishing as just a job. Majorities of respondents also disagreed with the notion that they would want to fish part-time, but non-IFQ scallop crew reported significantly less often than both groundfish and lobster crew members that they would have wanted to fish part-time. Finally among the items assessing views about fishing as a career, respondents were generally split on whether they had considered leaving the fishing industry. Roughly 43% of all respondents agreed that they had considered leaving the industry, whereas about 47% disagreed with the notion that they had considered it. The comparison of means test revealed a significant difference in means between non-IFQ scallop crew and lobster crew members such that non-IFQ crew were significantly more likely to have considered leaving than lobster crew.

The final series of items relating to well-being were constructed to explore levels of social capital among respondents. Since they were also intended as indicators of well-being, several separate analyses of each item were conducted in order to investigate whether and how scallop fishing in general, and IFQ participation in particular, was associated with these questions of social connectedness, pride, and leadership in respondents' primary fisheries. The vast majority of all respondents agreed that they were proud to identify as fishermen. According to a comparison of means, however, non-IFQ scallop crew members were significantly more likely to have agreed with this notion than crew members in the lobster fishery (Appendix E). Similar to feelings of pride, respondents overwhelmingly agreed that they felt a connection to other fishermen, but multiple differences emerged from comparisons of mean responses between fisheries. Both IFQ and non-IFQ scallop crew members reported significantly higher mean responses than crew in the lobster fishery, while only IFQ crew significantly differed from groundfish crew.

In terms of self-reported leadership, slightly over half of respondents disagreed with the notion that they were a leader in their communities and there were no significant differences by fishery. On the other hand, respondents were much more evenly divided on the question of whether they felt like leaders in the primary fisheries. Roughly 41% disagreed, 25% were neutral, and 39% agreed with the notion that they were leaders in their primary fisheries. According to *t* test results, comparisons of IFQ scallop, non-IFQ scallop, groundfish, and lobster yielded interesting results. Both IFQ and non-IFQ crew were significantly more likely to self-report their own leadership in their primary fisheries than lobster crew, but only non-IFQ crew expressed a higher mean response than groundfish crew on this item (Appendix E).

3. Discussion

There have been relatively few scientific efforts to understand commercial fishing crew members' views about fisheries management regimes and policies through the vehicle of survey research. Fewer still have there been any targeted efforts to understand the impacts of IFQ permit programs on attitudes and beliefs of commercial fishermen, and vice versa, specifically in the Northeast and Mid-Atlantic regions. This research contributes to the extant literature by directly addressing the impacts of the LAGC scallop IFQ program five years after its implementation through the investigation of the attitudes, beliefs and other aspects of commercial fishing crew members' perspectives on management, environmental stewardship, and overall job satisfaction. A multitude of interesting findings emerged from the descriptive statistics and comparative bivariate analyses using primary fishery as the predictor variable. While this study did not have the sample size necessary for reliable and representative multivariate analyses, future survey research should consider gathering larger representative samples of commercial fishing vessel crew and owners in order to construct a more complete picture of the correlates and potential third-variable effects associated with the variety of salient socio-demographic characteristics of individuals among these populations.

In summation, scallop crew members on vessels participating in the IFQ program differed from those on non-IFQ vessels in a few interesting ways. First, IFQ scallop crew were more likely than non-IFQ crew to report that they did not trust managing authorities to make the right decisions when it comes to managing fisheries. Prior research using data from surveys of Northeast recreational anglers has shown general distrust of federal-level management and scientific assessments of commercial fisheries compared to relative trust in local or regional management regimes, suggesting that part of this effect could be due to a regionally-specific cultural bias against federal management of fisheries. However, the effect was not static across all fisheries and scallop IFQ and non-IFQ programs, lending evidence to the possibility that the IFQ program has fostered more distrust of management or alternatively participants in the IFQ program were predisposed to distrust of management based on prior experiences and were driven into the program for these reasons. Second, IFQ scallop crew members were significantly more likely than non-IFQ crew to report that they were able to fish where they wanted to. While both groups were not highly likely to report being able to fish where they want, participants in the IFQ program appear to have slightly more flexibility than participants in other scallop permit categories. This is interesting given the rotational closures of the scallop fishery in general and the requirement of the LAGC IFQ vessels to fish in specific exemption areas within the open access areas. Third, IFQ scallop crew members were significantly more likely than non-IFQ crew to report that regulations had increased both levels of bycatch and discards in their primary fisheries. This was echoed by the fourth and final difference between these permit categories that IFQ scallop crew members were also significantly more likely than non-IFQ crew to report higher levels of bycatch and discards overall in their primary fisheries.

Perhaps as interesting as the differences between IFQ and non-IFQ scallop crew were those items on which they did not differ while mutually differing from those in other fisheries. There were no significant differences in any of the indicators of well-being and job satisfaction by IFQ status among crew members surveyed. Both IFQ and non-IFQ crew members expressed relatively high satisfaction with their earnings, time away from home, and the adventure of the job. Both groups of crew were also generally highly likely to express that they felt connected to other fishermen and were proud to be fishermen. As compared to crew fishing primarily in other fisheries, both IFQ and non-IFQ scallop crew members were significantly more likely to feel satisfied with their earnings and time away from home than crew members in the groundfish fishery. Moreover, both IFQ and non-IFQ scallop crew were significantly more likely to say they would advise the young to enter into fishing as a career than crew members in the groundfish fishery.

With respect to the future of the management of the LAGC scallop IFQ program, a number of important takeaways emerged from these analyses. First, future approaches to managing this fishery should consider ways to build trust in managers and the management process among members of the IFQ fishery. As identified by prior research, fishermen have been distrustful of the methods used to make species assessments and, ultimately, the amount of catch to allocate to particular fisheries (Acheson and Gardner 2011). This is particularly important to catch share programs in which utilization rates are generally high and leasing quota is common because those actually fishing may be adversely impacted by reductions in quotas or constraining stocks due to changes in assessments. Engaging with fishermen about the methods used to conduct scientific assessments of stocks, as well as considering their feedback about such methods or potential alternative approaches, could help to foster increased trust in the management process among fishermen. Trust among recreational fishermen has also been shown to be important to the effectiveness of management policies, especially in the case of trust in federal management regimes (Gray et al 2012).

Another important issue to consider for the future of the LAGC scallop IFQ program is the possibility that the program contributes in some way to levels of discarding and bycatch. As mentioned above, IFQ scallop crew were more likely to report high levels of bycatch and discards than non-IFQ crew members and were also more likely to report that regulations had been responsible for increasing these levels of bycatch and discards. The first LAGC IFQ performance report, published in 2014, concluded that the "overall impact of this fishery on bycatch is relatively small," (NEFMC 2014). This contrast in views among crew members in the IFQ fishery and the finding of this previous performance report regarding bycatch suggests the need for further investigation of whether and the extent to which bycatch has increased and whether the current management system has had any impact on this phenomenon. Additionally, it will be useful in future surveys of crew or other stakeholders in the fishery to include questions about the specific causes of bycatch and discarding, among other aspects of the management system and its impact on fishing methods.

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Table 1: Descriptive Information for "Management Process" Dependent Variables

Survey Item	N	Range	Mean	Standard Deviation
Participate – *"Fishermen have a responsibility to participate in the fisheries management process."*	363	1 (Strongly Disagree) – 5 (Strongly Agree)	3.91	0.97
Unfair – *"The people in charge of the process were not equally fair to everyone involved"*	190	1 (Strongly Disagree) – 5 (Strongly Agree)	3.70	1.14
Believe – *"I did not believe the information the people in charge of the process presented."*	184	1 (Strongly Disagree) – 5 (Strongly Agree)	3.54	1.19
Correct – *"I had no opportunity to correct information that I thought was inaccurate."*	174	1 (Strongly Disagree) – 5 (Strongly Agree)	3.47	1.18
Appeal – *"I had the right to appeal decisions that were being made that I thought were unfair."*	169	1 (Strongly Disagree) – 5 (Strongly Agree)	2.71	1.27
Add Info – *"I had the opportunity to add new information that was relevant to the decision making process"*	179	1 (Strongly Disagree) – 5 (Strongly Agree)	2.54	1.11
Opinions – *"I felt like the opinions of commercial fishermen were not taken seriously."*	195	1 (Strongly Disagree) – 5 (Strongly Agree)	4.02	1.08
Integrate – *"Commercial fishermen have been effectively integrated into the management process."*	72	1 (Strongly Disagree) – 5 (Strongly Agree)	2.18	1.21

Serious – *"I feel like fisheries managers are serious about involving commercial fishermen in the process of fisheries management."*	71	1 (Strongly Disagree) – 5 (Strongly Agree)	2.29	1.20
Not Welcome – *"I do not feel welcome in public meetings about fisheries management."*	71	1 (Strongly Disagree) – 5 (Strongly Agree)	2.94	1.19
Don't Trust – *"I do not trust the managing authorities to make the right decisions when it comes to regulating fisheries."*	71	1 (Strongly Disagree) – 5 (Strongly Agree)	3.90	1.07

Table 2. Descriptive Information for "Fisheries Management Plan" Dependent Variables

Survey Item	N	Range	Mean	Standard Deviation
Goals – *"The goals of the management plan for my primary fishery are being met."*	148	1 (Strongly Disagree) – 5 (Strongly Agree)	3.00	1.16
Protects – *"The management plan for my primary fishery helps protect the number of fish."*	153	1 (Strongly Disagree) – 5 (Strongly Agree)	3.06	1.17

Where – *"In my primary fishery, I am able (Crew - My fishing captain is able) to fish where I want."*	165	1 (Strongly Disagree) – 5 (Strongly Agree)	2.72	1.28
When – *"In my primary fishery, I am able (Crew – My fishing captain is able) to fish when I want.*	163	1 (Strongly Disagree) – 5 (Strongly Agree)	2.51	1.22
Opportunity – *"Opportunities for existing fishermen should not be reduced by new fishermen entering the fishery."*	157	1 (Strongly Disagree) – 5 (Strongly Agree)	3.59	1.16
Maximize – *"Management should aim to maximize the possible number of fishermen."*	154	1 (Strongly Disagree) – 5 (Strongly Agree)	2.78	1.05
Offlimits – *"Fishing areas should belong to the fishermen who use them and should be off limits to other users (for example, fishermen from another fishery or wind farm activity)."*	162	1 (Strongly Disagree) – 5 (Strongly Agree)	2.83	1.16

Change – *"Management can change quickly when conditions (income, stock levels, safety) change."*	147	1 (Strongly Disagree) – 5 (Strongly Agree)	3.20	1.15

Table 3. Descriptive Information for "Rules and Regulations" Dependent Variables

Survey Item	N	Range	Mean	Standard Deviation
Comply – *"The rules and regulations were easy for me to comply with when I was fishing in 2012."*	163	1 (Strongly Disagree) – 5 (Strongly Agree)	2.99	1.19
Restrict – *"Regulations in my primary fishery in 2012 were too restrictive."*	163	1 (Strongly Disagree) – 5 (Strongly Agree)	3.75	1.14
Fines – *"The fines associated with breaking the rules and regulations in my primary fishery were fair in 2012."*	131	1 (Strongly Disagree) – 5 (Strongly Agree)	2.43	1.21

Regs_Unfair – *“Most of the regulations in my primary fishery in 2012 were unfair.”*	161	1 (Strongly Disagree) – 5 (Strongly Agree)	3.46	1.12
Easy – *“It was easy to find information about the rules and regulations that governed my primary fishery in 2012.”*	149	1 (Strongly Disagree) – 5 (Strongly Agree)	3.11	1.23
Reg_Bycatch – *“[Under regulations] - Level of bycatch (catch of non-target species).”*	149	1 (Significantly Decreased) – 5 (Significantly Increased)	2.87	0.58
Reg_Discards – *“[Under regulations] Level of discards (live or dead catch of target or non-target species that is thrown overboard).”*	156	1 (Significantly Decreased) – 5 (Significantly Increased)	3.04	0.66
Reg_High – *“[Under regulations] Level of highgrading (low value fish thrown overboard in order to keep higher value fish).”*	150	1 (Significantly Decreased) – 5 (Significantly Increased)	2.95	0.53

Table 4. Descriptive Information for "Environmental Stewardship" Dependent Variables				
Survey Item	**N**	**Range**	**Mean**	**Standard Deviation**
Harm – *"I make every effort to ensure my actions do not harm the fishery unnecessarily."*	370	1 (Strongly Disagree) – 5 (Strongly Agree)	4.43	0.66
Overfish – *"The ocean is very large, there is no way we can over-fish it."*	359	1 (Strongly Disagree) – 5 (Strongly Agree)	2.35	1.11
Environment – *"The natural environment is important to me because that is how I make my living."*	369	1 (Strongly Disagree) – 5 (Strongly Agree)	4.38	0.74
Bycatch – *"[For primary fishery]* ***Level of bycatch"***	161	1 (Low), 2 (Medium), 3 (High)	1.35	0.63
	163	1 (Low), 2 (Medium), 3 (High)	1.57	0.82

Discards – *"[For primary fishery] Level of discards"*				
High – *"[For primary fishery] Level of highgrading"*	153	1 (Low), 2 (Medium), 3 (High)	1.28	0.60

Table 5. Descriptive Information for "Satisfaction and Well-Being" Dependent Variables

Survey Item	N	Range	Mean	Standard Deviation
Adventure – *"Adventure of the job."*	363	1 (Extremely dissatisfied) – 5 (Extremely satisfied)	3.43	1.08
Away – *"The amount of time spent away from home."*	361	1 (Extremely dissatisfied) – 5 (Extremely satisfied)	2.73	1.17

Earn – *"Your actual earnings."*	360	1 (Extremely dissatisfied) – 5 (Extremely satisfied)	3.34	1.22
Advise – *"Would you advise a young person to enter fishing?"*	353	0 (No), 1 (Yes)	0.48	0.50
Just Job – *"Fishing is just a job to me."*	367	1 (Strongly Disagree) – 5 (Strongly Agree)	2.12	1.10
Part-time – *"Right now, I want to continue fishing, but only part-time until I retire."*	363	1 (Strongly Disagree) – 5 (Strongly Agree)	2.07	1.00
Leave – *"Leaving the fishing industry is something I have considered."*	364	1 (Strongly Disagree) – 5 (Strongly Agree)	2.93	1.25
Proud – *"I am proud to identify myself as a fisherman."*	367	1 (Strongly Disagree) – 5 (Strongly Agree)	4.44	0.67
Connect – *"I feel a strong connection to other fishermen in the community."*	366	1 (Strongly Disagree) – 5 (Strongly Agree)	4.19	0.79

Leader – *"Most people (Crew – I feel like I am) would say that I am a leader in my local community."*	364	1 (Strongly Disagree) – 5 (Strongly Agree)	2.47	1.01
Leader2 – *"Most people would say (Crew – I feel like I am) that I am a leader in my primary fishery."*	364	1 (Strongly Disagree) – 5 (Strongly Agree)	2.85	1.06

Table 6: Two-group *t* tests comparing means of IFQ and non-IFQ scallop crew members on "Management Process"

	IFQ		**Non-IFQ**			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Participate	3.911	0.793	3.857	1.102	-0.276	99
Unfair	3.227	1.307	3.428	1.200	0.566	48
Believe	3.286	1.230	3.542	1.062	0.749	43
Correct	3.631	1.645	3.385	1.416	-0.621	43
Appeal	2.952	1.395	2.880	1.235	-0.187	44

Add Info	2.545	1.101	2.461	1.272	-0.242	46
Opinions	4.240	0.779	3.900	1.062	-1.330	53
Integrated	1.750	1.165	2.143	1.099	0.789	20
Serious	2.250	0.412	2.000	0.961	-0.544	20
Not Welcome	2.500	1.414	2.846	1.143	0.616	19
Don't Trust	**4.125**	**0.991**	**3.214**	**0.699**	**-2.526***	**20**

***-p<.05**

Table 7. Two-group *t* tests comparing means of IFQ and non-IFQ scallop crew members on "Fishery Management Plan"

	IFQ		**Non-IFQ**			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Goals	3.278	1.018	3.077	1.197	-0.581	42
Protects	3.421	1.071	3.320	1.029	-0.317	42
Where	**2.800**	**1.152**	**2.077**	**1.055**	**-2.214***	**44**
When	2.300	0.923	2.153	1.008	-0.505	44

Opportunity	3.842	1.167	4.269	0.827	1.438	43
Maximize	2.750	0.966	2.800	1.080	0.162	43
Off-limits	2.350	0.875	2.346	0.892	-0.015	44
Change	3.222	0.943	3.417	1.139	0.588	40

***-p<.05**

Table 8. Two-group *t* tests comparing means of IFQ and non-IFQ scallop crew members on "Rules and Regulations"

	IFQ		**Non-IFQ**			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Comply	3.428	0.978	3.346	1.056	-0.275	45
Restrict	4.095	0.768	3.692	1.049	-1.469	45
Fines	2.167	1.115	2.875	1.147	1.636	26
Regs_Unfair	3.400	1.046	3.231	1.032	-0.548	44

Easy	3.389	1.195	3.591	1.007	0.580	38
Reg_Bycatch	**3.118**	**0.485**	**2.833**	**0.381**	**-2.102***	**39**
Reg_Discards	**3.222**	**0.428**	**2.875**	**0.338**	**-2.941****	**40**
Reg_High	3.059	0.242	2.917	0.408	-1.282	39

***-p<.05**

****-p<.01**

Table 9. Two-group *t* tests comparing means of IFQ and non-IFQ scallop crew members on "Environmental Stewardship"

	IFQ		**Non-IFQ**			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Harm	4.378	0.111	4.414	0.078	0.273	101
Overfish	2.432	1.227	2.035	0.925	-1.853	99
Environment	4.341	0.479	4.500	0.504	1.611	100

Bycatch	**1.474**	**0.697**	**1.115**	**0.326**	**-2.306***	**43**
Discards	**1.579**	**0.901**	**1.115**	**0.326**	**-2.422***	**43**
High	1.368	0.684	1.192	0.567	-0.943	43

***-p<.05**

Table 10. Two-group *t* tests comparing means of IFQ and non-IFQ scallop crew members on "Satisfaction and well-being"

	IFQ		**Non-IFQ**			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Earn	3.886	1.104	3.696	1.320	-0.766	98
Away	3.432	1.043	3.036	1.095	-1.833	98
Adventure	3.659	0.963	3.411	1.058	-1.212	98
Advise	0.636	0.487	0.536	0.503	-1.007	98
Just Job	1.795	0.878	2.158	1.265	1.622	99

Part-time	1.953	1.068	1.719	0.818	-1.242	98
Leave	2.773	1.118	3.107	1.330	1.337	98
Proud	4.523	0.731	4.631	0.555	0.851	99
Connect	4.454	0.589	4.411	0.862	-0.297	98
Leader	2.581	1.052	2.536	1.159	-0.202	97
Leader2	3.091	1.030	3.196	1.052	0.502	98

Figure 1. "Don't trust management" by scallop permit type

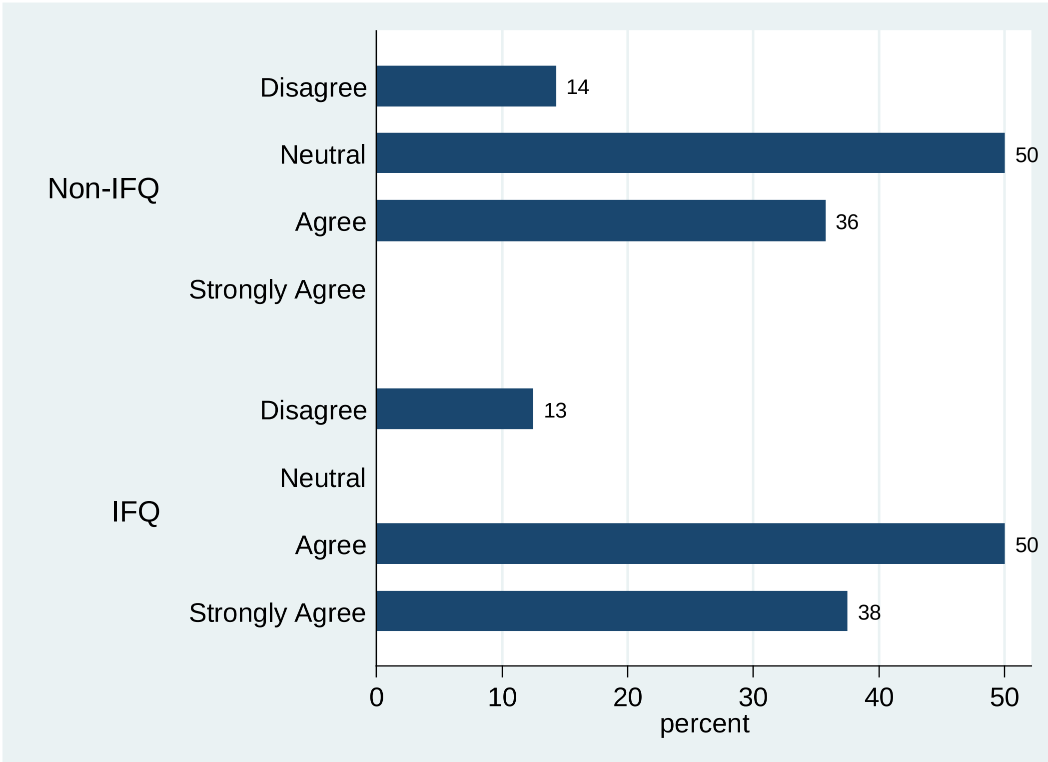


Figure 2. "Able to fish where we want" by scallop permit type

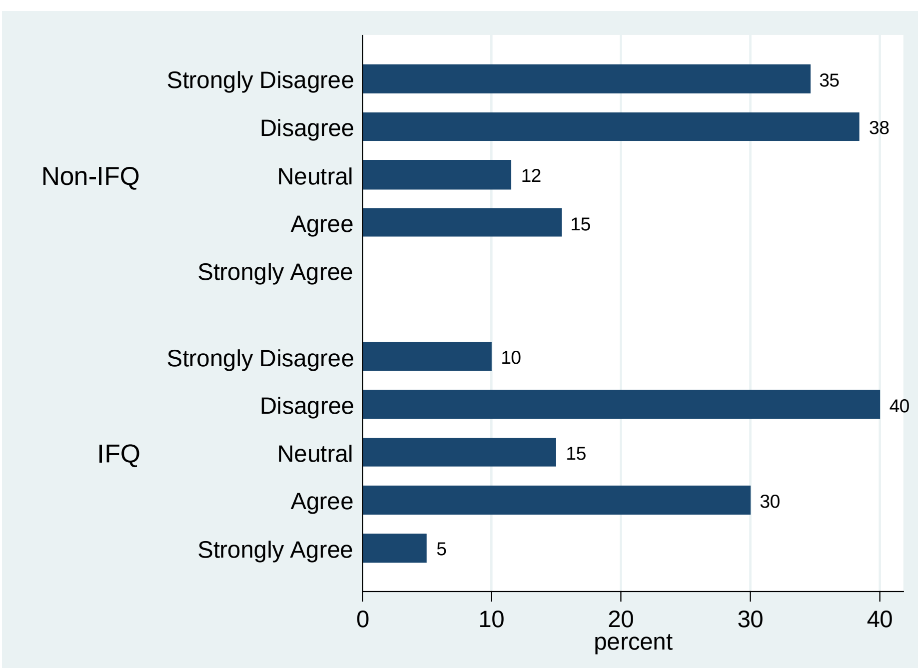


Figure 3. "Regulations' effect on bycatch" by scallop permit type

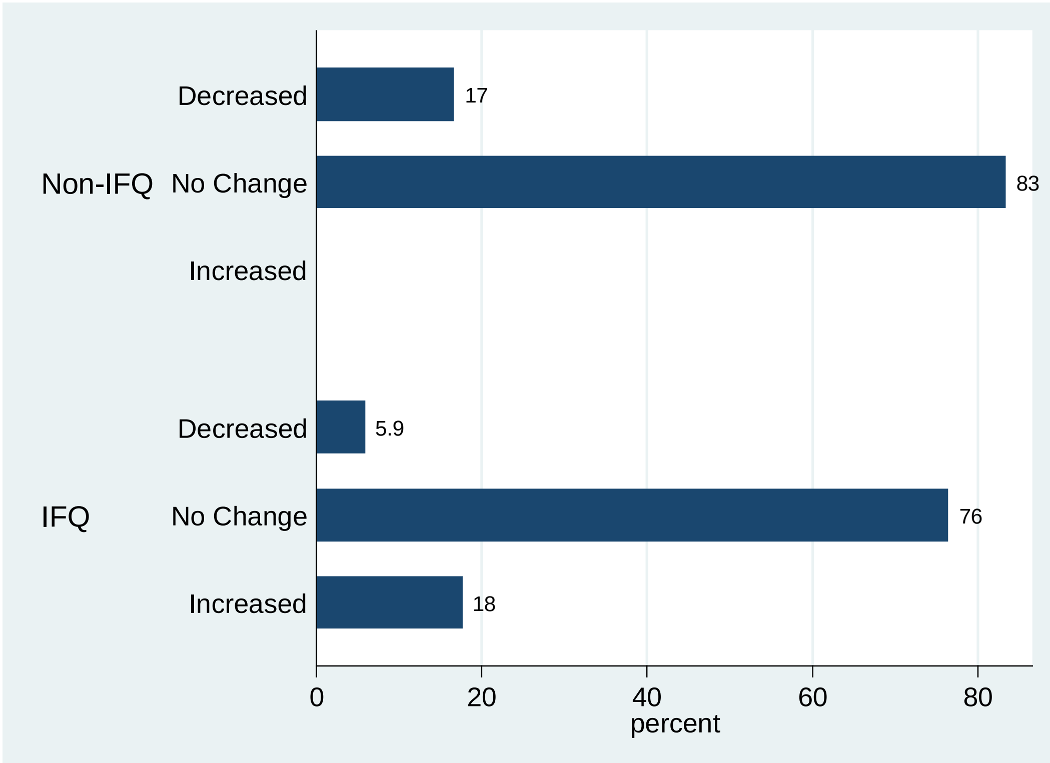


Figure 4. "Regulations' effect on discards" by scallop permit type

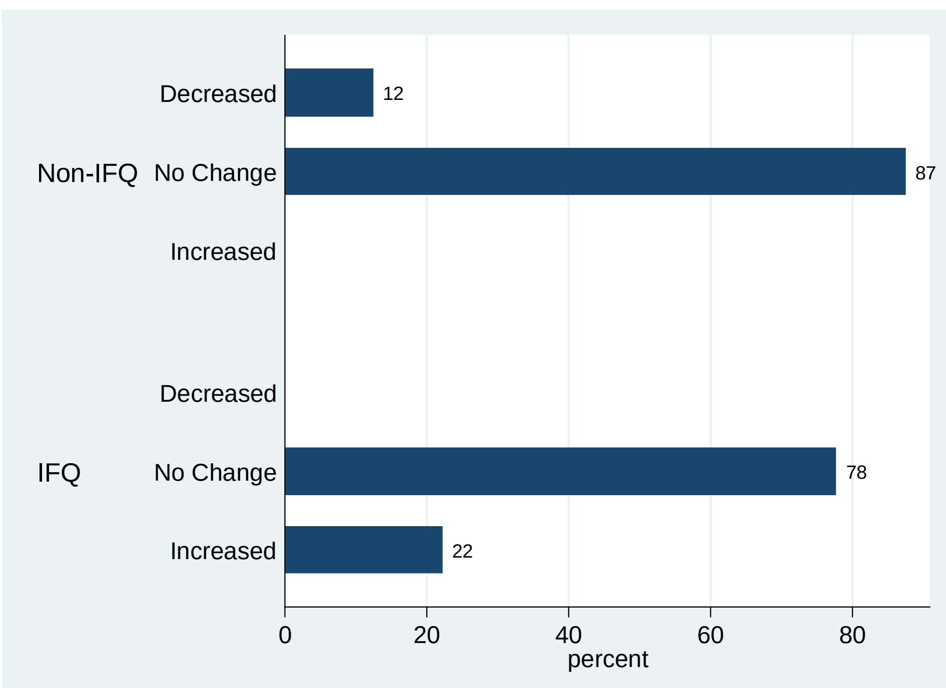


Figure 5. "Level of bycatch in primary fishery" by scallop permit type

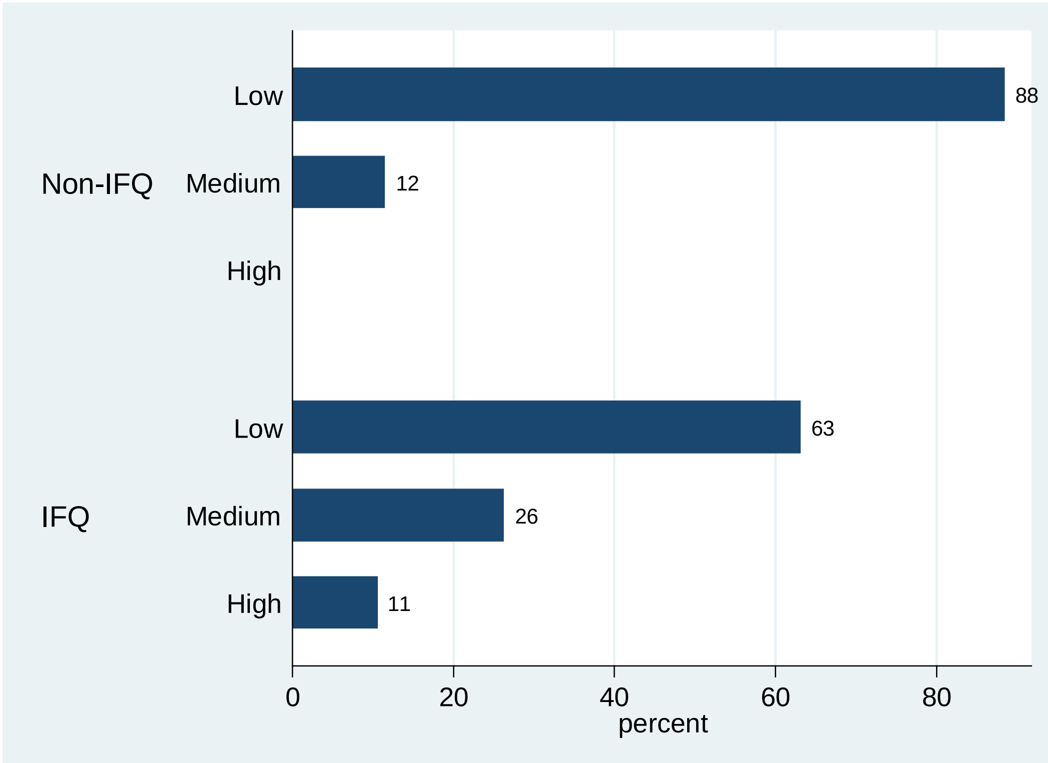
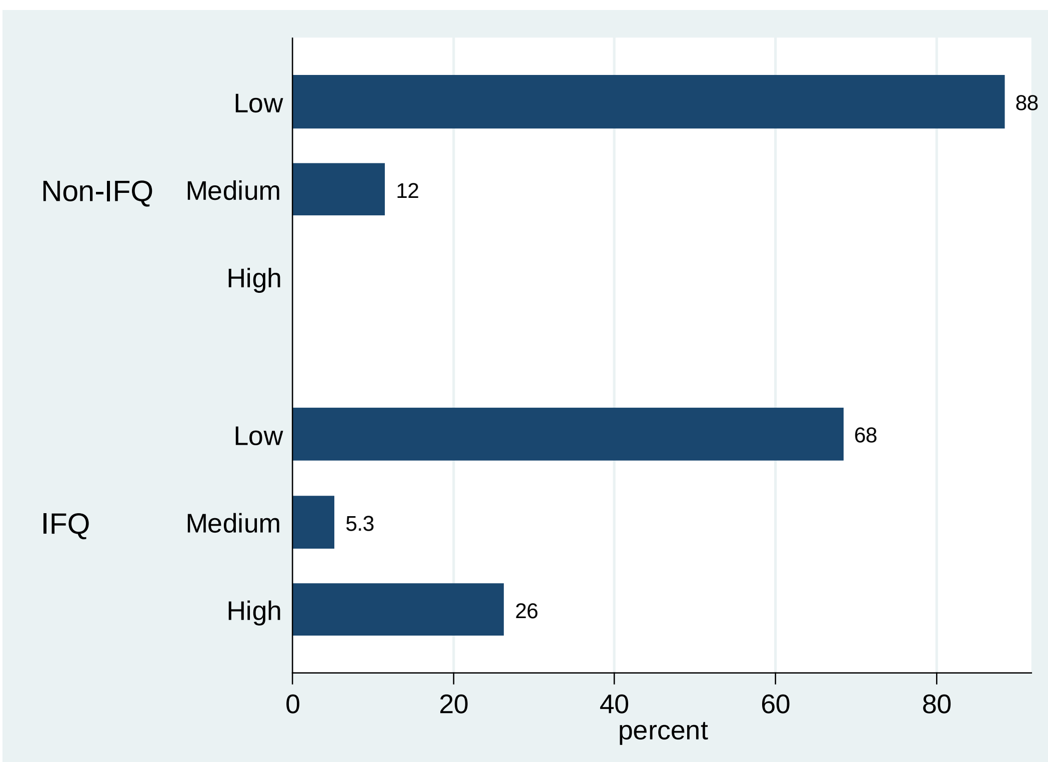


Figure 6. "Level of discards in primary fishery" by scallop permit type



Appendix A.

Table 11: Two-group *t* tests comparing means of IFQ scallop and Groundfish crew members on "Management Process"

	IFQ		Groundfish			
	Mean	Standard Deviation	Mean	Standard Deviation	*t*	*df*
Participate	3.911	0.793	3.864	1.094	-0.250	109
Unfair	**3.227**	**1.307**	**4.031**	**1.177**	**2.358***	**52**
Believe	3.286	1.230	3.806	1.108	1.590	50
Correct	3.631	1.165	3.893	1.031	0.809	45
Appeal	2.953	1.395	2.704	1.382	-0.616	46
Add Info	2.545	1.101	2.310	1.039	-0.780	49
Opinions	4.240	0.779	4.097	1.106	-0.547	54
Integrated	1.750	1.650	2.250	1.055	0.996	18
Serious	2.250	1.165	2.333	1.371	0.141	18
Not Welcome	2.500	1.414	2.833	1.267	0.551	18
Don't Trust	4.125	0.991	4.500	0.522	1.109	18

***-p<.05**

Table 12 Two-group *t* tests comparing means of non-IFQ scallop and Groundfish crew members on "Management Process"

	Non-IFQ		Groundfish			
	Mean	Standard Deviation	Mean	Standard Deviation	*t*	*df*

Participate	3.857	1.102	3.864	1.093	0.033	120
Unfair	**3.428**	**1.200**	**4.031**	**1.177**	**1.961***	**58**
Believe	3.542	1.062	3.806	1.108	0.895	53
Correct	3.385	1.416	3.893	1.031	1.516	52
Appeal	2.880	1.235	2.704	1.382	-0.484	50
Add Info	2.461	1.272	2.310	1.039	-0.485	53
Opinions	3.900	1.062	4.097	1.106	0.708	59
Integrated	2.143	1.099	2.250	1.055	0.252	24
Serious	2.000	0.961	2.333	1.371	0.726	24
Not Welcome	2.846	1.143	2.833	1.267	-0.027	23
Don't Trust	**3.214**	**0.699**	**4.500**	**0.522**	**5.234*****	**24**

***-p<.05**

*****-p<.001**

Table 13: Two-group *t* tests comparing means of IFQ and Lobster crew members on "Management Process"

	IFQ		Lobster			
	Mean	Standard Deviation	Mean	Standard Deviation	*t*	*df*
Participate	3.911	0.793	4.028	0.636	1.094	124
Unfair	3.227	1.307	3.615	1.042	1.273	59
Believe	3.286	1.230	3.210	1.212	-0.227	57
Correct	3.631	1.165	3.400	0.945	-0.791	52
Appeal	2.953	1.395	2.871	0.991	-0.246	50

Add Info	2.545	1.101	2.735	1.024	0.658	54
Opinions	4.240	0.779	3.820	1.167	-1.583	62
Integrated	**1.750**	**1.650**	**3.454**	**1.036**	**3.363****	**17**
Serious	2.250	1.165	2.800	1.135	1.010	16
Not Welcome	2.500	1.414	2.545	1.036	0.081	17
Don't Trust	4.125	0.991	3.200	1.135	-1.815	16

****-p<.01**

Table 14: Two-group *t* tests comparing means of non-IFQ scallop and Lobster crew members on "Management Process"

	Non-IFQ		Lobster			
	Mean	Standard Deviation	Mean	Standard Deviation	*t*	*df*
Participate	3.857	1.102	4.028	0.636	1.094	124
Unfair	3.428	1.200	3.615	1.042	0.679	65
Believe	3.542	1.062	3.210	1.212	-1.098	60
Correct	3.385	1.416	3.400	0.945	0.051	59
Appeal	2.880	1.235	2.871	0.991	-0.030	54
Add Info	2.461	1.272	2.735	1.024	0.924	58
Opinions	3.900	1.062	3.820	1.167	-0.292	67
Integrated	**2.143**	**1.099**	**3.454**	**1.036**	**3.036****	**23**

Serious	2.000	0.961	2.800	1.135	1.865	22
Not Welcome	2.846	1.143	2.545	1.036	-0.670	22
Don't Trust	3.214	0.699	3.200	1.135	-0.038	22

****-p<.01**

Appendix B.

Table 15. Two-group *t* tests comparing means of IFQ scallop and Groundfish crew members on "Fishery Management Plan"

	IFQ		**Groundfish**			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Goals	**3.278**	**1.018**	**2.548**	**1.312**	**-2.027***	**47**
Protects	**3.421**	**1.071**	**2.677**	**1.275**	**-2.122***	**48**
Where	2.800	1.152	2.286	1.319	-1.454	53
When	2.300	0.923	1.886	1.157	-1.369	53
Opportunity	3.842	1.167	3.273	1.008	-1.851	50
Maximize	2.750	0.966	3.029	1.141	0.918	52
Off-limits	**2.350**	**0.875**	**3.228**	**1.215**	**2.836****	**53**
Change	3.222	0.943	2.844	1.221	-1.136	48

***-p<.05**

****-p<.01**

Table 16. Two-group *t* tests comparing means of non-IFQ scallop and Groundfish crew members on "Fishery Management Plan"

	Non-IFQ		Groundfish			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Goals	3.077	1.197	2.548	1.312	-1.575	55
Protects	**3.320**	**1.029**	**2.677**	**1.275**	**-2.039***	**54**
Where	2.077	1.055	2.286	1.319	0.664	59
When	2.154	1.008	1.886	1.157	-0.944	59
Opportunity	**4.270**	**0.827**	**3.273**	**1.008**	**-4.071***	**57**
Maximize	2.800	1.080	3.029	1.141	0.780	57
Off-limits	**2.346**	**0.892**	**3.228**	**1.215**	**3.129**	**59**
Change	3.417	1.139	2.844	1.221	-1.788	54

***-p<.05**

****-p<.01**

*****-p<.001**

Table 17. Two-group *t* tests comparing means of IFQ scallop and Lobster crew members on "Fishery Management Plan"

	IFQ		Lobster			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***

Goals	3.278	1.018	3.481	0.975	0.674	43
Protects	3.421	1.071	3.467	1.008	0.151	47
Where	**2.800**	**1.152**	**4.043**	**1.055**	**4.868*** **	**49**
When	**2.300**	**0.923**	**3.100**	**1.241**	**2.460** **	**48**
Opportunity	3.842	1.167	3.633	1.159	-0.613	47
Maximize	2.750	0.966	2.621	1.115	-0.421	47
Off-limits	**2.350**	**0.875**	**3.069**	**1.252**	**2.219***	**47**
Change	3.222	0.943	3.071	1.086	-0.483	44

***-p<.05**

****-p<.01**

*****-p<.001**

Table 18. Two-group *t* tests comparing means of non-IFQ scallop and Lobster crew members on "Fishery Management Plan"

	Non-IFQ		**Lobster**			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Goals	3.077	1.197	3.481	0.975	1.351	51
Protects	3.320	1.029	3.467	1.008	0.532	53

Where	**2.077**	**1.055**	**4.043**	**1.055**	**8.535*** **	**55**
When	**2.154**	**1.008**	**3.100**	**1.241**	**3.100** **	**54**
Opportunity	**4.270**	**0.827**	**3.633**	**1.159**	**-2.329***	**54**
Maximize	2.800	1.080	2.621	1.115	-0.598	52
Off-limits	**2.346**	**0.892**	**3.069**	**1.252**	**2.440** **	**53**
Change	3.417	1.139	3.071	1.086	-1.117	50

***-p<.05**

****-p<.01**

*****-p<.001**

Appendix C.

Table 19. Two-group *t* tests comparing means of IFQ scallop and Groundfish crew members on "Rules and Regulations"

	IFQ		**Groundfish**			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Comply	**3.428**	**0.978**	**2.788**	**1.218**	**-2.027***	**52**
Restrict	4.095	0.768	4.235	1.046	0.531	53
Fines	2.167	1.115	2.029	1.218	-0.343	44
Regs_Unfair	3.400	1.046	3.844	0.987	1.541	50
Easy	3.389	1.195	3.031	1.257	-0.983	48
Reg_Bycatch	**3.118**	**0.485**	**2.677**	**0.748**	**-2.183***	**46**
Reg_Discards	**3.222**	**0.864**	**2.735**	**0.864**	**-2.243***	**50**
Reg_High	2.806	0.749	2.806	0.749	-1.345	46

***-p<.05**

Table 20. Two-group *t* tests comparing means of non-IFQ scallop and Groundfish crew members on "Rules and Regulations"

	Non-IFQ		**Groundfish**			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Comply	3.346	1.056	2.788	1.218	-1.851	57
Restrict	**3.692**	**1.049**	**4.235**	**1.046**	**1.989***	**58**
Fines	**2.875**	**1.147**	**2.029**	**1.218**	**-2.331***	**48**
Regs_Unfair	**3.231**	**1.032**	**3.844**	**0.987**	**2.304***	**56**
Easy	3.591	1.007	3.031	1.257	-1.738	52
Reg_Bycatch	2.833	0.381	2.677	0.748	-0.931	53
Reg_Discards	2.875	0.338	2.735	0.864	-0.751	56
Reg_High	2.917	0.408	2.806	0.749	-0.649	53

***-p<.05**

Table 21. Two-group *t* tests comparing means of IFQ scallop and Lobster crew members on "Rules and Regulations"

	IFQ		Lobster			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Comply	3.428	0.978	3.290	1.189	-0.441	50
Restrict	**4.095**	**0.768**	**3.133**	**1.306**	**-3.023****	**49**
Fines	2.167	1.115	2.928	1.215	1.861	38
Regs_Unfair	3.400	1.046	2.933	1.201	-1.415	48
Easy	3.389	1.195	3.233	1.278	-0.418	46
Reg_Bycatch	3.118	0.485	3.036	0.508	-0.533	43
Reg_Discards	2.735	0.864	3.367	0.615	0.876	46
Reg_High	2.806	0.749	2.965	0.499	-0.720	44

****-p<.01**

Table 22. Two-group *t* tests comparing means of non-IFQ scallop and Lobster crew members on "Rules and Regulations"

	Non-IFQ		**Lobster**			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Comply	3.346	1.056	3.290	1.189	-0.186	55
Restrict	3.692	1.049	3.133	1.306	-1.747	54
Fines	2.875	1.147	2.928	1.215	1.861	38
Regs_Unfair	3.231	1.032	2.933	1.201	-0.986	54
Easy	3.591	1.007	3.233	1.278	-1.087	50
Reg_Bycatch	2.833	0.381	3.036	0.508	1.603	50
Reg_Discards	**2.875**	**0.338**	**3.367**	**0.615**	**3.517*** **	**52**
Reg_High	2.917	0.408	2.965	0.499	0.384	51

*****-p<.001**

Appendix D.

Table 23. Two-group *t* tests comparing means of IFQ scallop and Groundfish crew members on "Environmental Stewardship"

	IFQ		**Groundfish**			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Harm	4.378	0.747	4.551	0.557	1.414	112
Overfish	2.432	1.227	2.318	1.242	-0.472	108
Environment	4.341	0.479	4.464	0.901	0.832	111
Bycatch	1.474	0.697	1.529	0.706	0.277	51
Discards	1.579	0.901	1.543	0.780	-0.154	52
High	1.368	0.684	1.258	0.514	-0.649	48

Table 24. Two-group *t* tests comparing means of non-IFQ scallop and Groundfish crew members on “Environmental Stewardship”

	Non-IFQ		**Groundfish**			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Harm	4.414	0.593	4.551	0.557	1.340	125
Overfish	2.035	0.925	2.318	1.242	1.414	121
Environment	4.500	0.504	4.464	0.901	-0.272	125
Bycatch	**1.115**	**0.326**	**1.529**	**0.706**	**2.768****	**58**
Discards	**1.115**	**0.326**	**1.543**	**0.780**	**2.625****	**59**
High	1.192	0.567	1.258	0.514	0.459	55

****-p<.01**

Table 25. Two-group *t* tests comparing means of IFQ scallop and Lobster crew members on "Environmental Stewardship"

	IFQ		**Lobster**			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Harm	4.378	0.747	4.444	0.500	0.578	115
Overfish	2.432	1.227	2.265	0.924	-0.820	110
Environment	4.341	0.479	4.430	0.668	0.776	114
Bycatch	**1.474**	**0.697**	**1.129**	**0.427**	**-2.173***	**48**
Discards	1.579	0.901	1.968	0.912	1.469	48
High	1.368	0.684	1.393	0.737	1.115	45

***-p<.05**

Table 26. Two-group *t* tests comparing means of non-IFQ scallop and Lobster crew members on "Environmental Stewardship"

	Non-IFQ		**Lobster**			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Harm	4.414	0.593	4.444	0.500	0.319	128

Overfish	2.035	0.925	2.265	0.924	1.382	123
Environment	4.500	0.504	4.430	0.668	-0.655	128
Bycatch	1.115	0.326	1.129	0.427	0.133	55
Discards	**1.115**	**0.326**	**1.968**	**0.912**	**4.523*****	**55**
High	1.192	0.567	1.393	0.737	1.114	52

*****-p<.001**

Appendix E.

Table 27. Two-group *t* tests comparing means of IFQ scallop and Groundfish crew members on "Satisfaction and well-being"

	IFQ		**Groundfish**			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Earn	**3.886**	**1.104**	**2.882**	**1.178**	**-4.512*****	**110**
Away	**3.432**	**1.043**	**2.209**	**0.977**	**-5.277*****	**109**
Adventure	**3.659**	**0.963**	**3.203**	**1.145**	**-2.193***	**111**
Advise	**0.636**	**0.487**	**0.242**	**0.432**	**-4.454*****	**108**
Just Job	1.795	0.878	2.101	1.139	1.516	111
Part-time	1.953	1.068	2.103	0.995	0.749	109
Leave	2.773	1.118	3.014	1.289	1.022	111
Proud	4.523	0.731	4.435	0.675	-0.654	111
Connect	**4.454**	**0.589**	**4.145**	**0.809**	**-2.193***	**111**
Leader	2.581	1.052	2.449	0.978	-0.675	110
Leader2	3.091	1.030	2.765	1.173	-1.506	110

***-p<.05**

*****-p<.001**

Table 28. Two-group *t* tests comparing means of non-IFQ scallop and Groundfish crew members on "Satisfaction and well-being"

	Non-IFQ		**Groundfish**			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Earn	**3.696**	**1.320**	**2.882**	**1.178**	**-3.625*** **	**122**
Away	**3.036**	**1.095**	**2.209**	**0.977**	**-4.423*** **	**121**
Adventure	3.411	1.058	3.203	1.145	-1.044	123
Advise	**0.534**	**0.503**	**0.242**	**0.432**	**-3.465*** **	**120**
Just Job	2.158	1.265	2.101	1.139	-0.263	124
Part-time	**1.719**	**0.818**	**2.103**	**0.995**	**2.326***	**123**
Leave	3.107	1.330	3.014	1.289	-0.394	123
Proud	4.631	0.555	4.435	0.675	-1.763	124
Connect	4.411	0.826	4.145	0.809	-1.809	123
Leader	2.536	1.159	2.449	0.978	-0.452	123
Leader2	**3.196**	**1.052**	**2.765**	**1.173**	**-2.136***	**122**

***-p<.05**

*****-p<.001**

Table 29. Two-group *t* tests comparing means of IFQ scallop and Lobster crew members on "Satisfaction and well-being"

	IFQ		Lobster			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Earn	3.886	1.104	3.609	1.046	-1.346	111
Away	**3.432**	**1.043**	**2.971**	**1.076**	**-2.250***	**112**
Adventure	3.659	0.963	3.543	1.003	-0.612	112
Advise	0.636	0.487	0.682	0.469	0.490	108
Just Job	**1.795**	**0.878**	**2.268**	**0.999**	**2.577****	**113**
Part-time	1.953	1.068	2.183	0.915	1.218	112
Leave	2.773	1.118	2.614	1.231	-0.693	112
Proud	4.523	0.731	4.324	0.692	-1.465	113
Connect	**4.454**	**0.589**	**4.056**	**0.791**	**-2.880****	**113**
Leader	2.581	1.052	2.535	0.954	-0.241	112
Leader2	**3.091**	**1.030**	**2.620**	**0.916**	**-2.555****	**113**

***-p<.05**

****-p<.01**

Table 30. Two-group *t* tests comparing means of non-IFQ scallop and Lobster crew members on "Satisfaction and well-being"

	Non-IFQ		**Lobster**			
	Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	***t***	***df***
Earn	3.696	1.320	3.609	1.046	-0.415	123
Away	3.036	1.095	2.971	1.076	-0.331	124
Adventure	3.411	1.058	3.543	1.003	0.717	124
Advise	0.534	0.503	0.682	0.469	1.657	120
Just Job	2.158	1.265	2.268	0.999	0.548	126
Part-time	**1.719**	**0.818**	**2.183**	**0.915**	**2.986****	**126**
Leave	**3.107**	**1.330**	**2.614**	**1.231**	**-2.154***	**124**
Proud	**4.631**	**0.555**	**4.324**	**0.692**	**-2.724****	**126**
Connect	**4.411**	**0.826**	**4.056**	**0.791**	**-2.458****	**125**
Leader	2.536	1.159	2.535	0.954	-0.003	125
Leader2	**3.196**	**1.052**	**2.620**	**0.916**	**-3.299*****	**125**

***-p<.05**

****-p<.01**

*****-p<.001**

APPENDIX J – NETWORK ANALYSIS

Multi-Scale Network Analysis of the Atlantic Sea Scallop General Category IFQ Program

Gabriela Stocks, Ph.D., Independent Contractor, Environmental Anthropology

Summary of Key Findings

The Atlantic Sea Scallop General Category IFQ share transfer network is characterized by few participants, low cohesion, and one-time transfers between business entities.

The Atlantic Sea Scallop General Category IFQ quota leasing network is characterized by many participants, increasing cohesion, and multi-year participation, but also by few multi-year leasing relationships between participants.

The number of federally permitted seafood dealers receiving landings from the IFQ fleet has decreased over time, and relationships between fishing businesses and dealers tend to be short term. There is some consistency in the largest sea scallop dealers across years.

1. Introduction

While all fishery management actions include an assessment of potential social and economic impacts, finer scale analyses of the post-implementation impacts of regulatory action is often lacking. In particular, the evaluation of catch share programs, which dedicate a secure share of annual quota to qualifying fishermen and/or vessels, requires a detailed assessment of the longitudinal effects of this management strategy. Changes in fishing practices due to catch share programs may involve shifts in relationships between fishermen, entrance into or exit from certain fisheries as constraints change, shifts in the species composition of vessel catch, etc.

The project described in this report was developed as one method for evaluating the first six years of the Atlantic Sea Scallop General Category Individual Fishing Quota (IFQ) program. The Final Rule for the IFQ program was published on April 14, 2008 (effective June 1, 2008) as part of the development of a limited access program for the General Category Atlantic scallop fishery. There was then a two-year transition from open access fishing to IFQ fishing. The goal of the program was to reduce overcapacity in the fishery, as the number of General Category vessels landing scallops had increased from 181 in 1994 to 600 in 2005. This new management strategy allocated 95% of the annual scallop fishery allocation to a limited access "days at sea" fleet and 5% of the annual allocation to an IFQ fleet. Initial IFQ shares were distributed to vessels based on their best year of scallop landings and the number of fishing years that they were active between March 1, 2000 and November 1, 2004, with an accumulation limit of 2.5% per vessel and 5% per individual.

This report describes the use of network analysis as an exploratory tool for understanding various dynamics of the Atlantic Sea Scallop IFQ fleet from 2010-2015. Specifically, the project analyzed two large datasets:

1. Share and lease transactions from the Atlantic Sea Scallop IFQ program for the 2010-2015 fishing years
2. Dealer transactions for the 2010-2015 fishing years, minus the last two months (January and February) of the 2015 fishing year.

The primary goal of this study was to begin to characterize how the introduction of the Atlantic General Category Sea Scallop IFQ program in the mid-Atlantic region may have influenced relationships between fishermen and between fishermen and seafood dealers.

2. A Brief Introduction to Social Network Analysis

This project employed both one- and two-mode network analysis. One-mode network analysis was used to analyze IFQ share and lease transaction data, while two-mode network analysis was used to analyze dealer data.

2.1 One-Mode Network Analysis

In one-mode network analysis, a network is composed of only one type of entity. For example, a researcher may be interested in the relationships among people in a specific group (e.g., a classroom or a company). An adjacency matrix like Table 1 reflects whether or not each person has a tie with every other person in the group (a "1" indicates the presence of a tie, a "0" indicates the absence of a tie). The tie can be anything defined by the researcher, for example knowing someone, having worked with someone, liking/disliking someone, etc. The entities in the rows and columns in one-mode networks are identical but the ties are not necessarily symmetrical (i.e., Sue might claim to know Mark but Mark might not claim to know Sue).

Table 1: A one-mode network adjacency matrix

	Sue	Mark	John	Bob	Bill
Sue		1	1	0	1
Mark	1		1	0	0
John	1	1		1	1
Bob	0	0	1		0
Bill	1	0	1	0	

Table 1: A one-mode network adjacency matrix

Network analysis software, like UCINET and its accompanying network visualization program Netdraw, can translate Table 1 into a network diagram, automatically arranging the nodes in space based on their similarity (Figure 1). In Figure 1, the group members (aka “nodes”) are represented by squares, and the relationships between them are represented by lines (aka “edges” or “ties”). The nodes in Figure 1 are sized based on degree centrality (i.e., the number of other nodes to whom a particular node is connected). In this case, John has the highest degree centrality because he is the only person who has ties to all four remaining group members.

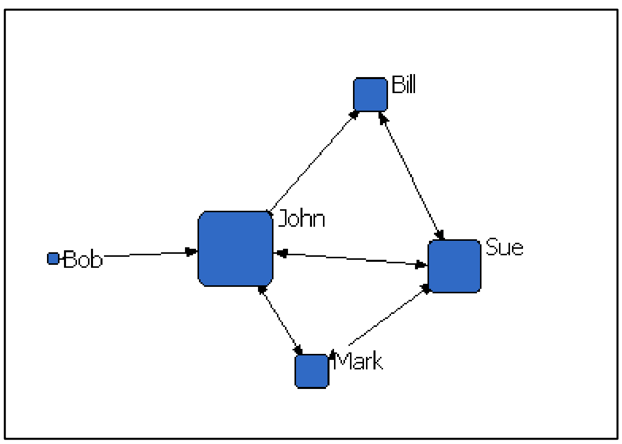


Figure 1: A one-mode network diagram

Degree centrality can also be directional based on the number of nodes who claimed to have a tie with a given node (aka “in-degree centrality”, often associated with the social prominence of that node) or the number of nodes with whom a particular node claimed to have a tie (aka “out-degree centrality”, often associated with the social influence of that node). Other individual measures of centrality include betweenness centrality (a measure of the extent to which a node lies on the pathway between other nodes) and closeness centrality (a measure of the distance of a given node from all other nodes in the network). At the whole network level, a number of compositional and structural measures can also be calculated. Compositional measures include number of nodes, number of ties, and the distribution of node attributes (e.g., age, gender, occupation, etc. of network members). Structural measures include network density (the number of ties in the network as a proportion of the total possible number of ties), network centralization (a measure of the concentration of power within a network), number of components (isolated sub-groups), and average degree centrality (the average number of connections between nodes).

2.2 Two-Mode Network Analysis

In two-mode network analysis, the network is composed of two different types of entities. For example, a researcher may be interested in understanding membership patterns in various community organizations. In Table 2, rows represent people and columns represent organizations to which people might belong (a "1" indicates membership; a "0" indicates the absence of membership). Again, this tie can be anything defined by the researcher.

	PTA	Elk's Club	Rotary Club
Sue	1	1	1
Mark	1	0	1
John	1	1	0

Table 2: A two-mode network adjacency matrix

A network analysis software package translates Table 2 into a network diagram (Figure 2). In Figure 2, people are represented by red circles and organizations are represented by blue squares. Membership is represented by edges that link people to organizations. The nodes in Figure 2 are sized based on degree centrality (i.e., the number of organizations to which a person belongs or the number of people that belong to an organization). In this case, Sue has the highest individual degree centrality because she is a member of all three organizations. The PTA has the highest organizational degree centrality because all three people are members.

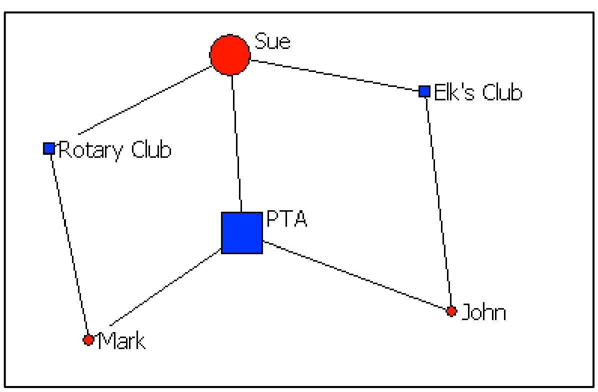


Figure 2: A two-mode network diagram

As in one-mode network analysis, betweenness centrality and closeness centrality can also be calculated, as can other network-level structural and compositional measures. In addition, two-mode networks can be transformed into one-mode networks through a correspondence analysis of entities that share ties. In Figure 2, for example, we could construct new one-mode networks of only people or only organizations with ties representing co-membership (e.g., if two organizations had members in common, those organizations would be connected in the one-mode network).

3. Atlantic Sea Scallop IFQ Share and Quota Transaction Networks

As noted above, the Atlantic Sea Scallop IFQ program reserves 5% of the annual sea scallop allocation for an IFQ fleet composed of smaller-scale fishing vessels. The initial distribution of shares, based on vessels' fishing histories, occurred in 2010, after which shares could be permanently transferred and quota pounds could be annually leased to other vessels that qualified for the program. Share and quota transactions occur between IFQ participants and therefore represent social and/or economic relationships between these entities. These relationships can be used to conduct a social network analysis, which, in turn, allows us to understand how the IFQ transaction networks may have changed over the life of the Atlantic General Category Sea Scallop IFQ program. For the current project, one-mode network analysis was conducted for all share and quota transfers that occurred in each of the 2010-2015 fishing years.

3.1 Data Processing

Records of share and quota transfers are maintained by the Greater Atlantic Regional Fisheries Office (GARFO). Transfers occur between a “transferor” and a “transferee”, each of whom is identified by a combination of a moratorium right id (MRI) and a permit number. On any given date, the MRI-permit combination is affiliated with a unique business entity, though this affiliation can change at any point, potentially daily, as rights and permits can be transferred (either together or independently) to other IFQ participants at any time. Data collected about each transfer also includes the date of transfer, share or pounds transferred, and value of the transfer.

To date, most analyses of the IFQ program have used data associated with individual permit numbers, rather than on an accumulation of ownership basis. For the current social network analysis, however, we believed that it was important to understand the relationships between fishing businesses, many of which have multiple permitted vessels, rather than between the individual vessels themselves. Because a vessel can change ownership at any time, tracking IFQ share and quota transfers at the vessel level provides very little information about the human actors involved in the transactions. By aggregating transfers at the business entity level, we get a better sense of the social map created in response to the IFQ program. In some cases, the transferor and the transferee are different business entities. In other cases, the transferor and transferee are the same business entity and are transferring shares or quota from one vessel to another, or are different business entities but have some overlap in ownership. This information is important to assessing the impact of the program on fishermen.

The data cleanup required to connect the MRI-permit combination to business entities was substantial due to gaps in ownership data associated with Confirmation of Permit History (CPH) vessels. CPH vessels, otherwise known as “paper boats”, do not have active fishing permits, which means that ownership information is only updated if/when the vessel permits are sold.[12] Because current ownership data was not easily accessible for CPH vessels, the business entity was missing for any transfers originating from or terminating with a CPH vessel. For share transfers, a CPH vessel was the transferor, transferee, or both in 105 of 183 transfers (57%) from 2010-2015; for quota leases a CPH vessel was the transferor, transferee, or both in 963 of 1853 transfers (52%) from 2010-2015.

The first round of data cleanup involved matching MRI-permit combinations with the business entity associated with that combination *on the date of the IFQ share or lease transfer*. This was achieved through a relatively simple database query. The second round of data cleanup involved manually filling in missing CPH vessel ownership data, which required searching for individual CPH vessel permit numbers in a variety of databases, including permit applications, moratorium right eligibility records, and business ownership records (which included ownership data at the person level). When the date of the IFQ transfer did not match the ownership data in these datasets—which was the case for the majority of records—the most recent ownership data on record was used. As such, the business entity data used to generate the transaction networks discussed in the following two sections should be viewed with caution and would benefit from ground truthing.

3.2 IFQ Share Transaction Networks

Figure 3 represents the networks of Atlantic Sea Scallop IFQ share transfers for the 2010-2015 fishing years. In the network diagrams, nodes represent businesses entities, lines represent at least one transfer of shares in that fishing year, and arrowheads indicate the direction of the transfer (transferor to transferee). Grey lines represent transfers between unrelated accounts (i.e., no owners in common), red lines represent transfers between related accounts (i.e., at least one owner in common), and green lines represent transfers between accounts of unknown relation due to missing data.

[12] The original purpose for the CPH program was to allow vessel owners whose vessel was sunk or otherwise disabled, or the owner was unable to fish due to illness or injury, to put all permits into suspended animation until the owner was able to replace a lost vessel and start fishing. Permits attached to a vessel put in CPH also stay there until the permits are sold. Since the permits in CPH do not have to be renewed every year, the ownership information stays the same for as long as the vessel remains in CPH. However, if the permits in CPH are sold, the ownership change is recorded.

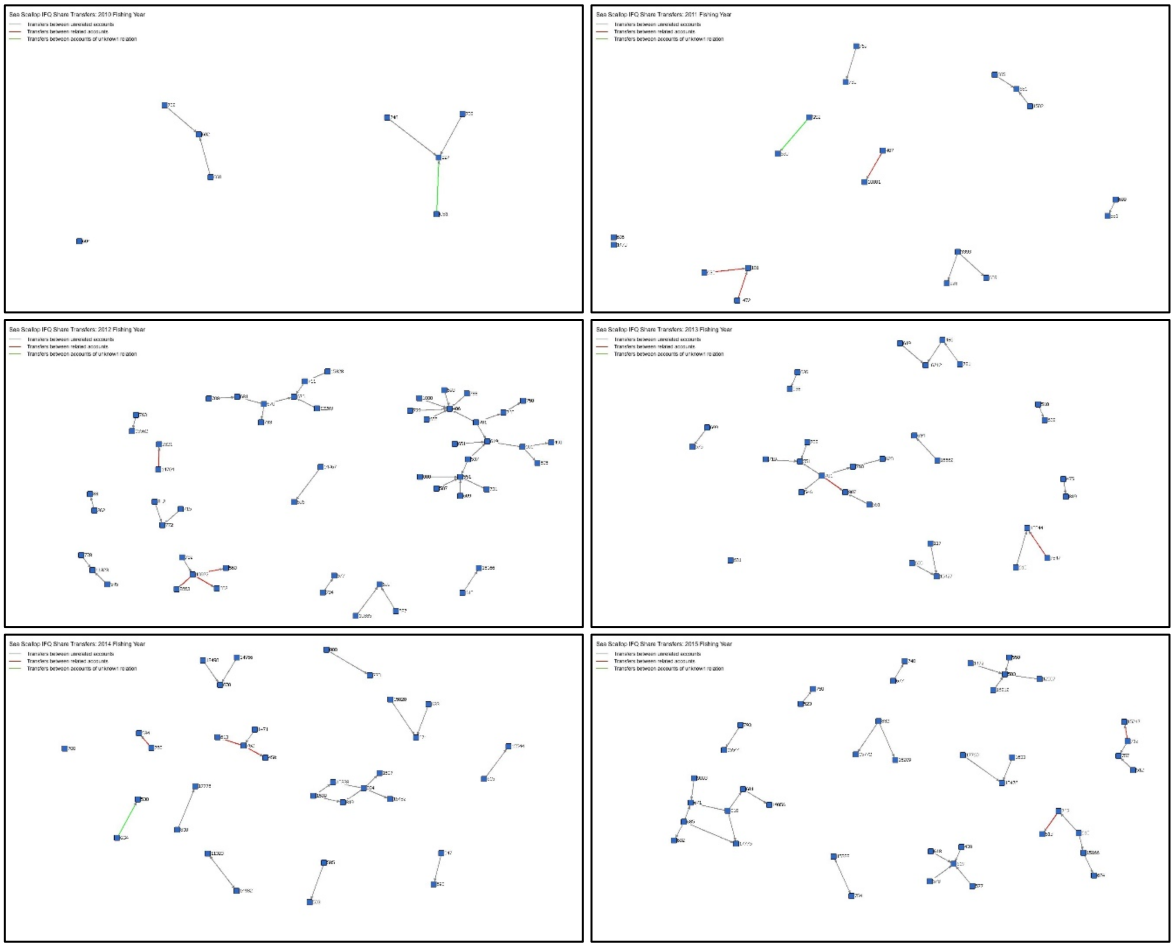


Figure 3: Atlantic Sea Scallop IFQ share transfer networks, 2010-2015 fishing years (first row: 2010-2011; second row: 2012-2013; third row: 2014-2015). Nodes represent business entities; lines represent at least one share transfer in that fishing year.

In 2010, only 8 businesses entities participated in share transfers, one of which was between related accounts (the isolated node in the lower left hand corner represents the transfer of shares between permits owned by the same business entity). The 2010 network diagram reveals that some business entities attempted to accumulate shares from other shareholders in the first year of the program, forming small sub-groups of interconnected actors (aka “components”). Specifically, Business 602 acquired shares from Businesses 732 and 660, while Business 827 acquired shares from Businesses 746, 702, and GS1. On the whole, however, the low number of participants in the 2010 share transaction network indicates that participants were not particularly interested in permanently transferring shares in the first year of the IFQ program. In subsequent years, more participants began to transfer shares: 19 in 2011, 54 in 2012, 30 in 2013, 33 in 2014, and 41 in 2015 (Figure 4).

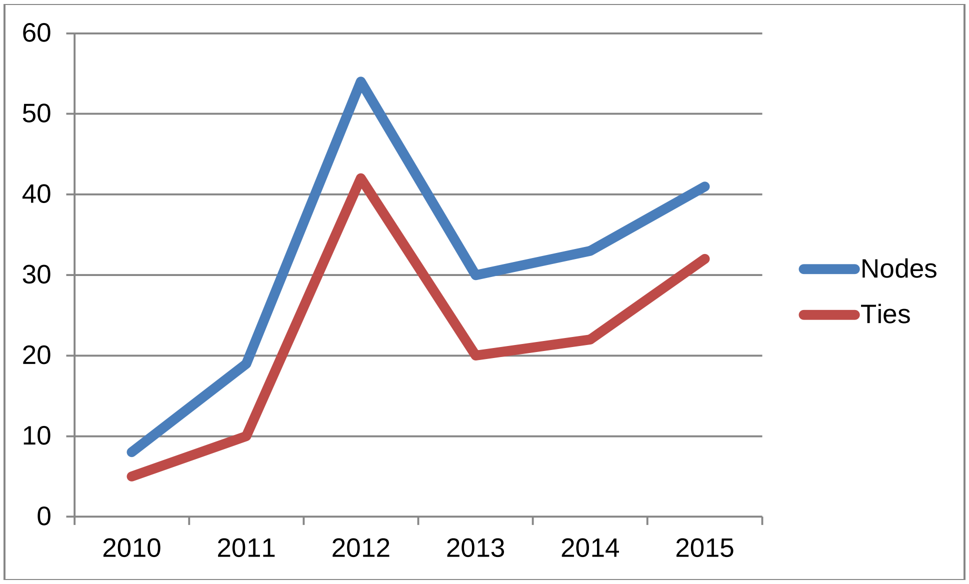


Figure 4: Number of nodes and ties in the Atlantic Sea Scallop IFQ share transfer networks, 2010-2015 fishing years.

In all years, share transfers usually occurred among small components of 2-3 nodes. The 2012 fishing year was somewhat anomalous in both the number of participants and the size of the components. This may be due to the fact that 2012 was the first year in which IFQ vessels could sell portions of shares rather than full shares.

Though some larger components formed in 2012 and later years, they were largely ephemeral. For example, of the 20 nodes in the largest component in 2012, only two remained in the same component in 2013. Furthermore, of the most eight most frequent participants in share transfers, only one entity transferred shares to the same entities in more than one year (Business 615 transferred shares to Business 15166 in 2012 and 2015, and to Business 15544 in 2013 and 2014). In sum, the vast majority of participants transferred shares in only one year, and few repeat relationships were formed. Figures 5-7 illustrate these patterns. Figure 4 is a diagram of the aggregated share transfer networks from 2010-2015, with nodes sized and colored by the number of years of participation in share transfers. Small blue nodes (participants in only one year) dominate the network.

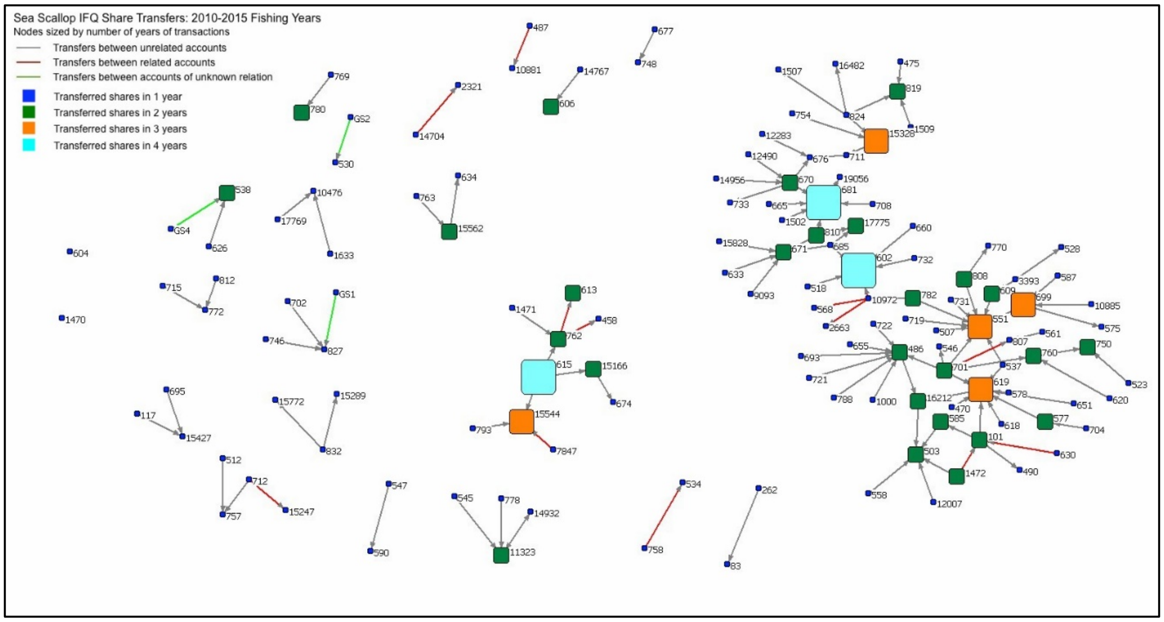


Figure 5: The aggregated 2010-2015 share transfer network. Nodes are colored and sized by the number of years they participated in share transfers.

Figure 6 quantitatively summarizes the network in Figure 5. Of 140 total unique business entities, 106 transferred shares in only one year, 26 in two years, 5 in three years, and 3 in four years. No participants transferred shares in more than four years between 2010 and 2015.

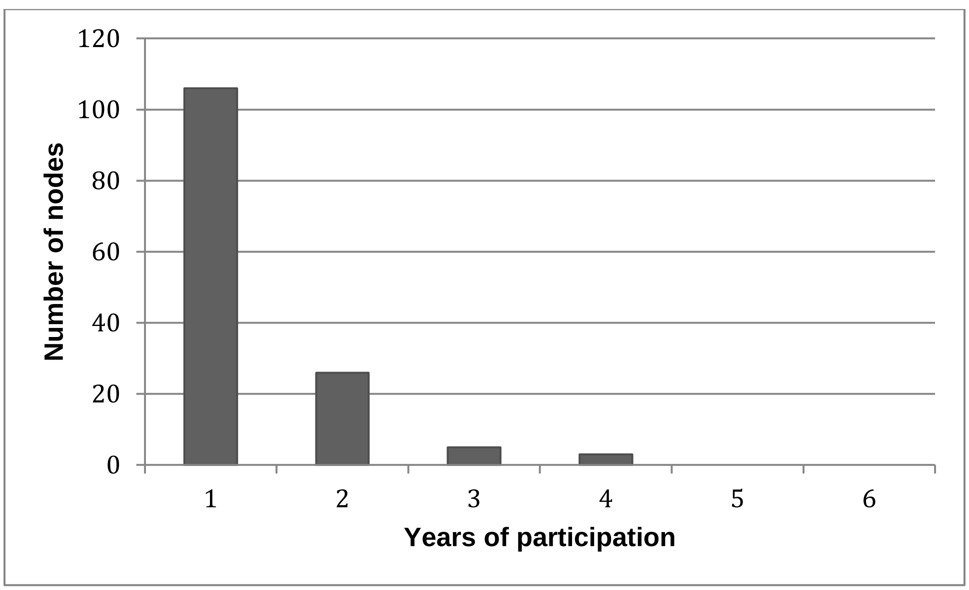


Figure 6: Years of participation in share transfers. A majority of participants transferred shares in only one year.

Figure 7 illustrates the number of years in which share transfers occurred between the same entities, indicating a small number of repeat relationships. Of 137 unique pairs of transferors and transferees between 2010-2015, 129 pairs transferred shares in only one year and eight pairs transferred shares in two years (including share transfers between related accounts). No pairs of nodes transferred shares in more than two years. There are two likely explanations for this phenomenon. First, share transferors may have been selling their entire quota and therefore were unable to participate in more transactions. Second, share transferees may have reached the cap on quota accumulation and thus would not participate in future transactions.

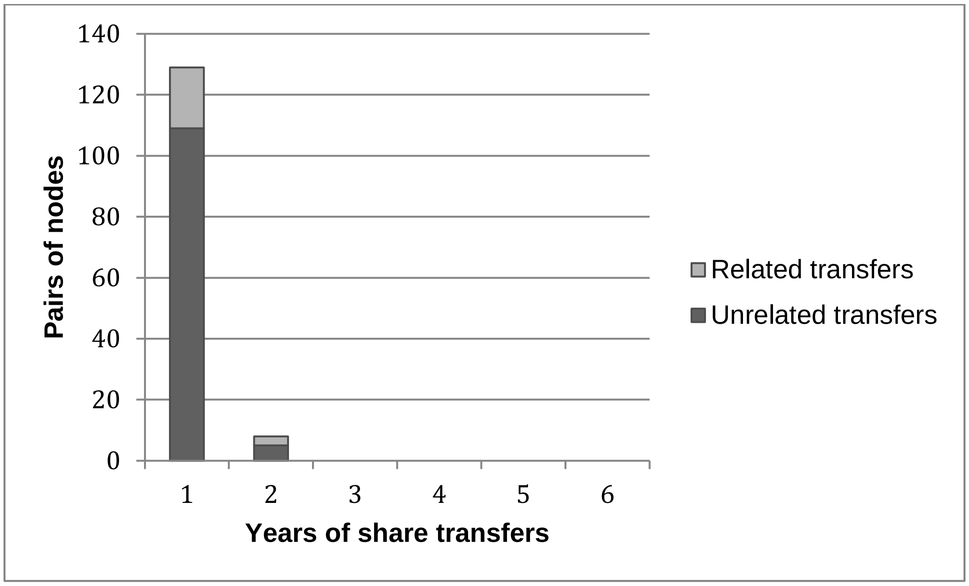


Figure 7: Length of relationship of share transfer network participants. A majority of participants interacted with each other in only one year.

In addition to the compositional network characteristics just discussed, some structural measures of network cohesion can also be calculated. Cohesion can be thought of as how "interconnected" a network is. Table 3 summarizes these measures. It should be noted that these measures were calculated only for share transfers that occurred between *unrelated* accounts in order to get a sense of the structure of the network of independent actors. When the relationship between actors was unknown, they were assumed to be unrelated for the purposes of this analysis.

Fishing Year	Unrelated Nodes	Unrelated Ties	Network Density	Components	Degree Centralization	Average Degree Centrality
2010	7	5	0.238	2	0.367	1.429
2011	12	7	0.106	5	0.091	1.167
2012	49	38	0.032	11	0.097	1.551
2013	28	18	0.048	10	0.068	1.286
2014	28	19	0.048	11	0.108	1.286
2015	39	30	0.039	11	0.07	1.487

Table 3: Measures of network cohesion for IFQ share transfer networks (unrelated transfers only).

Network density (i.e., the interconnectedness of the network as measured by the number of existing ties as a proportion of the number of possible ties) was quite low across all years, indicating a sparsely populated and potentially disconnected network. In 2010 and 2011, network density was higher than in later years due to the small number of nodes. From 2012-2015, network density ranged from only 3.2%- 4.8%.

Another measure of the connectedness of a network is the number of components (i.e., disconnected sub-groups) that form the network. Assuming the same number of network participants, the smaller the number of components, the more connected the network. In 2010-2011, there were few components due to the small number of actors. From 2012 to 2015, the number nodes decreased but the number of components stayed relatively stable, pointing to a network that may be becoming less cohesive over time. The extent to which this is true in this particular network is questionable, however, given the low frequency of repeat relationships. Less cohesion may simply be an artifact of mostly new actors engaging in transfers each year; it would not be expected that networks formed of new participants would be particularly cohesive.

Network degree centralization is a measure of the concentration of power in a network. A star network in which a central actor has exclusive access to all other actors, and therefore controls the flow of information and resources between actors, has a degree centralization of 100%. The General Category Atlantic Sea Scallop IFQ share transaction network is both sparse and disconnected and thus had low degree centralization over the life of the program, ranging from a low of 6.8% in 2013 to a high of 36.7% in 2010. Once again, the high level of centralization in 2010 is somewhat misleading because of the small number of nodes in the network and the existence of a small star sub-group. Years 2012-2015 are a more accurate representation of degree centralization in the share transaction network, with an average of 8.5% across those years. This suggests that power is largely distributed throughout the network; no one actor has disproportionate influence. Researchers concerned with equity among actors in a network would consider this a positive finding.

The structural measures just discussed focus on the network as a whole. Average degree centrality is slightly different in that it calculates node-level degree centrality across all of the individual nodes in a network. Recall from above that degree centrality refers to the number of other nodes to which a node is connected. In the IFQ share transaction network, average degree centrality is quite low across all years, ranging from 1.167 to 1.551. While every social network has unique structural characteristics that make comparisons difficult, this could be interpreted as a small average number of connections, again indicating a sparse network and low cohesion.

3.3 IFQ Quota Leasing Networks

Figure 8 represents the networks of Atlantic Sea Scallop IFQ leases for the 2010-2015 fishing years. As in the previous analysis of share transfers, nodes represent businesses entities, lines represent at least one transfer of quota in that fishing year, and arrowheads indicate the direction of the transfer (transferor to transferee). Grey lines represent quota leases between unrelated accounts (i.e., no owners in common), red lines represent leases between related accounts (i.e., at least one owner in common), and green lines represent leases between accounts of unknown relation due to missing data.

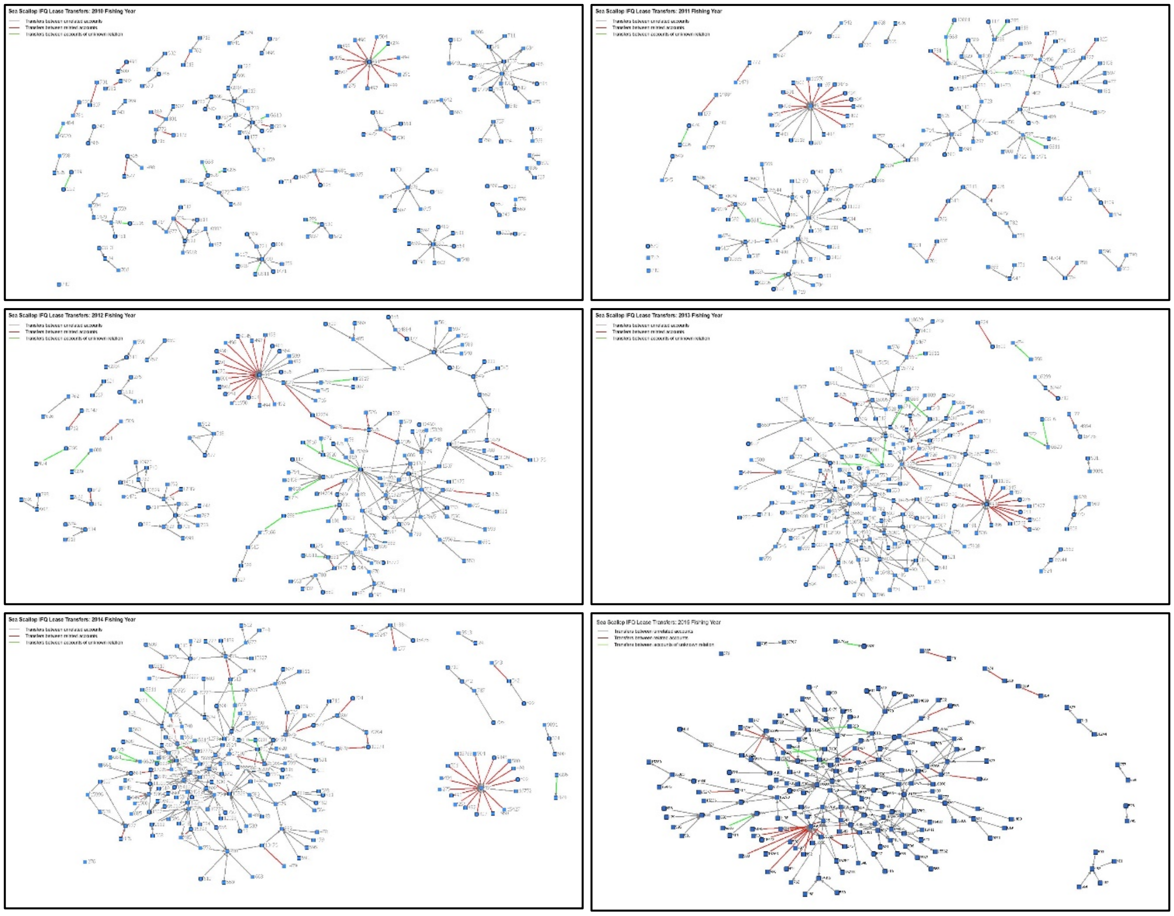


Figure 8: Atlantic Sea Scallop IFQ quota leasing networks, 2010-2015 fishing years (first row: 2010-2011; second row: 2012-2013; third row: 2014-2015). Nodes represent business entities; lines represent at least one quota lease in that fishing year.

It is immediately apparent that the IFQ leasing networks are significantly different from the share transfer networks in both composition and structure. First, the number of participants and the number of relationships in the leasing network are much greater. In 2010, 177 business entities participated in lease transactions (versus eight in the 2010 share transaction network); this number increased in subsequent years. In addition, in 2010 there were 147 ties between business entities, which increased to 256 in 2015 (Figure 9).

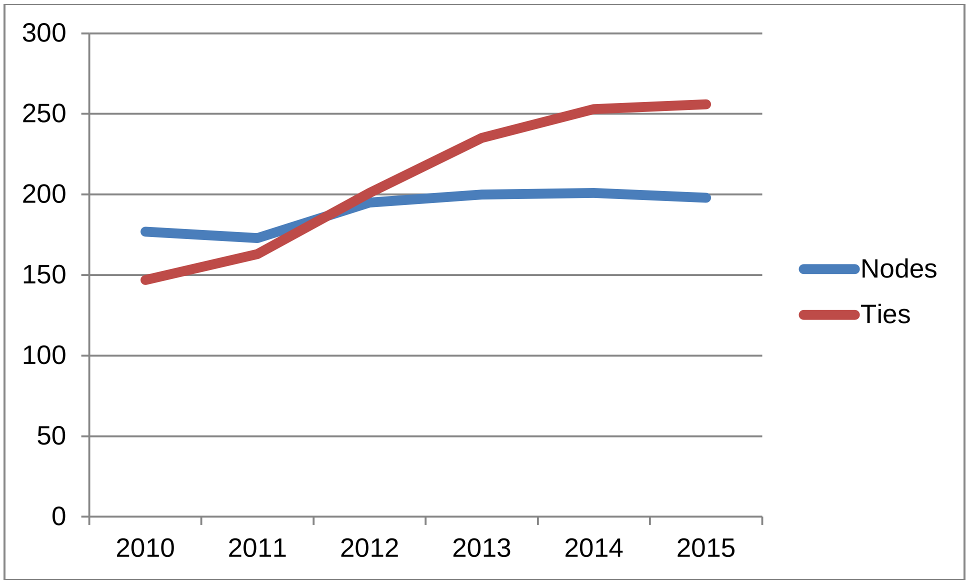


Figure 9: Number of nodes and ties in the Atlantic Sea Scallop IFQ quota leasing networks, 2010-2015 fishing years.

Second, while share transfers usually occurred among small components of 2-3 nodes, particularly in the earlier years, the quota leasing networks are characterized by much larger components. The 2010 network contains components ranging from 2 to 20 nodes. In later years, the main (i.e., largest) component size increased substantially as the network became more cohesive, peaking at 178 participants in 2013. Other measures of network cohesion will be discussed in more detail below.

Third, unlike in the share transfer networks in which actors tended to participate in transfers in only one year, the quota leasing networks are characterized by reoccurring actors. However, much like in the share transfer networks, few repeat relationships occurred. Figures 10-12 illustrate these patterns. Figure 10 is a visualization of the aggregated quota leasing networks from 2010-2015, with nodes shaded according to the number of years of participation in quota leases. Darker nodes participated in quota leasing more frequently and form about half of the network.

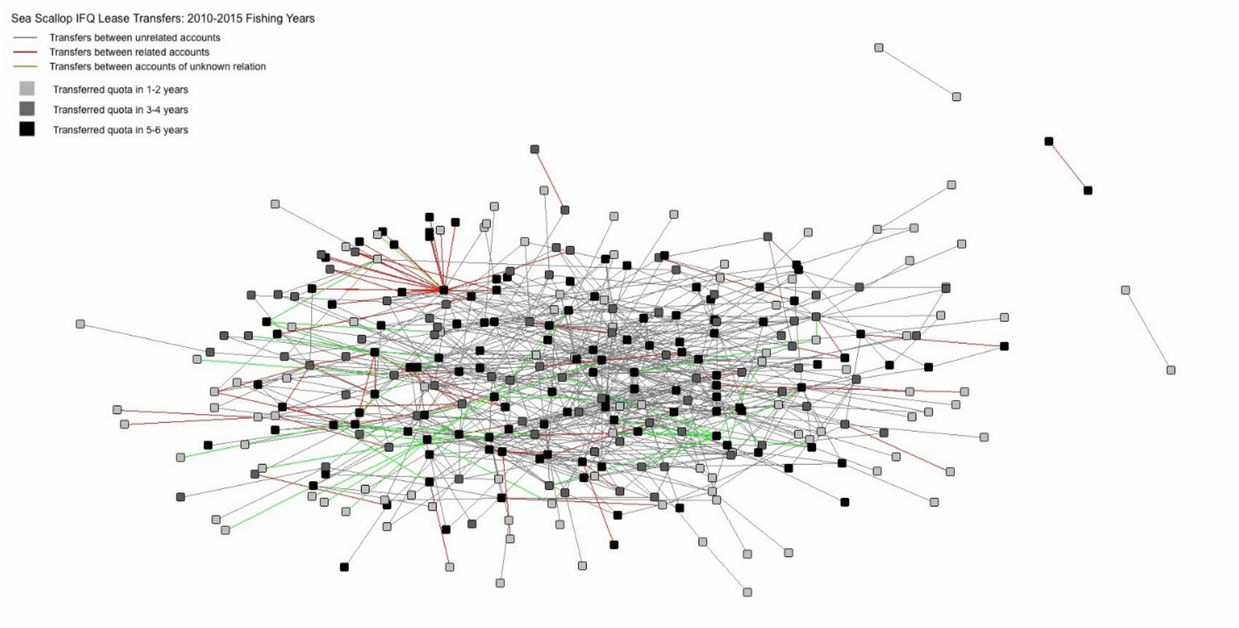


Figure 10: The aggregated 2010-2015 quota leasing network. Nodes are shaded according to the number of years they participated in quota leasing.

Figure 11 quantitatively summarizes the network in Figure 10. Of 312 total unique business entities, 79% participated in lease transactions in two or more years, and 53% participated in lease transactions in four or more years between 2010 and 2015.

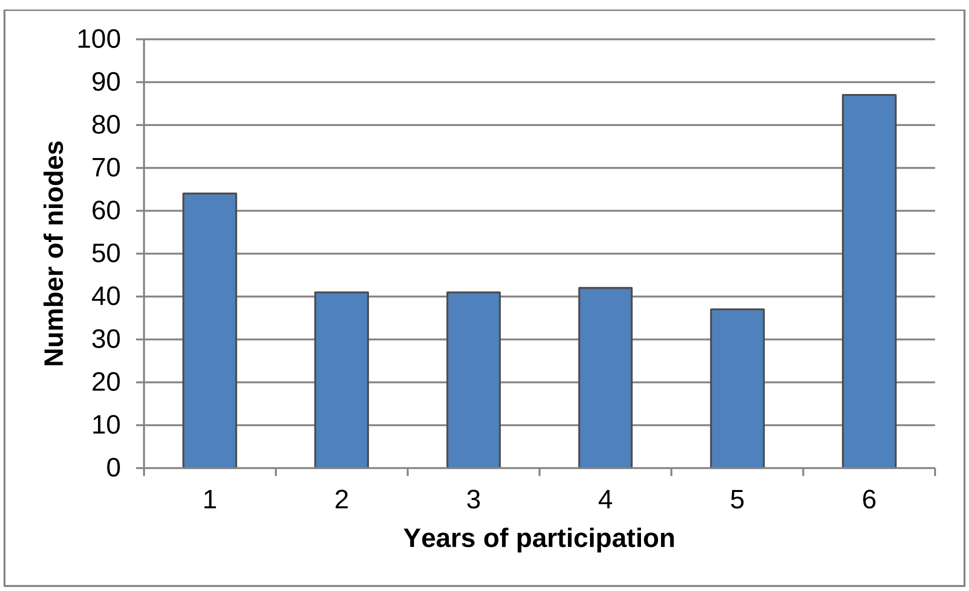


Figure 11: Years of participation in quota leasing. Over 50% of participants participated in quota leasing in four or more years.

Figure 12 illustrates the number of years in which transfers occurred between the same pairs of business entities, indicating a small number of repeat relationships. Of 837 unique pairs of quota transferors and transferees between 2010-2015, 639 pairs (74%) transferred shares in only one year. Only 14 pairs of nodes transferred quota in all six years, eight of which were between related accounts.

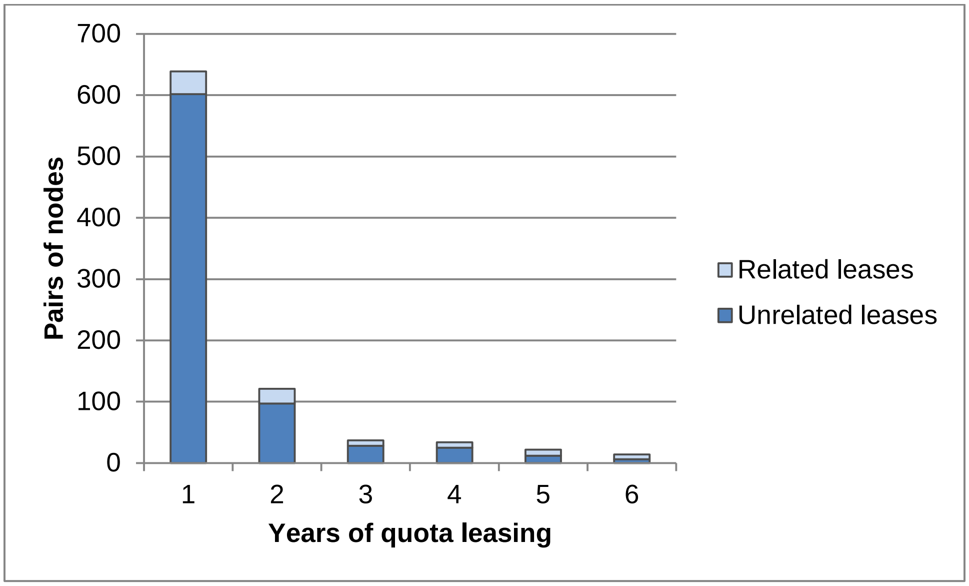


Figure 12: Length of relationship of quota leasing network participants. A majority of participants interacted with each other in only one year.

As in the analysis of share transfers, structural measures of network cohesion were also calculated for the quota leasing networks. Table 4 summarizes these measures. These measures were calculated only for quota leases that occurred between *unrelated* accounts, again assuming no relation where one was unknown.

Fishing Year	Unrelated Nodes	Unrelated Ties	Network Density	Components	Degree Centralization	Average Degree Centrality
2010	150	124	0.011	34	0.05	1.653
2011	144	136	0.013	15	0.058	1.889
2012	169	173	0.012	14	0.072	2.047
2013	178	204	0.013	10	0.067	2.292
2014	176	218	0.014	9	0.073	2.42
2015	173	226	0.015	7	0.067	2.601

Table 4: Measures of network cohesion for the IFQ quota leasing networks (unrelated transfers only).

Network density increased slightly between 2010-2015 but was generally low, ranging from 1.1%-1.5%. This stability in network density is due to simultaneous increases in the number of nodes and ties. In other words, while the number of ties increased over time, which would normally lead to an increase in density, so did the number of nodes. Thus the proportion of actual ties to possible ties remained stable over time. This indicates that that network is growing over time, but that actors are not necessarily forming many redundant pathways to each other (i.e., the networks remained sparse).

Changes in the number of components tell a similar story. In 2010, the quota leasing network had 34 individual components. This number decreased each year, culminating in only seven components in 2015. This decrease in the number of components occurred despite an increase in the number of nodes, indicating that the network became more connected over time and incorporated new nodes into the main component. This is clearly visible in the network diagrams above (Figure 8) as the main component gets larger, incorporating the smaller peripheral components.

Network degree centralization in the quota leasing networks was relatively low, ranging from a low of 5% in 2010 to a high of 7.3% in 2014. The highest levels of degree centralization occurred in 2012 and 2014, likely due to a few actors who were in key bridging positions between large clusters of nodes, giving them more the power to control information flow throughout the network. These actors were not consistently in the same bridging positions in multiple years, however, so their positions in the 2012 and 2014 networks may have been a random event. Overall, an average degree centralization of 6.4% across all years is low, suggesting that power is distributed throughout the network. Various pathways are available to connect network actors and no one actor has disproportionate influence.

Finally, average degree centrality increased over time, beginning at 1.653 in 2010 and culminating in 2.601 in 2015. On average, then, network participants became more connected to each other over time. While an average of 2.6 connections is relatively low, it is an indication that the network became more cohesive over time.

In sum, stable network density despite an increase in network size, a decrease in the number of components, and an increase in average degree centrality all suggest that the IFQ quota leasing network has become more cohesive over time, potentially consolidating into a leasing market. However, power in the network, as measured by degree centralization, has not become monopolized by only a few actors.

4. IFQ Fleet Dealer Transaction Networks

Fishery management actions do not simply affect fishermen, but can also have cascading effects throughout the fishing industry. Given that fact, the final component of this project consisted of an analysis of the relationships between federally permitted seafood dealers and the IFQ fleet. In this case, the IFQ fleet was defined as vessels that held only an IFQ permit for sea scallops (i.e., were not dual permitted for scallops) in the given fishing year. However, not all vessels in these networks sold sea scallops, nor did all dealers in these networks purchase sea scallops from each IFQ vessel with which they interacted.

4.1 Data Processing

This analysis was conducted using a database of sales transactions between federally permitted seafood dealers and permitted vessels for the 2010-2015 fishing years, minus the final two months of the 2015 fishing year (January and February 2016). Fields in the sales database for each transaction included the date (month/year), vessel permit number, dealer number, species, landings, and value. Again, it is important to note that while all dealers in this analysis received landings of at least one species from IFQ vessels, they did *not* necessarily receive sea scallops from those vessels.

As in the IFQ share and quota transaction analysis discussed in Section 3 of this report, we believed that it was most informative to conduct this analysis using the business entities associated with permitted vessels, rather than the vessels themselves. This allows for a better understanding of the social and economic relationships between fishermen and dealers (remembering that many businesses have multiple permitted vessels and that those vessels can change ownership). By aggregating transfers at the business entity level, we get a better sense of the social and economic map created in response to the IFQ program. Dealer data was not aggregated in any way.

As in prior analyses, linking businesses entities to vessel permits involved significant effort. The first step consisted of matching the date of the sales transaction to the vessel permit owner *on that date*. This was done using a database of permit applications that contained the permit number, dates the permit was issued and canceled, and the business name and ID. This process resulted in exact matches for approximately half of the records; for the other half, the date of the transaction did not match with the time span of a permit for that vessel. This was further complicated by the fact that the dealer data is reported monthly, but permit ownership can and does change multiple times within a given month. Filling in missing data required manually searching for the permit numbers in the ownership database and using the most recent owner prior to the date of the dealer transaction, or making an educated guess when changes of ownership occurred within a month. For example, when permit ownership changed hands for only one day in a given month, and landings were reported in that same month, it was assumed that the one-day owner was the business entity that was conducting the fishing and completing the dealer transaction. Ultimately, of 57,913 sales transaction records between 2010-2015, only 646 records were filled in using questionable data, all of which were repetitions of the same 28 business entities. The networks generated from this analysis are therefore likely largely correct, but should still be viewed with some caution.

4.2 Dealer Transaction Networks

Figure 13 presents the two-mode dealer networks for select fishing years between 2010 and 2015. Dealers are represented by blue squares and business entities are represented by red diamonds. Edges indicate landings of at least one species (not necessarily sea scallops). Dealer nodes are sized by the pounds of sea scallop received in that fishing year, and those that received more than 50,000 pounds of sea scallops in that year (aka “key dealers”) are labeled with an ID number.

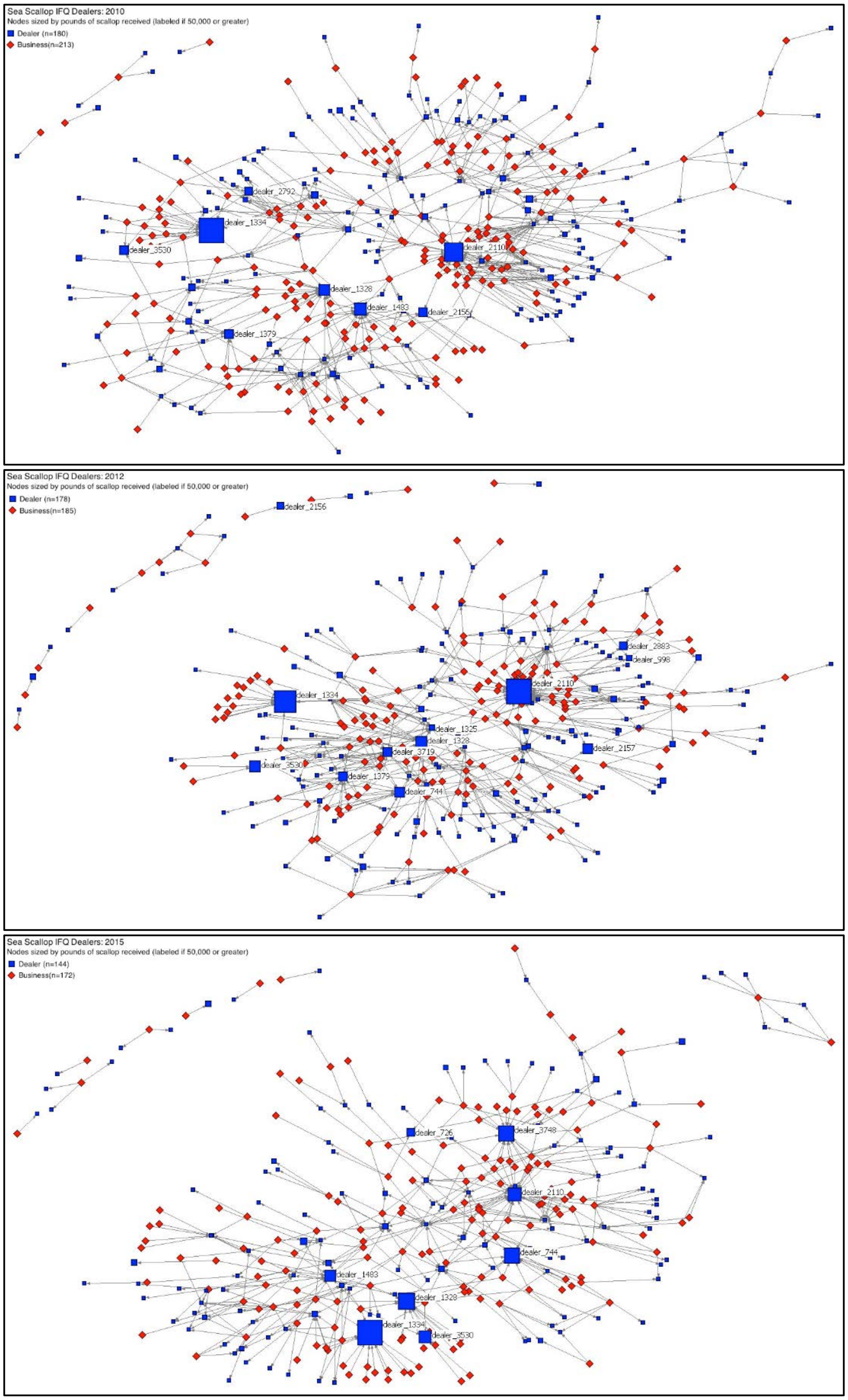


Figure 13: Sea scallop IFQ dealer networks for the 2010, 2012, and 2015 fishing years. Dealers are represented by blue squared, businesses entities are represented by red diamonds. Dealer nodes are

sized by pounds of sea scallop received in that fishing year. Dealers that received more than 50,000 lbs of sea scallops are labeled.

In interpreting these networks, four characteristics are notable. First, the networks are quite consolidated. Essentially all of the nodes are part of the main central component and there are very few peripheral sub-groups (only 5 in 2010, 10 in 2012, and 9 in 2015). Second, despite the high level of consolidation, the networks are extremely sparse. Network density is quite low; only 1-2% of all possible ties exist, indicating that fishing businesses tend to transact with a small number of dealers, and vice versa. Third, over the course of the IFQ program, the number of IFQ-associated businesses entities has decreased, as has the number of dealers receiving landings from them (Figure 14).

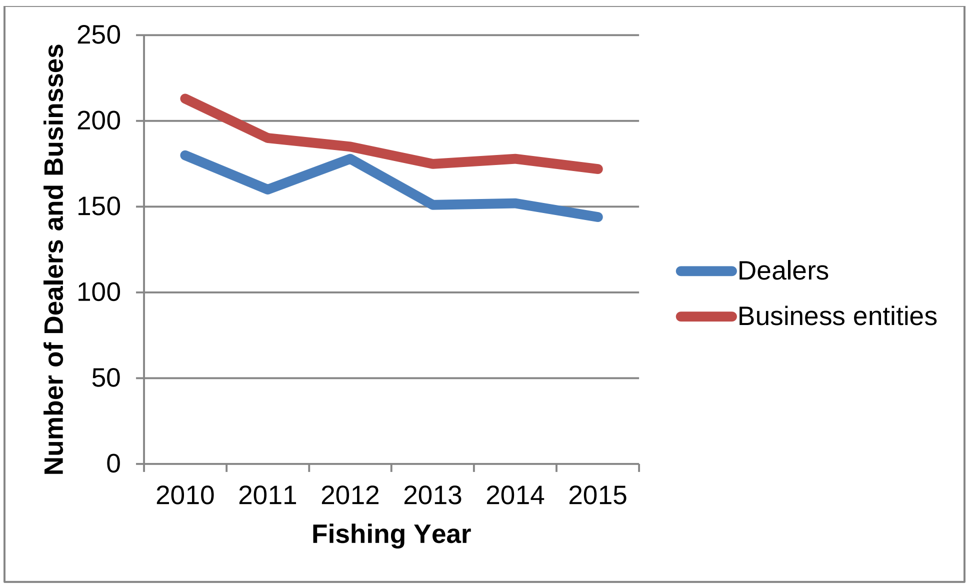


Figure 14: Number of dealers and businesses in the IFQ dealer network over time.

In addition, as in the IFQ share and lease transaction networks, a majority (68%) of participants in the dealer network interacted with each other in only one or two years (Figure 15). Longer-term relationships were more rare; only 10% of participants interacted in all six years of the program. It should be noted, however, that these seemingly short-term relationships could be an artifact of individual owners conducting business under different businesses entities from year to year with the same dealers.

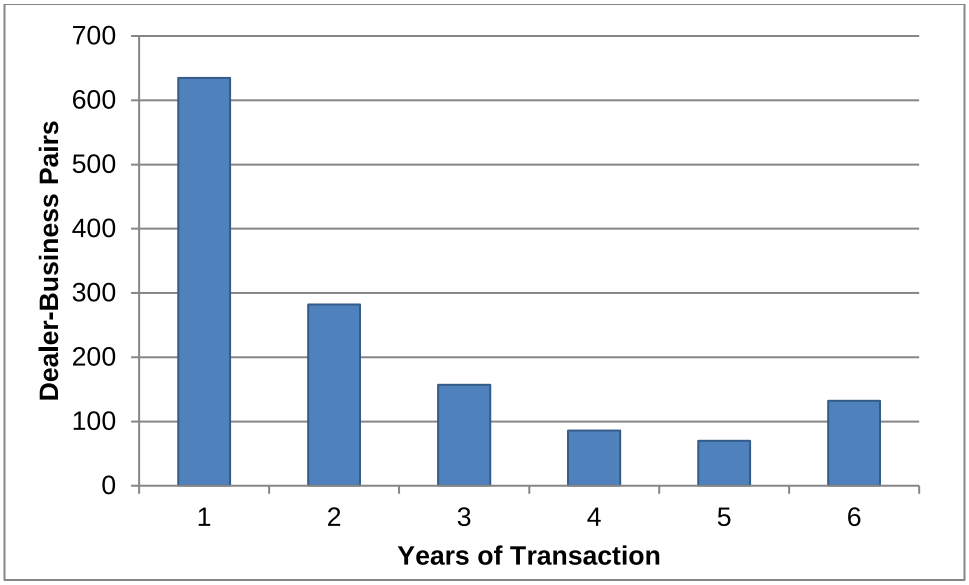


Figure 15: Number of dealers and businesses in the IFQ dealer network over time.

Finally, there is some consistency in a dealer's role as a "key dealer". Across all six fishing years, there were 19 dealers that received more than 50,000 lbs of sea scallops in at least one year. Of those, five (26%) achieved this status in two or fewer years, and 14 (74%) achieved this status in three or more years (Figure 16). In other words, the largest dealers have remained somewhat consistent over time, though new actors occasionally emerge.

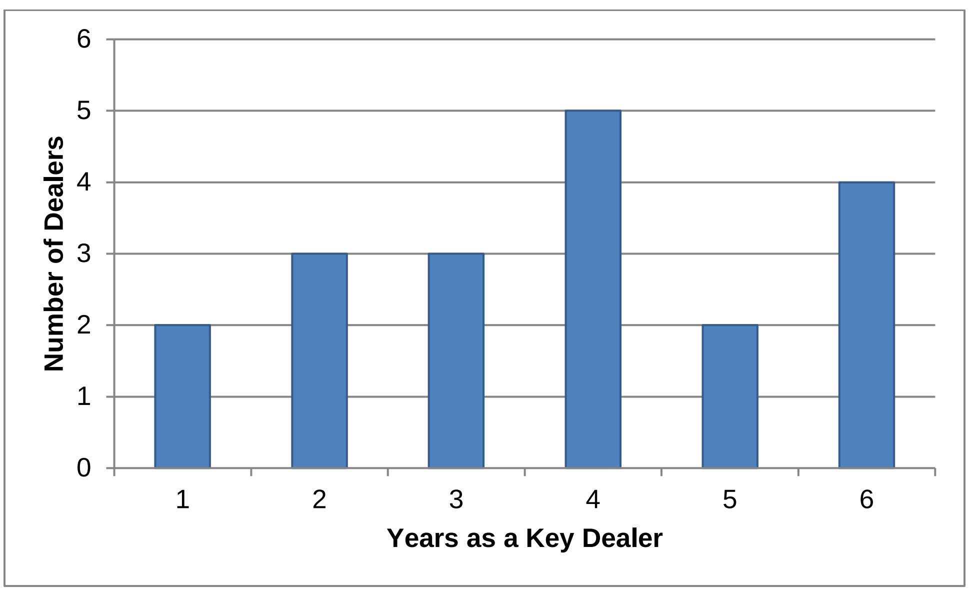


Figure 16: Number of years in which key dealers (i.e., those receiving more than 50,000 lbs of sea scallop in at least one fishing year) retained their status as key dealers.

7. Conclusions

Network analysis can be a useful tool for understanding the cumulative and longitudinal impacts of catch share programs. Visual representations of transaction networks can be extremely informative, allowing for the identification of patterns that may be difficult to see when transactional data are stored in a traditional database format. In addition, network analysis allows for a deeper understanding of the social environment created in response to shifts in natural resource management policies. What, then, can be said about the Atlantic Sea Scallop IFQ Program in the six years since its inception?

The IFQ program, similar to many catch share programs around the country, stimulated the formation of an active leasing market, in which participation is relatively consistent across years. The same cannot be said for the share market, which is much more limited in scope and in which participation is largely inconsistent. However, in both the lease and share transaction networks, very few relationships lasted more than a year or two, indicating that the relationships that form are likely economic in nature, perhaps driven by convenience, rather than new lasting social connections that might influence behavior in the future. The same seems to be true of seafood dealer-fisherman relationships. While the largest seafood dealers have retained their status since the beginning of the IFQ program, the relationships they form with fishermen largely seem to be short-lived.

The current project is the first attempt to use network analysis to evaluate long-term effects of the Atlantic Sea Scallop IFQ program, six years after its implementation. This report presents a summary of the activities conducted for this project. For more information, please contact Lisa Colburn (lisa.l.colburn@noaa.gov) or Gabriela Stocks (gabriela.stocks@gmail.com).

Glossary

Average degree centrality: The average number of nodes to which other nodes are connected.

Components: Portion of the network that are disconnected from each other; isolated sub-groups.

Degree centralization: A measure of the concentration of “power" in a network. A star network, in which one central actor is connected to all other actors but those other actors are not connected to each other, has a degree centralization of 1.0 or 100%.

Density: The number of existing ties as a proportion of the total number of possible ties.

Edge/Tie: A line indicating a relationship between network nodes.

Node: An actor in a network

APPENDIX K – TABLES AND FIGURES

Prepared by Dr. Demet Haksever, Council Staff

Table 22. Affiliations, permits and allocations

Fishyear	Values	Business entity	Permit Bank	Grand Total
2010	Number of affiliations	230	3	233
	Number of permits	309	22	331
	% share of allocations	90%	10%	100%
2011	Number of affiliations	214	4	218
	Number of permits	315	15	330
	% share of allocations	93%	7%	100%
2012	Number of affiliations	213	4	217
	Number of permits	301	16	317
	% share of allocations	92%	8%	100%
2013	Number of affiliations	216	4	220
	Number of permits	299	17	316
	% share of allocations	92%	8%	100%
2014	Number of affiliations	208	4	212
	Number of permits	300	16	316
	% share of allocations	92%	8%	100%
2015	Number of affiliations	188	4	192
	Number of permits	296	17	313
	% share of allocations	92%	8%	100%

Figure 11. Number of inactive affiliations by leasing activity

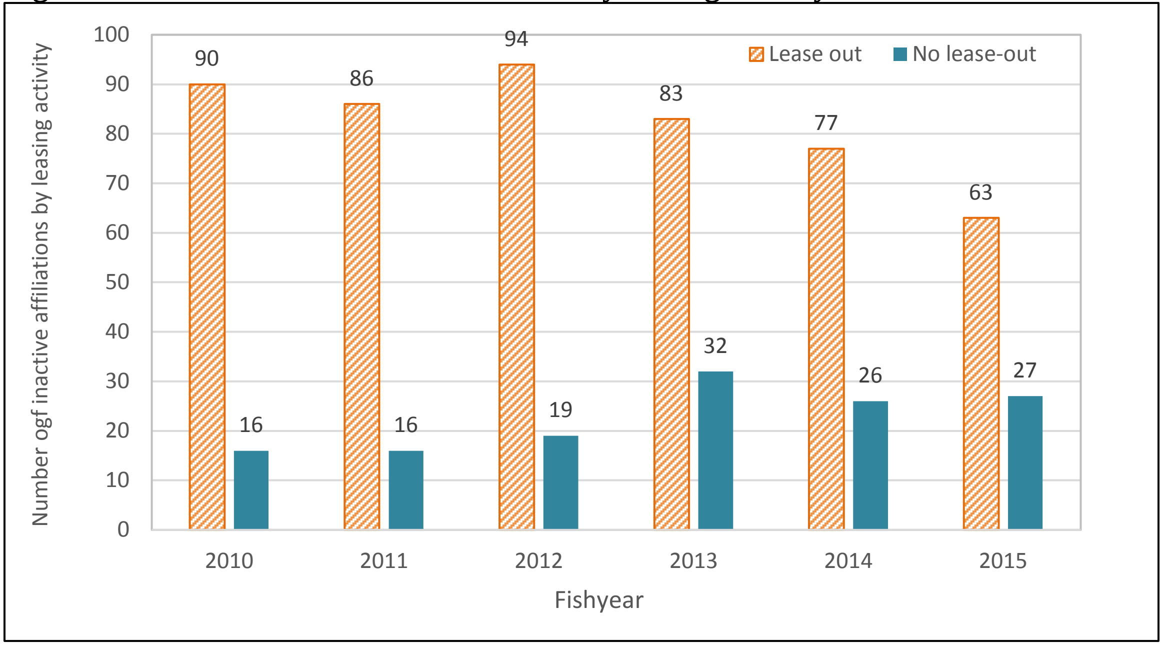


Table 23- DAS and access area allocations per full-time vessel

Year	Action	AA trips	CA1	CAII	NLS	HC	ETA	DMV
2010	FW21	4	Closed	Closed	1 trip	Closed	2 trips	1 trip
2011	FW22 and EA	4	1.5 trips	0.5 trips	Closed by emergency	1 trip	converted to open area	1 trip
2012	FW22 and EA	4	1 trip[13]	1 trip	0.5 trips	1.5 trips	Closed (Dec 12, 2012, by EA)	Closed by EA (trips converted to CA1)
2013	FW24	2	118 trips[14]	182 trips	116 trips	210 trips	Closed	Closed
2014	FW25	2	Closed	197 trips	116 trips	Closed	Closed	313 trips[15]
2015	FW26	3[16]		Closed	Closed	Merged into one MAAA, but inshore part of ETA closed		

[13] *1 trip after emergency action May 2012 (157 vessels get initial trip per FW22 and 156 get CA1 trip converted from initial DMV trip).*

[14] *FW25 then allows unused trips to be carried over to future year.*

[15] *Vessels given choice of Delmarva trip or 5 DAS.*

[16] *Vessels were not allocated trips in access areas, instead a poundage was allocated with a possession limit.*

APPENDIX J – OPPPORTUNITY COSTS OF CAPITAL

Prepared by Dr. Demet Haksever, Council Staff

As a first step in estimating opportunity costs of capital, scallop vessel values are estimated using 2011-2012 cost survey data. Because the data is available and only for a limited number of vessels, the estimations including some macro values such as interest rates or vessel characteristics other than length turned out to be statistically insignificant. For those reasons, values of vessels active in the scallop fishery are estimated as function of vessel length (LEN), crew size (CREW), and scallop revenue (SCREV) using a double logarithmic function including vessels with IFQ permits. The results show that those three variables (LEN, CREW and SCREV) explain about 80% of the variation in vessel values with statistically significant coefficients. The variations in the level of scallop revenue per vessel seems to have the largest influence, followed by length of vessels and crew size (Table 24).

The equation provided in Table 24 is used to estimate the values for each vessel operating in the fishery. In the next step, opportunity costs for the fleet were estimated using Moody's Seasoned Baa Corporate Bond Yield.

Table 24. Estimation of vessel values

The MODEL Procedure

Nonlinear GMM Summary of Residual Errors

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq	Durbin Watson
lnvesval	4	46	11.1107	0.2415	0.4915	0.8138	0.8017	2.0734

Nonlinear GMM Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|
INTERCEPT	2.035421	1.2991	1.57	0.1240
CREW	0.688399	0.2547	2.70	0.0096
LEN	2.043248	0.3625	5.64	<.0001
SCREV	0.189819	0.0250	7.58	<.0001

Number of Observations		Statistics for System	
Used	50	Objective	4.12E-26
Missing	3	Objective*N	2.06E-24

Opportunity costs of labor we estimated using average hourly earnings of production and nonsupervisory employees.