Contrasting Trends in the Northeast United States Groundfish and Scallop Processing Industries

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Funding: This research was funded in part by NOAA's Office of Science and Technology.

1. INTRODUCTION

Since the mid 1990s, landings from two major fisheries in the northeast United States, groundfish and sea scallops, have tracked in opposite direction. U.S. groundfish[i] landings declined from 34,000 metric tons (mt) in 1998 to 20,000 mt in 2015, continuing a long-term decline that began in 1983, when landings peaked at 186,000 mt (Figure 1). In 2014, ten of the 22 groundfish stocks were classified as overfished, while six were classified as experiencing overfishing (NOAA Fisheries 2015a). Due to statutory mandates to rebuild depleted stocks, groundfish landings are not likely to recover soon to 1980s highs or even 1990s levels.

In contrast to groundfish species, the higher priced sea scallops sharply increased from 6,000 mt in 1998 to 29,000 mt in 2004 (the record year for U.S. scallop landings) and remained near that peak, until declining in 2013 and 2014 (Figure 1). From 2006 through 2015, scallop landings in meat weight almost equaled groundfish landings in landed weight. Atlantic sea scallops are neither classified as overfished nor are experiencing overfishing (NOAA Fisheries 2015a).

[Figure 1 approximately here]

Substitutes abound for fillets produced from regionally landed groundfish including whitefish fillets produced from groundfish landed at U.S. Pacific ports, from Canada, fromNorthern Europe, from Australia, and from New Zealand, each of which currently exceeds U.S. Atlantic groundfish landings. In addition to these direct groundfish substitutes, Bronnmann

et al (2016) showed that farmed pangasius and tilapia has been integrated with the wildfish groundfish market to form a worldwide market for whitefish fillets.

While there are other species of scallops consumed in the U.S. (bay, calico, weathervane, and Hokkaido scallops), only Hokkaido scallops are a close substitute for Atlantic sea scallops in terms of size, color, taste and density. Landings of Hokkaido scallops in Japan from 2002 through 2012 were roughly 30% greater than landings of Atlantic sea scallop landings in the U.S. (FAO 2012), but have declined since then.

Since the commercial fishery began in the 19th Century, nearly all groundfish landed in northeastern U.S. ports were filleted and sold by fresh groundfish processors, mostly located in New England. These processors also filleted large quantities of whole groundfish imported from Canada until the Canadian cod fishery was closed in 1992 (Doeringer and Terkla 1995). While shucked at sea, almost all scallops landed in the U.S. were packaged and sold by fresh scallop processors, a set of firms that were distinct from the fresh groundfish processors.

This article examines the impact of changes in landing patterns on U.S. Atlantic groundfish and scallop processors using business strategies based on comparative advantages. Evidence is presented that processors adopted different strategies which depended on the market they wished to service. Groundfish processors diversified into highly competitive product markets to satisfy their customers, while scallop processors invested in marketing, activities that would increase future sales or prices, in response to sharply increasing regional landings.

Before presenting the methods used to examine both strategies, brief histories of U.S. Atlantic groundfish and scallop fisheries and management are presented. This is followed by the methods and data section. Findings are then discussed with a focus on processor adjustments to changing resource availability, followed by conclusions.

2. BRIEF HISTORIES OF U.S. ATLANTIC GROUNDFISH AND SCALLOP FISHERIES AND MANAGEMENT

With high local demand for fresh fish fillets from its Catholic population, Boston led all New England ports in processing groundfish with the opening of the Boston Fish Pier in 1914, then the world's largest (White 1954). Groundfish fillets were a basic commodity with processors competing fiercely on price (White 1954). Foreign factory ships, which could not land fish in the U.S., sharply increased their effort on Georges Bank and in the Gulf of Maine during the 1960s and early 1970s (Dewar 1983). Groundfish prices increased in the U.S. during this period due to reduced supply and shifts in consumer preferences toward low-cholesterol, low-calorie, nutritious food groups without much marketing investments by the fishing industry (Dewar 1983).

The increase in domestic groundfish landings following the Fishery Conservation and Management Act (FCMA) of 1976 was caused by the "Americanization" of the fleet in replacing foreign vessels. Standardized days fished with trawl gear in the Gulf of Maine, Georges Bank, and the Mid-Atlantic Bight nearly doubled to 48,000 days from 1976 to 1985, causing groundfish landings to peak in 1983 and then fall as decreases in catch per unit effort overwhelmed increases in fishing effort (NEFSC 1993).

In 1994, in response to a court ruling that required ending overfishing of the New England groundfish stocks, the management regime switched from output controls to effort controls systems using Days-at-Sea (DAS) designed to achieve annual target (soft) catch limits (NEFMC 1994). Due to compromises on allocations based on landings histories, the initial allocation of DAS was more than four times higher than the peak DAS fished, which failed to

constrain fishing mortality of some key stocks (NEFMC 1994). Subsequent management actions intended to reduce fishing mortality of specific diminished stocks reduced groundfish DAS, introduced differential values for DAS in specific areas frequented by diminished stocks, and added or changed output constraints (Hennessey and Healey 2000; Brodziak et al 2008). Also in 1994, management regulations closed three large areas off the coast of New England to groundfish trawls and scallop dredges (NEFMC 1998; Murawski et al 2000).

The DAS system, with these frequent adjustments, remained the primary method of controlling fishing mortality until 2010. In 2010, partially due to general dissatisfaction with the complex system of input controls and partially in response to 2007 revision in the FCMA that mandated hard quotas, fishery managers adopted a catch-share system in which groups of fishermen (sectors) were allocated shared quotas by species with transferability within and between sectors (NEFMC 2009). After a brief increase in landings in 2010 and 2011, groundfish landings resumed their general decline, although at a slower rate with hard quotas enforced by accountability measures.

From the beginning of the commercial fisheries in the 1930s, scallops were shucked on board, landed as meats in 40-pound cloth bags, and sold to processors, dealers, and wholesalers. Minimal on-shore processing occurred until the 1970s when some scallop vessel fleet owners built shore-side scallop processing plants, repackaging scallops to sell directly into wholesale and retail markets.

Scallop processors sorted some scallops by size in their plants because customers paid higher prices for larger scallops, but these price signals were not transmitted to fishing vessels. The original New Bedford scallop auction, which ran from 1941 until 1986, sold entire trips of

fish and scallops without reference to size category (Peterson and Georgianna 1988). Older scallopers taught shackers (trainees) the mantra, "Cut 'em all large & small, they pay the same for 'em all" (Captain Tony Alvernaz per. comm.).

From 1982 to 1994, the scallop management plan used a minimum meat-count to limit the catch of small scallops, enforced by random sampling of scallop bags (Hart and Rago 2006). In response to this regulation, scallopers separated their catch by size on deck, then mixed large and small scallops into the same bag. Although the meat-count standard was discontinued in favor of the DAS system in 1994, the custom of culling scallops by size continued in order to sell larger scallops at higher prices.

An ad-hoc program of access into previously closed areas began in 1999, which led in 2004 to a formal rotational program (NEFMC 2003). This program combined DAS in open areas with scheduled trips with fixed quotas in access parts in closed area, based on predicted gains in yield-per-recruit and unusually large year classes (O'Keefe and Stokesbury 2015; Hart 2003). Three areas were added in the Mid-Atlantic region to the rotational system. Scallop production increased rapidly in the closed areas (Hart and Rago 2006). By 2013, the biomass in Georges Bank and the Mid-Atlantic were, respectively, fourteen and seven times larger than the 1993 levels (NEFSC 2015). U.S. scallop landings increased from 5,600 mt in 1998 to 10,100 mt in 1999 (with 2,729 mt from the access area) and continued to increase to 29,000 mt in 2004 (with 2,415 mt from the access area). Scallop landings remained near that record peak until 2012 before declining in 2013 and 2014. (Figure 1).

The closed areas allowed scallops to grow to larger sizes, which could be cut in shorter time allowing more pounds shucked per day (given maximum crew size regulations), and the trip

quotas in access areas allowed more time to search for larger scallops. Landings of U10 and 10-20s increased from 25% of total landings in 1998 to 75% in 2005 (Hart and Rago 2006).

Valderrama and Anderson (2007) credited rotational management with increases in economic rent mostly due to price premiums for larger scallops, which they assumed were constant. Hart (2009) agrees that rotational area management improved scallop production and landings but questioned the previous authors' optimistic conclusion for higher rents by showing declines in price premiums following increased landings of large scallops.

3. METHODS AND DATA

According to Wernerfelt (1984), "a firm's resources at a given time could be defined as those (tangible and intangible) assets, which are tied semi-permanently to the firm." Unlike marketable assets such as physical capital, firm-specific resources are not easily sold to other firms and costly for other firms to duplicate, giving "resource position barriers" or comparative advantage to the initial or dominant holder of the resource (Wernerfelt 1984; Montgomery 1994). Barney (1986) notes that some of these resources, like corporate reputation, are "strategic factors," resources necessary to implement a strategy. Dierickx and Cool (1989) argue that corporate reputation is a strategic asset that is accumulated through investment in costly behavior by the firm. Other firm-specific intangible resources, which may return higher than normal profits, include favorable access to inputs, production experience, and customer loyalty.

Firms diversify in response to excess capacity in those intangible resources that experience declining availability or increasing costs by acquiring other resources that the firm needs (Montgomery and Wernerfelt 1988). A firm that diversifies into more competitive markets will earn lower returns than in its core business; with returns decreasing as it diversifies further

from its core business. A firm that diversifies into less competitive markets will earn higher returns than in its core business, encouraging that firm to invest in firm-specific assets to increase its competitive advantage.

Applying this theory, groundfish and scallop processing firms relied on firm-specific resources, such as access to product, product development and reputation for product delivery to maintain or increase profits. Intangible firm-specific resources to secure fish inputs included quasi-formal agreements with vessel owners to receive product. In order to sell fishery products, processors invested in marketing to secure firm-specific resources, including reputation and loyalty,

In-person interviews with firms in the processing and wholesaling industry were used to collect primary source data to examine these hypotheses. As usual, scheduling and completing interviews with processors proved extremely difficult. Eight fresh groundfish processors and five dealers and wholesalers in Massachusetts, which bought 9% of total landings from vessels, and nine scallop processors or wholesalers in Massachusetts or New Jersey, which bought 36% of total landings from vessels were formally interviewed. Information collected during these interviews were augmented with interviews with owners of the Whaling City Seafood Display Auction and the Cape Ann Seafood Exchange and in conversations with processors on the Boston Fish Pier and on the docks in New Bedford. One of the authors (Georgianna) attended the 9 AM Whaling City scallop auction (which sold 33% of domestic landings of Atlantic sea scallops in 2015) almost every day from June 2014 through March 2017 and occasionally attended the other auctions. Attending these auctions was an invaluable source of industry information on landings, prices, and markets. Most captains or boat owners attended the Whaling City Auction when their catch was sold. Buyers, who bid through the Whaling City's computer

system, or their representatives, inspected fish and scallops before the auctions and were occasionally in the auction room when fish or scallops were auctioned.

The interview data are supplemented with data on landings and prices from NOAA dealer databases by species and size categories, including scallops by size categories that began in 1998 and data on imports and exports (excluding re-exports) on finfish and scallops from U.S. Census trade databases (NOAA Fisheries 2015b). Unfortunately, no data were available on movement of fish within different regions of the United States, such as Pacific cod shipped from Alaska to the Northeast U.S. The Whaling City Auction provided annual data on scallop sales by size category and area from 2001 (the first year of the scallop auction) through 2016.

The NMFS dealer data were used to construct Bennet Indicators to provide insight into how changes in landings and prices have affected fishery value over time (Bennet 1920). An attractive feature of the Bennet Indicator is that the overall indicator is equal to the sum of its subcomponents. This allows for a decomposition of the Bennet Indicator to understand whether value changes are driven by changes in harvest levels, the mix of sizes or species landed, or by changes in prices. For example, a change in the output mix of a fleet (for example, a relative shift from cod to Acadian redfish) would cause value to change without any price changes because the outputs command different prices. A brief overview of the Bennet Indicator is provided here.

The total value of output of an industry producing *j* products at time *t* is equal to the sum of all value of all products:

	$$\mathrm{TV} = \sum_{\mathrm{j}=1}^{\mathrm{J}} p_j^t y_j^t$$	(1)

Value change between any two time periods, say *t* and a base-year 0, is then $TV^t - TV^0$, which can also be expressed as:

$$\Delta TV = \sum_{j=1}^{J} p_j^t y_j^t - \sum_{j=1}^{J} p_j^0 y_j^0 \quad (2)$$

This change can further be decomposed into a volume change component, hereafter called a volume indicator (VI) and a price change component, also called a price indicator (PI). The volume indicator is calculated using the following formula (Moosberg, Färe, Grosskopf and Roos 2007):

$$VI = \frac{1}{2}\left(\sum_{j=1}^{J} p_j^t y_j^t - \sum_{j=1}^{J} p_j^t y_j^0 + \sum_{j=1}^{J} p_j^0 y_j^t - \sum_{j=1}^{J} p_j^0 y_j^0\right) \quad (3)$$

The price indicator (PI) is calculated as follows:

$$PI = \frac{1}{2}\left(\sum_{j=1}^{J} p_j^t y_j^t - \sum_{j=1}^{J} p_j^0 y_j^t + \sum_{j=1}^{J} p_j^t y_j^0 - \sum_{j=1}^{J} p_j^0 y_j^0\right) \quad (4)$$

Total value change between time 0 and time *t* is the sum of the VI and PI. Because the indicator is additive, changes for each individual product category can be examined separately in both the VI and PI. For example, changes in scallop value can be examined through the volume and price indicator for each size class. The sum of all VI and PI measures at the size class level will equal value change.

4. DISCUSSION

4.1 Groundfish Processors' Adjustments to Declines in Regional Landings.

As the value of their advantage to local landings eroded, the larger Boston processors interviewed reported selling hundreds of fish products, including Atlantic and Pacific groundfish fillets, other fillets, scallops, clams, lobsters, other shellfish, swordfish, tuna, and other pelagic species, essentially selling any fishery product their customers were willing to buy. This diversification into new input and output markets were likely associated with lower profit margins than activity in "core" groundfish processing activities due to buying inputs and selling outputs in more competitive markets. However, redeploying excess firm-specific capital (like reputation and sales networks) was more attractive than the alternative: going out of business.

Major changes have occurred in the way these firms operate. Groundfish processors previously focused on filleting and selling fresh groundfish fillets; salesmen would spend most of their day telephoning customers to drum up business. As groundfish landings declined, their focus broadened to search the world for seafood products to satisfy these customers. Investing in favorable access to new sources of supply, both domestic and international, and in marketing gave some processors new sources of profitability. Some of the groundfish processors interviewed have been expanding. Stavis Seafood, a Boston based processor since 1929, currently sells 1,100 products from 50 countries. Stavis Seafood opened a sales office in Miami in 2004, upgraded its processing facility and sales branch there, and announced plans to add a 40,000-square foot facility for frozen seafood products north of Boston in 2017 (www.stavis.com/recent-news/news-press/stavis-seafoods-open-additional-facility-peabody-massachusetts 2017).

Fresh fillet imports into the U.S. from wild fish and farmed fish increased from 56,000 mt in 1998 to 161,000 mt in 2014. Fresh fillets, which are imported from very competitive markets,

offered U.S. groundfish processors less expensive products to sell their customers than locally landed groundfish fillets but also heightened sales competition with brokers and wholesalers who were licensed to import fishery products (Bronnmann et al 2016).

The retail grocery landscape has changed dramatically over the past 20 years, as "one-stop" supercenters that held down prices grew more prevalent (Little 2004; Hausman and Leibtag 2007, 2009). Supermarkets offered customers specific fishery products at prices that were guaranteed in advertising circulars and web pages. Therefore, formal and informal agreements between supermarkets and processors became quite detailed, specifying quantities of products by species, prices, and dates of delivery. Supermarkets gained bargaining power over groundfish processors with declines in retail fish markets that had been groundfish processors' major customers. Supermarket chains also placed large orders, which gave them additional bargaining power given competition between the wide array of wholesalers that supermarkets could buy from. Smaller scale customers, such as restaurants, also wanted a wider array of products on demand from reliable wholesalers and food service suppliers. Groundfish processors and wholesalers reported that they sometimes sold products at losses to keep customers, consistent with Dierickx and Cool's (1989) idea that customer lists and reputations for rapid delivery and quality are capital assets requiring costly investments over time.

Interviews with processors on the Boston Fish Pier showed that small scale groundfish processors in Boston focused on restaurants. At least two New Bedford groundfish processors diversified into the restaurant business, and at least one restaurant chain (Legal Seafoods) diversified into processing and wholesaling, with a large-scale processing plant on Seafood Way, near the Boston Fish Pier, which supplied their restaurants and sold branded product to other wholesalers and retailers.

These results correspond with and extend earlier studies (Doeringer and Terkla 1995; Georgianna and Dirlam 1994) that found that those groundfish processors who survived declining local groundfish landings adjusted through some combination of finding other sources of whole groundfish to fillet, especially Pacific cod, expanding their product line by wholesaling fishery products and selling to niche markets, and investing in expanding their customer base.

Given declining availability of groundfish landings, ex-vessel value could only increase if prices increased more in percentage terms than landings declined. In order to construct the Bennet indicator, along with the corresponding VI and PI, landings and value between 1998 and 2015 were aggregated into three categories: cod and haddock (i.e. primary roundfish), flatfish and other groundfish species. Prices were then calculated implicitly, by dividing total value by total landings in each category. The VI, PI and overall Bennet indicator were constructed using 2002 as the base year, making all changes relative to 2002 levels (Table 1). This was done to be consistent with the methods used to calculate the indicators for scallops. Results are reported in millions of U.S. dollars with all prices deflated to 2009 levels using the GDP implicit price deflator.

[TABLE 1 APPROXIMATELY HERE]

Because 2002 was the year of highest groundfish value, the overall Bennet indicator was negative for all years. The decomposition into VI and PI reveals that these decreases in value were usually caused by lower volumes, rather than lower prices. In only one year (2001) was there a positive VI meaning that declining volume was usually a negative influence on value growth. Prices contributed positively to value change in all but four years (2001, 2003, 2004 and

2009). The generally positive contribution of prices was expected given the decline in landings since processors would respond by bidding up prices in order to keep their individual plants operating. Alternatively, processors could also substitute fish imported into the region from other regions, or nations. In the case of groundfish, imports may have limited upward pressure on prices.

Decomposing the VI and PI further into species groups yields further insight into this industry. With the exception of 2000 and 2001, flatfish negatively contributed to the VI, while roundfish were negative throughout the entire time series (Table 1). This means that in most years, decreases in landed quantities of these two categories were contributors to value decreases in this fishery. Quantities are all in relation to the year 2002, and the large value of the volume indicator particularly in later years in the time series shows a significant deterioration in the volumes of flatfish and roundfish. In comparison, the "other groundfish" category contributed positively to the VI, although the quantities were not enough to overcome the negatives from the other two categories. The PI showed positive trends for flatfish and roundfish through most years in the series, while the other groundfish showed a negative trend. Thus, in relation to 2002, increasing prices contributed to positive value gain in most years. However, as stated previously, these gains were not enough to overcome the negative volumes that occurred during the time series.

4.2 Scallop Processors Adjustments to Increases in Atlantic Sea Scallop Landings.

The rapid increase in scallop landings delivered both more scallops for processors to sell and a new product, large scallops, rarely seen before by customers. Restaurant diners were used

to seeing 10-15 small scallops on their plates at lower tier restaurants or 5 to 10 larger scallops, at higher-class ("white table"), restaurants. Processors and wholesalers had to convince restaurants and the food service industry that their customers would accept 3 to 5 scallops on a plate as fine dining. Simply cutting scallops in half was not profitable, because consumers had always preferred whole scallops.

In 1998, U.S. scallopers landed only 92 mt of U10 scallops (fewer than 10 meats per pound). In 1999, landings of U10s increased to 1,676 mt, almost all from the newly opened access area and continued to rise to 6,640 mt in 2007. The Whaling City Auction began selling all scallops by size category in 2001, including a new size category: U12 (between 10 and 12 scallop meats per pound). Their business strategy proved successful. The percentage of total U.S. scallop landings sold by the Auction increased from 4% in 2001 to 33% in 2015 with the Auction size categories standard in the fishery.

Scallop processors and wholesalers had to find new customers to buy the increase in scallop landings, especially the glut in large scallops. Processors interviewed reported exporting more scallop meats, a claim supported by U.S. trade data. The pattern in total exported scallop meats mirrors the increase in U.S. landings, but data by size categories and by firms selling exports were not available. Exports of scallop meats to Western Europe increased from 500 mt in 1998 to 8,500 mt in 2009 before gradually falling back to 4,100 mt in 2015.

The fishery business press and Internet reports showed investments by the large scallop processors in exports. Eastern Fisheries, the largest U.S. scallop processor, created a new subsidiary 2015 in the Netherlands, Eastern Fisheries Europe, which gave Eastern direct access to European markets (www.undercurrentnews.com/2014/07/16/eastern-fisheries-buys-into-one-of-japans-largest-scallop-exporters 2017). Atlantic Capes, another large-scale scallop vessel

owner and processor has also bought scallop processing and wholesaling plants in Europe (www.undercurrentnews.com/2015/04/17/atlantic-capes-buys-uk-based-scallop-supplier/ 2017).

Scallop processors also reported selling more high quality frozen product, especially Individually Quick Frozen (IQF) product. Sold with a glaze covering, this product was ideal for restaurants that wanted to maintain portion control and reduce waste of these high-priced inputs. Eastern Fisheries reported 110,000 square feet of processing and freezing space, capable of producing 6,500 pounds IQF scallops per hour (www.easternfisheries.com/eastern-fisheries-inc-boosts-productivity-quality-new-iqf-processing-line/ 2017). With the exception of 2013 and 2014, trade data show increases in exports of frozen scallops to France, Belgium and the Netherlands, the main importers of U.S. scallop products.

In contrast to the large increase in fresh fillets, fresh and frozen scallop imports into the U.S. remained roughly constant at an annual average of 24,000 mt between 1998 and 2015 Imports fell into two categories; one-third were larger Canadian Atlantic and Hokkaido scallops from Japan, close substitutes for American scallops and two-thirds were smaller bay scallops. Prices of Canadian imported scallops roughly equaled U.S. exvessel prices for U10, while Hokkaido scallops imported from Japan roughly equaled U.S. exvessel prices for 10-20s and 20-30s. Neither quantity nor price data for imported Hokkaido scallops from China were available.

Scallop processors reported from 10% to 30% of their scallop production was imported, all Canadian Atlantic or Hokkaido scallops. U.S. processors have long imported fresh scallop meats from Canada (Edwards 2002), and many of the processors that bought at the Whaling City Auction reported increasing their imports of frozen Hokkaido scallop meats for processing and sale. Import data support these reports, but as with exports, imports by firms were not available. Imported scallops from Japan have increased since 2007, except in 2011 after the meltdown at

the Fukushima Daiichi reactor, while scallop imports from Canada declined. Hokkaido scallops typically do not grow to the larger sizes, leaving little competition for U.S. and Canada scallop processors in the world market for U10s and U12s.

Frozen bay scallops from China, Argentina, Peru, and other countries were imported into the U.S., averaging about 1/3rd of prices for Hokkaido scallops from Japan over this period. These small scallops bypassed the U.S. scallop processing network and were sold directly by importers to supermarkets, all-purpose superstores, and other lower priced retailers.

There is some qualitative evidence in fishery business websites and Internet reports that the larger scallop processors expanded their access to scallops by investing in imports. Eastern Fisheries, owns scallop farms in Japan and two processing plants in China, which produces Hokkaido sea scallops transplanted from Japan. It has also recently bought a minority share in Japan's largest scallop exporter (www.undercurrentnews.com/2016/04/04/eastern-fisheries-growth-strategy-about-being-on-the-ground-in-europe-japan/ 2017).

Most scallop processors mitigated the risk of buying scallops at higher prices than their competitors through owning and buying additional scallop vessels. These vertically integrated firms profited at either or both ex-vessel and wholesale level with rising prices. Landings in surplus of their customers' orders could be sold to other processors through the Whaling City Auction. These firms, usually divided into vessel, processing, and sales divisions, both bought and sold scallops at the Auction, often on the same day, to match size category to customer orders, according to the largest scale buyer and seller at the Auction.

The Bennet Indicator was used to explore how the scallop fishery value changed between 1998 and 2015 (Table 2). Total value and value change for the years 1998-2015 were calculated using price and quantity data from four different size categories of scallop landings in ranges of

scallop meats per pound (U10, 11-20, 21-30, and >30). Value change and the calculated VI and PI use 2002 as the base year[ii]. Before 2002, value change was negative while after 2002 there was positive value change with a peak change of $325.6 million in 2011 followed by declining but still positive change from 2012-2014. Examination of the VI shows a negative, but increasing VI prior to 2002; indicating an increase in landed volume. After 2002, the VI was positive until 2013, when it became negative. The PI was positive for all years except 2001, with a peak PI of $283.8 million in 2014. The large PI in the year 2013-2015 more than offset the negative VI in these years with the result that overall value change was positive relative to 2002 levels.

[Table 2 approximately here]

Decomposition of the VI by individual size category reveal that increases in the VI after 2002 were driven exclusively by increases in the U10 and 11-20 categories (Table 2). In other words, compared to 2002, the volumes of the largest two size classes were positively contributing to value change. From 2004 onward, the VI was being negatively impacted by declining volumes in the 21-30 category and the >30 category. During the last three years of the time series (2013-2015) when the VI was negative, volumes in these two size categories declined enough to offset increases in the two large size categories. Increasing volumes in the two larger size classes after 2004 indicate a shift to the larger size classes.

Compared to the VI, the PI showed positive contributions to value change from all four size categories in each year, with the exception of 2001 (Table 2). The positive price contribution for the two smallest size classes is consistent with a classic explanation of declining supply, seen in the decreasing VI, and increasing price. However, for the two largest size classes, the PI is

increasing throughout the time series, as is the VI. Increasing real prices, along with increasing quantities indicate increasing demand. While the increasing volumes of the two large size classes are an outcome of the management strategy, increasing prices as shown by the PI could be coherently explained by investment in marketing and product channels for larger scallops leading to higher prices. Without those channels, prices might have declined if the markets could not absorb the increased volumes from the two large size categories.

6. CONCLUSION

Interviews and Bennet indicators support the hypothesis that groundfish processors substituted other sources of supply from more competitive markets to satisfy their customers, rather than bid up exvessel prices for regional groundfish landings. Similar data for scallops support the hypothesis that scallop processors invested in marketing new products and new markets, especially for larger scallops, when scallop landings increased, which caused increases in exvessel prices. These results support Valderrama and Anderson (2007) conclusion that rotational management increased economic rents in the scallop fishery.

U.S. scallop management regulations contributed to these results. Rotational area management for scallops led to increases in biomass and landings, especially of larger scallops, improving the U.S. and Canadian comparative advantage in large scallops. In some cases, the success of scallop management was serendipitous. For example, the meat-count standards of the early 1990s, widely seen as a failure, encouraged scallopers to separate catch by size. Closures of large fishing areas in 1994 were intended to rebuild depleted groundfish stocks rather than increase scallop productivity (Hart and Rago 2006).

U.S. management for groundfish has not been as successful: 10 of New England's 22 groundfish stocks are overfished, and legal requirements to rebuild stocks to MSY affect quotas for these species. Recently, the annual catch limits for individual stocks of groundfish have varied widely from year-to-year, which makes business planning difficult for both fishermen and processors.

ACKNOWLEDGEMENTS

The authors thank interviewers Captain Alan Cass and Sharon Challingsworth and the processing firm owners and managers who agreed to be interviewed. We also thank Captain Cass, Susan Inglis, Tammy Murphy, Julia Olson, Patricia Pinto da Silva, Kevin Stokesbury, Eric Thunberg, and anonymous reviewers for their comments. All remaining errors are those of the authors. The scientific results and conclusions, as well as any views or opinions expressed herein, are those of the authors and do not necessarily reflect those of NOAA or the Department of Commerce.

This research was funded partially by National Marine Fishery Service Office of Science and Technology.

REFERENCES.

Barney, J. B. 1986. “Strategic Factor Markets: Expectations, Luck, and Business Strategy.” Management Science 32(10): 1231-1241.

Bennet, T.L. 1920. The Theory of Measurement of Changes in Cost of Living. Journal of the Royal Statistical Society, 82(3):455-462.

Brodziak, J., S.X. Cadrin, C.M. Legault, & S.A. Murawski. 2008. “Goals and strategies for rebuilding New England groundfish stocks.” Fisheries Research. 94(3):355-366.

Bronnmann, J., I. Ankamah-Yeboah, and M. Nielsen. (2016). Market integration between farmed and wild fish: Evidence from the Whitefish market in Germany. Marine Resource Economics, 31(4): 421-432.

Dierickx, I. and K. Cool. 1989. “Asset Stock Accumulation and Sustainability of Competitive Advantage.” Management Science, 35(12): 1504-1511

Dewar, M.E. 1983. Industry in Trouble: The Federal Government and the New England Fisheries. Philadelphia: Temple Univ. Press.

Doeringer, P.B. and D.G. Terkla. 1995. Troubled Waters: Economic Structure, Regulatory Reform, and Fisheries Trade. Toronto: Univ of Toronto Press.

Edwards, S. 2002. Rent-Seeking and Property Rights Formation in the U.S. Atlantic Sea Scallop Fishery. Marine Resource Economics, 16: 263–275.

FAO 2012. Fishery and Aquaculture Statistics. Capture Production. ftp://ftp.fao.org/FI/CDrom/CD_yearbook_2012/navigation/index_content_capture_e.htm#D

Georgianna, D., and J. Dirlam. 1994. “Recent Adjustments in New England Atlantic Groundfish Processing.” Marine Resource Economics 9:375-84.

Hart, D.R. and P.J. Rago. 2006. Long-term dynamics of U.S. Atlantic Sea Scallop Placopecten Magellanicus populations. North American Journal of Fisheries Management, 26:490–501. DOI: 10.1577/M04-116.1

Hart, D.R. 2003. "Yield and Biomass-Per-Recruit Analysis for Rotational Fisheries, with an Application to the Atlantic Sea Scallop (Placopecten Magellanicus)." Fishery Bulletin 101:44–57.

Hart, D. R. 2009. ‘‘Improving Utilization of the Atlantic Sea Scallop Resource: An Analysis of Rotational Management of Fishing Grounds: Comment.’’ Land Economics 85 (2): 378–382

Hennessey, T., and M. Healey. 2000. “Ludwig's Ratchet and the Collapse of New England Groundfish Stocks.” Coastal Management 28(3): 187-213.

Hausman, J. and E. Leibtag. 2007. “Consumer Benefits from Increased Competition in Shopping Outlets: Measuring the Effect of Wal-Mart.” Journal of Applied Econometrics, 22:1157-1177.

Hausman, J. and E. Leibtag. 2009. “CPI Bias from Supercenters: Does the BLS Know that Wal-Mart Exists?” In Price Index Concepts and Measurement, ed. W.E. Diewert, J.S. Greenlees, C.R. Hulten, 203-231. Chicago, IL: University of Chicago Press.

Little, P. 2004. “Channel Blurring Redefines the Grocery Market.” Competitive Edge. June: 34

Magnuson-Stevens Fishery Conservation and Management Act as Amended Through January 12, 2007, Public Law 94-265, U.S. Department of Commerce.

Montgomery, C.A., 1994. “Corporate Diversification.” Journal of Economic Perspectives, 8: 163-178.

Montgomery, C.A. and B. Wernerfelt. 1988. “Diversification, Ricardian Rents, and Tobin's q.” *The RAND Journal of Economics* 19: 623-632.

Moosberg, H. J., R. Färe, S. Grosskopf, and P. Roos. 2007. Volume and Price Indicators: Decomposition and revenue with an application to Swedish pharmacies. 8 p. Department of Economics. Oregon State Univ., Corvallis, Oregon.

Murawski, S.A., R. Brown, H.-L. Lai, P. J. Rago, and L. Hendrickson. 2000. "Large-Scale Closed Areas as a Fishery-Management Tool in Temperate Marine Systems: The Georges Bank Experience." Bulletin of Marine Science, 66: 775–798.

New England Fishery Management Council (NEFMC). 1994. Amendment 5 to the Northeast Multispecies Fishery Management Plan. NEFMC, Newburyport, MA.

--. 1998. Final Amendment for Essential Fish Habitat incorporating the Environmental Assessment Volume I. NEFMC, Newburyport, MA.

--. 2003. Amendment 10 to the Atlantic Sea Scallop Fishery Management Plan. NEFMC, Newburyport, MA.

--. 2009. Final Amendment 16 to the Northeast Multispecies Fishery Management Plan including a Final Supplemental Environmental Impact Statement and an Initial Regulatory Flexibility Analysis. NEFMC, Newburyport, MA.

Northeast Fisheries Science Center (NEFSC). 1993. Status of Fishery Resources off the Northeastern United States for 1993. US Department of Commerce, Northeast Fisheries Center Technical Memo TM F/NEC 101. National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026

--. 2015. 60th Northeast Regional Stock Assessment Workshop (60th SAW) Assessment Report. U.S. Department of Commerce, Northeast Fisheries Science Center Reference Document. 15-08; 870 p. National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026

NOAA Fisheries. 2015a. “Status of Stocks 2014.” Annual Report to Congress on the Status of U.S. Fisheries.

--. Office of Science and Technology. 2015b, Commercial Fishery Statistics, Foreign Trade. http://www.st.nmfs.noaa.gov/commercial-fisheries/foreign-trade/applications/annual-product-by-countryassociation 2017

O’Keefe, C.E., and K.D.E. Stokesbury. 2015 Best Practices in Fisheries Management: US Sea Scallop Fishery. In Successful Fisheries Case Studies. Eds. R. Hilborn. FAO. Rome.

Peterson S. and D. Georgianna. 1988. “New Bedford's Fish Auction: A Study in Auction Method and Market Power.” Human Organization 47: 235-241

Valderrama, D. and J.L. Anderson, 2007. “Improving Utilization of the Atlantic Sea Scallop Resource: An Analysis of Rotational Management of Fishing Grounds,” Land Economics 83(1):86–103.

Wernerfelt, B. 1984. “A Resource-Based View of the Firm.” Strategic Management Journal 5:171-80.

White, D.J. 1954. The New England Fishing Industry. Cambridge: Harvard Univ. Press.

[i] Throughout the manuscript, "groundfish" is used to denote the set of Atlantic groundfish frequently landed in the Northeast United States: American plaice (*Hippoglossoides platessoides*), cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), pollock (*Pollachius virens*), Acadian redfish (*Sebastes fasciatus*), white hake (*Urophycis tenuis*), windowpane flounder (*Scophthalmus aquosus*), winter flounder (*Pseudopleuronectes americanus*), witch flounder (*Glyptocephalus cynoglossus*), and yellowtail flounder (*Limanda ferruginea*).

[ii] 2002 was selected for the base year because a few of the early years in the time-series have moderate amounts of "un-classified" size scallop that are reported. By setting the base year to 2002, this allows us to capture changes in sizes over time; using an earlier time period for a base year would include both a "classification" effect and these changes in sizes.

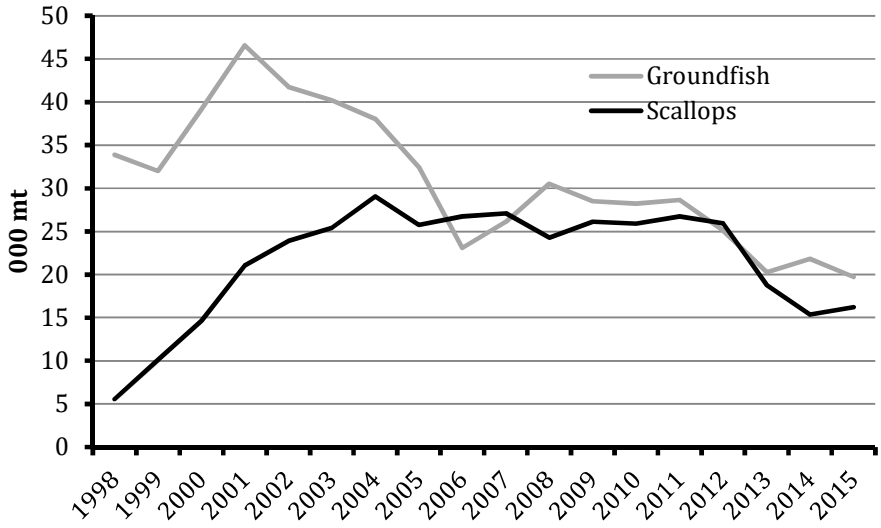
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Table 1. Bennet Indicator and related decompositions for groundfish in millions of US$

Year	Value	Bennet Indicator	Volume Indicator (VI)	Price Indicator (PI)		VI components				PI components		
						Round	Flat	Other		Round	Flat	Other
1998	$112.63	-$11.26	-$28.26	$17.00		-$20.06	-$10.51	$2.31		$3.88	$13.07	$0.05
1999	$107.11	-$16.78	-$33.90	$17.11		-$24.00	-$10.83	$0.93		$6.80	$8.05	$2.27
2000	$114.79	-$9.10	-$10.26	$1.16		-$15.72	$5.12	$0.35		$3.63	-$2.56	$0.09
2001	$123.70	-$0.20	$12.61	-$12.81		$0.59	$10.75	$1.27		-$3.41	-$7.38	-$2.01
2002	$123.89	Not Applicable										
2003	$112.16	-$11.73	-$7.76	-$3.97		-$9.00	-$2.39	$3.64		$1.86	-$1.01	-$4.82
2004	$98.63	-$25.26	-$13.87	-$11.39		-$14.21	-$2.73	$3.07		$0.96	-$8.05	-$4.30
2005	$95.70	-$28.20	-$32.95	$4.75		-$19.62	-$18.09	$4.77		$4.79	$3.24	-$3.29
2006	$80.90	-$42.99	-$71.39	$28.40		-$37.82	-$36.39	$2.81		$13.23	$17.74	-$2.57
2007	$84.24	-$39.65	-$64.10	$24.45		-$29.67	-$40.93	$6.51		$11.65	$18.74	-$5.94
2008	$88.95	-$34.94	-$47.01	$12.06		-$16.33	-$40.25	$9.57		$5.46	$13.09	-$6.49
2009	$74.95	-$48.95	-$45.59	-$3.36		-$15.77	-$36.45	$6.63		-$3.82	$5.15	-$4.69
2010	$83.93	-$39.96	-$46.48	$6.51		-$7.27	-$42.60	$3.39		-$1.95	$9.67	-$1.20
2011	$87.98	-$35.91	-$48.05	$12.14		-$21.52	-$36.03	$9.49		$10.41	$4.21	-$2.49
2012	$77.91	-$45.98	-$69.27	$23.29		-$48.70	-$33.26	$12.70		$18.57	$6.19	-$1.47
2013	$58.58	-$65.31	-$79.19	$13.88		-$53.64	-$33.70	$8.15		$10.49	$4.06	-$0.67
2014	$58.87	-$65.02	-$67.98	$2.96		-$37.93	-$38.69	$8.63		-$1.49	$5.99	-$1.54
2015	$51.99	-$71.90	-$73.75	$1.85		-$36.17	-$43.59	$6.00		-$4.77	$8.82	-$2.19

Table 2. Bennet Indicator and related decompositions for scallops in millions of US$

Year	Value	Bennet Indicator	Volume Indicator (VI)	Price Indicator (PI)		VI components					PI components			
						U10	11-20	21-30	>30		U10	11-20	21-30	>30
1998	$96.37	-$141.43	-$255.16	$113.73		-$17.65	-$36.46	-$195.65	-$5.39		$3.17	$18.23	$69.73	$22.61
1999	$153.26	-$84.54	-$173.16	$88.62		$8.10	-$31.26	-$162.49	$12.49		$3.02	$15.06	$54.25	$16.29
2000	$196.85	-$40.95	-$103.10	$62.15		-$1.25	-$10.02	-$101.11	$9.27		$4.66	$12.39	$33.53	$11.57
2001	$206.06	-$31.74	-$27.41	-$4.33		-$7.04	$15.35	-$48.59	$12.87		$1.00	-$1.29	-$2.17	-$1.88
2002	$237.80	Not Applicable												
2003	$264.36	$26.56	$17.54	$9.02		$6.19	$19.51	-$12.45	$4.28		-$2.65	-$0.05	$11.35	$0.38
2004	$358.14	$120.34	$63.66	$56.68		$14.28	$96.41	-$36.20	-$10.83		$0.62	$16.85	$32.96	$6.25
2005	$471.36	$233.56	$36.64	$196.93		$35.32	$160.55	-$141.69	-$17.53		$10.04	$74.03	$90.11	$22.74
2006	$405.10	$167.30	$43.06	$124.24		$68.26	$129.42	-$138.44	-$16.18		-$1.67	$44.67	$67.03	$14.21
2007	$405.09	$167.28	$59.55	$107.74		$81.58	$132.54	-$145.69	-$8.88		$5.07	$41.07	$48.14	$13.46
2008	$374.08	$136.28	$21.47	$114.81		$67.82	$120.10	-$136.66	-$29.79		$5.89	$41.72	$55.05	$12.14
2009	$373.13	$135.33	$41.18	$94.15		$45.23	$154.14	-$121.84	-$36.35		$8.93	$33.63	$44.42	$7.17
2010	$445.28	$207.48	$39.87	$167.61		$52.59	$161.87	-$131.10	-$43.49		$21.95	$55.66	$75.07	$14.93
2011	$563.40	$325.60	$53.59	$272.02		$49.15	$266.18	-$215.80	-$45.95		$18.88	$128.88	$101.44	$22.81
2012	$532.03	$294.23	$43.74	$250.48		$62.38	$233.52	-$209.38	-$42.78		$20.65	$112.41	$100.36	$17.07
2013	$437.09	$199.29	-$64.31	$263.60		$56.22	$136.90	-$216.60	-$40.83		$28.38	$97.02	$122.58	$15.63
2014	$389.73	$151.93	-$131.82	$283.75		$54.33	$94.64	-$227.34	-$53.45		$34.16	$88.55	$128.79	$32.26
2015	$398.17	$160.37	-$107.49	$267.86		$36.92	$105.46	-$199.60	-$50.27		$31.53	$89.07	$122.81	$24.44