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An Overview of Retail Sales of Seafood in the USA, 2017–2019

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ABSTRACT

While a large number of studies have investigated seafood consumption in various markets, surprisingly little is known about the types of seafood sold in retail outlets or their product forms in the USA. This is particularly true for fresh seafood, which is generally regarded as the most valuable product form of seafood. In this article, a unique dataset on retail in-store seafood sales that includes information about three main product forms (fresh, frozen, and shelf-stable products) was analyzed. Fresh seafood is important, as it makes up 43% of sales revenue. Moreover, some species are almost exclusively sold fresh, with trout and lobster as prime examples. Fresh also includes the greatest diversity of species and, as such, is the most likely product form for new producers to succeed. National sales are dominated by a few species, with salmon and shrimp accounting for a large portion of the fresh (27%) and frozen categories (43%), respectively, and tuna dominating the shelf-stable category (75%). There are also a large number of species with mostly small market shares. There are few differences in regional sales patterns for the main species, with notable exceptions such as whitefish in New England and crawfish in Louisiana and Texas. The degree of urbanization and income level appears as the important drivers for seafood sales.



KEYWORDS


Fish; fresh; frozen; retail; seafood

1. Introduction

Seafood consumption in the USA has gradually increased for decades and includes a mixture of wild-caught and aquacultured species, from both domestic and imported sources (Shamshak et al. 2019; Love et al. 2020). As US fish stocks are generally well-managed at or near maximum sustainable yield and aquaculture production in the USA is limited, most of the increase in consumption originates from imports (Gephart et al. 2019; Shamshak et al. 2019). Readily available data on domestic landings, some aquaculture production, and trade enable estimates of availability (Shamshak et al. 2019; Kroetz et al. 2020);

however, information on where seafood is consumed – in terms of both food sourcing and sub-national data, and in which product categories – is highly limited, particularly at the species level. Love et al. (2020) recently found that about two-thirds of expenditures on seafood occurs away from home, primarily at restaurants, while seafood purchased for at home consumption makes up a much larger share by weight (56% at home vs 31% at restaurants and 13% at other outlets) (Love et al. 2020). Moreover, these shares vary significantly by species and region. For instance, 52% of shrimp consumption occurs at home compared with 70% of salmon and 77% of tilapia consumption (Love et al. 2020), and per capita consumption in

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Atlantic coastal regions is twice than that of the Midwest (Love et al. 2020). The origin and product forms of purchased seafood are important to understand the growth in opportunities for the seafood industry – in particular in the specific market segments where domestic landings compete with typically lower priced imports – and how different parts of the seafood market respond to shocks or other sources of instability and natural variation.

This article uses US retail sales data from Nielsen, a retail measurement company, to shed light on retail purchases as a proxy for seafood consumption patterns of fresh and shelf-stable seafood across the entire USA and by region. Earlier research has used retail sales data to provide an overview of sales trends for frozen seafood products with a focus on potential competitors for US catfish producers (Dey et al. 2017), and a number of studies investigated demand for specific groups of products (Singh et al. 2014, 2012; Surathkal et al. 2017). These and other similar studies did not evaluate fresh seafood and few analyzed shelf-stable products, with the exception of one study on canned tuna and salmon (Wessells and Wallström, 1999).

The gap in the literature on fresh seafood is important since this product category constitutes a large and valuable share of the market, and some species such as trout, lobster, halibut, crab, and salmon are predominantly sold as fresh, making these species difficult to study with previous work focused on retail sales data for frozen products. US retail sales of seafood favors frozen (42% of total) over fresh product categories (35%) by volume, but by value fresh makes up a larger share (43% of total) compared with frozen (39%). The shelf-stable category makes up the remainder of seafood sales (23% by volume and 18% by value). Fresh products, therefore, have a significantly higher unit value than frozen and shelf-stable products. For most species, fresh is the most valuable product form for the producers, and it is a product form where closer proximity to markets should be a benefit for local fishers and fish farmers. Fresh products are highly perishable, which highlights the importance of efficient logistics – features that favor large fisheries producers and aquaculture (Asche and Smith 2018).

Seafood consumption levels differ among regions, and retail sales data can help explore these trends. For example, demand, price elasticity, and substitution of frozen fish vary considerably across 52 US markets (Singh et al. 2014). Using dietary recall data, seafood consumption was influenced by region, proximity to the coastline, and population density (US EPA 2014; Love et al. 2020). It is unknown whether this regional

variation is in the product category mix, species mix, or a combination of both. Transportation cost is in itself an argument for why fresh seafood should be more available along the coast, particularly for domestic fish. On the other hand, if logistics are sufficiently good to inland areas, this should not matter much. Love et al. (2020) indicated that seafood consumption was higher in urban areas, suggesting that some combination of logistics, market size, consumer demand, and household income may impact consumption (Love et al. 2020).

Our analysis provides the most current and detailed characterization of the US retail seafood market. National patterns in seafood sales are described by product type and species, and retail sales patterns are compared across regions. In the next section, the dataset and methods used to structure it are presented. Then comes a detailed discussion of national and regional retail sales patterns before offering conclusions based on these findings.

2. Data

2.1. Nielsen retail scanner data

Nielsen retail scanner data (eXtended All Outlet Combined, xAOC product, New York, NY) contained national- and state-level annual sales at the unique product code (UPC) level for January 1, 2017 to December 31, 2019. The UPC provides a unique number for each product, much like a barcode. Nielsen sampled 237 store brands and 109,695 individual stores (e.g., grocery, convenience, drug, club, big box, military, pet, and dollar stores) and then made national-level and state-level sales projections (Table 1), which is collectively called “retail sales” in this manuscript. State-level projections were available for 31 states where Nielsen collects data, and were

Table 1. Nielsen retail scanner study data footprint.

Type of store	Brands (n)		Individual store locations (n)		% Sampled by Nielsen
	Sampled	Not sampled	Sampled	Not sampled	
Grocery stores	113	26	16,480	4,610	78.1%
Convenience stores	86	38	35,925	5,842	86.0%
Drug stores	12	10	20,011	473	97.7%
Club and big box stores	10	1	7,369	546	93.1%
Pet stores	9	16	4,397	817	84.3%
Military stores	5	–	1,011	–	100.0%
Dollar stores	2	3	24,502	45,736	34.9%
Total	237	90	109,695	58,024	65.4%
Total excluding pet, drug, and dollar stores	214	65	60,785	10,998	84.7% ^a

^aNielsen sampled 60,785 stores where US seafood sales occur (~85% of all locations) and made projections for the remaining ~15% of stores.

selected because they contain major metropolitan markets and provide good regional coverage. The dataset that was purchased does not contain retail sales by store brand, so, for example, we were not able to disaggregate sales from grocery stores versus big box stores, or one grocery store chain from another.

2.2. Data cleaning and processing

Retail sales volumes were converted to kilograms from ounces (and in a few cases from pints), adjusted revenue (\$), and unit price (\$/kg). Data were deflated using the Consumer Price Index (CPI-U series, non-seasonally adjusted) and adjusted to 2019 for annual inflation. Regional price indices were used for state-level data. The Nielsen department category “seafood” was renamed “fresh,” and the “grocery” category was renamed “shelf-stable,” and the “frozen” category was not renamed. The majority (>90%) of products in the “fresh” category were sold as random weight (i.e., by the pound), which suggests they were truly fresh. Missing weights were imputed using the average unit price of a similar item and matched using a concatenation term. Data were analyzed using R (v 4.0.2) programming (R Core Team, 2021) in R.Studio (v. 1.3).

3. Results

3.1. National results

An average of 813,700 metric tons per year of seafood was purchased at the retail level, generating \$12.2 billion in retail sales (Table 2). Retail seafood is grouped into three main product categories: fresh, frozen, and shelf-stable products. The frozen product category made up the majority of sales by volume, while the fresh product category made up the most sales by revenue (Table 2).

A feature that has received particular interest in recent decades is the increased use of private labels (i.e., store brands) in retail seafood sales (Roheim et al. 2007; Sogn-Grundvåg et al. 2019). The importance of brand name products varies by department

Table 2. Average US retail seafood sales by product category according to Nielsen, 2017–2019.

Product category	Annual revenue		Annual volume	
	billion \$ (st dev)	% of total	1,000 metric tons (st dev)	% of total
Fresh	5.30 (0.14)	43.3%	288.9 (8.39)	35.4%
Frozen	4.80 (0.08)	39.1%	341.6 (7.60)	42.0%
Shelf-stable	2.14 (0.01)	17.5%	184.2 (2.81)	22.6%
Total	12.2 (0.23)	100%	813.7 (13.4)	100%

Table 3. Brand use by product category for US retail seafood, Nielsen 2017–2019.

Brand	Sales by revenue ^a			Sales by volume ^a		
	Fresh	Frozen	Shelf-stable	Fresh	Frozen	Shelf-stable
No company listed	84.8%	0.4%	0.0%	85.8%	0.3%	0.0%
Branded	10.2%	45.2%	87.7%	9.8%	48.2%	82.1%
Private label	5.0%	54.4%	12.3%	4.5%	51.5%	17.9%

^asee Table 1 for total revenue and volume.

(Table 3). By both revenue and volume, most fresh products do not list a company. This is because most (85% by revenue) of fresh products are sold as random weight items and are not packaged. In contrast, frozen products were mostly branded (45% by revenue) and private label (54%) products. Shelf-stable products were mostly sold as branded products (88% by revenue) with the remaining sold under a private label (12%). Hence, private labels have the strongest impact for frozen seafood, while the traditional brands are holding up well for shelf-stable products. Internationally, there is a trend toward centralized packing outside of the store, which includes fresh seafood (Landazuri-Tveteraas et al. 2018), and industry contacts indicate that this is also the case in the USA. The data provide no evidence, however, that this is leading to branding of fresh seafood in a similar fashion as for terrestrial meats (Asche et al. 2018), with the exception of smoked products.

Exploring the national data by species suggests that sales are highly concentrated among a few species groups, but that there is important variation between product categories. Shrimp, salmon, tuna, crab, and tilapia species groups made up 75% of retail sales by revenue and 71% of retail sales volume (Figure 1). It is also interesting to note that three of the species groups have large aquaculture components (shrimp, salmon, and tilapia), while tuna and crab are primarily wild caught. Moreover, all are predominantly imported. Shamshak et al. (2019) showed that five species groups (shrimp, salmon, tuna, tilapia, and catfish) made up over 70% of US seafood consumption, largely mirroring imports and global production (Garlock et al. 2020a). Notably, crab replaces catfish in the top-5 retail sales, while catfish has greater overall consumption.

The relative importance of the product category varies significantly by species. Many species are mostly sold fresh (Figure 2). For example, more than 90% of the total sales of lobster and trout were sold fresh. Lobster is the highest value species group in the US based on ex-vessel value, and trout is the second largest finfish species farmed in the USA (NMFS 2020). In addition, more than 73% of salmon sales, the

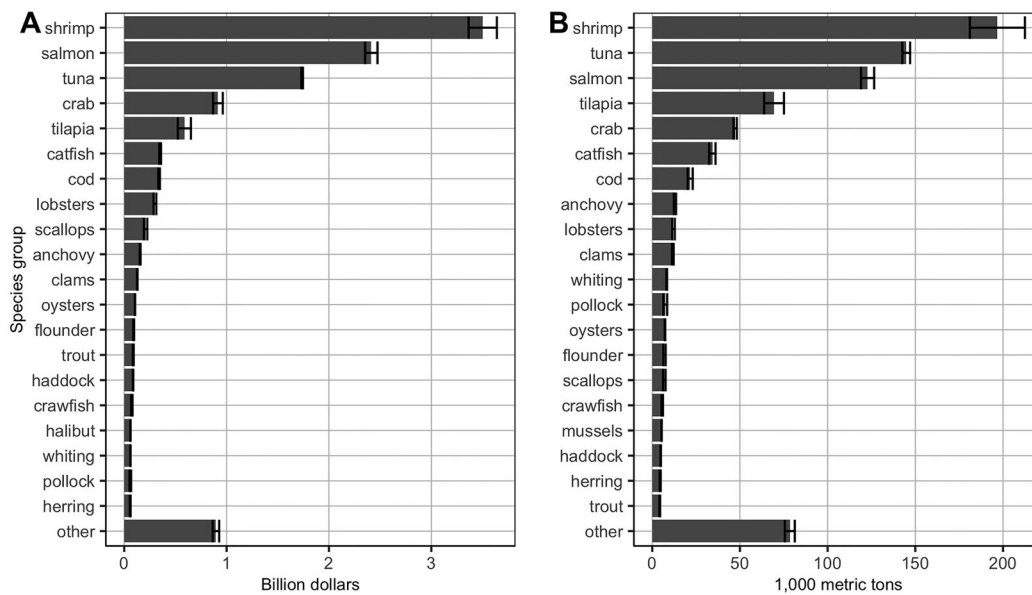


Figure 1. Annual sales of the top-20 retail seafood species groups by (A) revenue (billion dollars) and (B) volume (1,000 metric tons) in the USA, Nielsen 2017–2019. Standard deviation error bars provided. “Other” is a combination of all other species groups. See Supplemental data, [Table A1](#) for values reported in this figure.

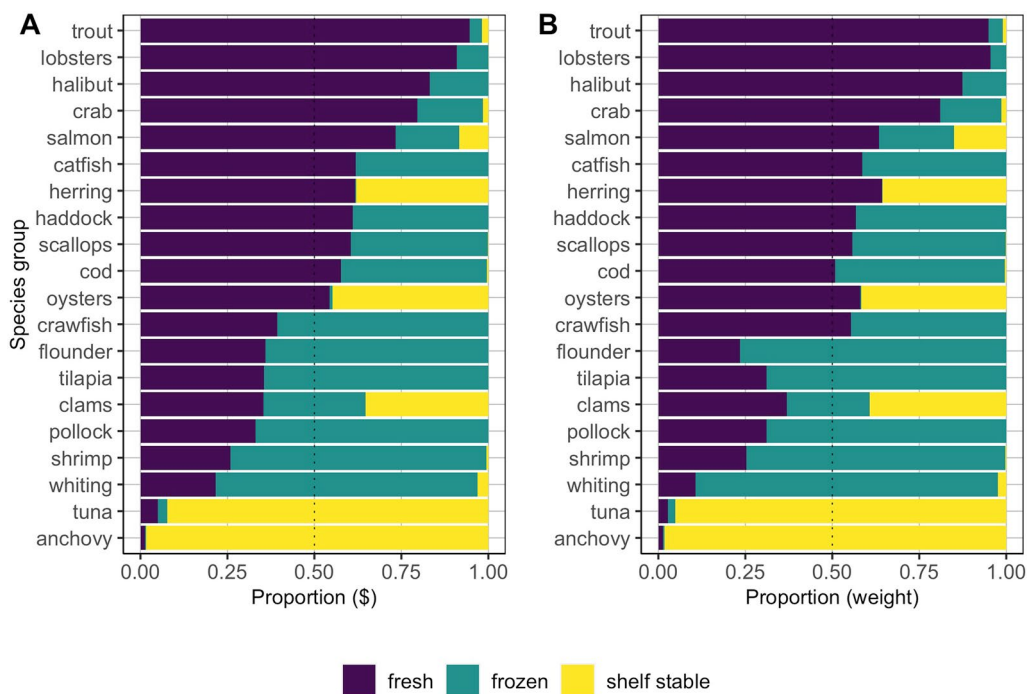


Figure 2. Average sales proportion by (A) revenue and (B) quantity for species and product categories in US retail seafood, Nielsen 2017–2019. Dotted vertical line at $x=0.5$ for comparison purposes.

second most consumed species in the USA are fresh. Other species such as whiting (87%), flounder (77%), shrimp (75%), pollock (69%), and tilapia (69%) are primarily sold as frozen. Tuna (95%) and anchovies and sardines (98%) were predominantly sold as shelf-stable products, and oysters (42%), clams (39%), herring (36%), and salmon (15%) also had large shelf-stable components.

The fresh category was generally more expensive than frozen or shelf-stable categories ([Table 4](#)). For example, there was a \$5.70/kg premium for fresh salmon compared to frozen salmon. While this is partly due to costlier logistics, it supports arguments that fresh and unprocessed fish are the most valuable ([Anderson and Bettencourt 1993](#); [Roheim et al. 2007](#); [Asche and Smith 2018](#)). The distribution of sales by

Table 4. Average unit price (\$/kg) by species and product category, Nielsen 2017–2019.

Species group	Unit price \$/kg (st dev) ^a		
	Fresh	Frozen	Shelf-stable ^b
Halibut	44.07 (6.52)	53.35 (6.40)	–
Scallops	33.08 (3.39)	27.83 (1.66)	–
Lobsters	26.86 (6.25)	51.8 (5.37)	–
Tuna	22.64 (2.27)	14.34 (1.86)	11.43 (0.99)
Salmon	22.37 (1.88)	16.67 (1.11)	11.54 (1.91)
Haddock	21.60 (3.19)	16.36 (1.19)	–
Trout	20.66 (1.57)	21.8 (10.49)	–
Shrimp	19.39 (2.17)	17.55 (1.04)	–
Flounder	18.89 (5.47)	10.7 (0.84)	–
Crab	18.77 (2.52)	20.73 (3.12)	–
Cod	17.48 (1.90)	13.52 (0.78)	–
Anchovy	16.84 (9.98)	10.14 (2.27)	12.56 (1.58)
Oysters	16.26 (5.33)	24.57 (9.51)	16.03 (2.10)
Whiting	15.00 (4.85)	6.29 (0.46)	–
Herring	12.56 (1.33)	15.46 (6.23)	14.01 (1.94)
Tilapia	12.31 (2.31)	8.00 (0.45)	–
Catfish	12.12 (1.58)	9.17 (0.84)	–
Crawfish	11.35 (1.75)	12.96 (3.38)	–
Pollock	9.52 (1.12)	7.93 (0.73)	–
Clams	9.38 (2.43)	12.81 (1.97)	9.62 +/- 0.8

^aunit price based on the average and standard deviation of 31 U.S. states.

^bonly the main shelf-stable species are reported.

unit price is plotted next. Fresh and frozen products generally ranged from \$5/kg to \$20/kg with fresh skewing more expensive, while shelf-stable seafood was more tightly focused in the \$5 to \$10/kg range (Figure 3). The most affordable products were frozen whiting (\$6.29/kg), frozen pollock (\$7.93/kg), frozen tilapia (\$8.00/kg), shelf-stable salmon (\$11.54/kg), and shelf-stable tuna (\$11.43/kg) (Table 4).

Given that there are a large number of species available at retail outlets, it is of interest to investigate if there are some species that dominate, causing a product form to be highly concentrated within a few species. One way to measure concentration in a market is a Herfindahl index (HHI), which is the sum of squared market shares S_i of the products in a market, i.e., $HHI = \sum_i S_i^2$. The index takes values between 0 and 1, where it is close to zero if there is little concentration and it takes the value 1 if a market consists of only one product. In an antitrust context, a market is regarded as highly concentrated if the index has a value higher than 0.25. The Herfindahl index was 0.169 for fresh seafood, 0.315 for frozen seafood, and 0.575 for shelf-stable seafood. Market concentration was similar at the regional level as at the national level. While the antitrust threshold of 0.25 does not necessarily transfer to the number of species, the index does suggest that both the shelf-stable and the frozen categories are highly concentrated. This is not a surprise given the high market share of canned tuna; however, it was surprising that the frozen market is so highly concentrated in a few species. Shrimp, tilapia, and salmon

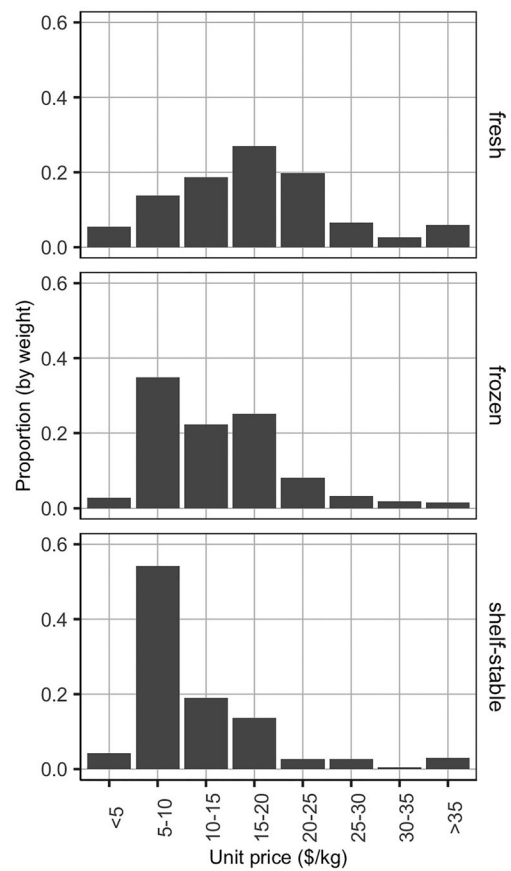


Figure 3. Average sales of (A) fresh, (B) frozen, and (C) shelf-stable seafood sales quantity by unit price in U.S. retail seafood, Nielsen 2017–2019. See Supplemental data, Figure A1 for a similar plot based on revenue.

make up 65% of total frozen seafood sales, and none of the traditional whitefish species (cod, haddock, pollock) are represented. The lower degree of concentration in the fresh seafood category makes this a potentially easier category to enter into if a firm is competitive on other attributes. This most likely reflects the importance of locally caught species to a large extent, although Garlock and colleagues show that the market for smaller local species can also be dominated by imports (Garlock et al. 2020b). The combination of high prices and low concentration in the fresh seafood market creates an opportunity for US fisheries or aquaculture producers of new species since the market seems to be relatively open and willing to pay for quality.

3.2. Regional results

Little prior work has explored regional patterns of different forms of seafood sales, particularly in the fresh seafood category. To fill this gap, a multivariate linear regression was conducted for the sales shares (S_j) of the three product categories (j) using 2019

Table 5. Parameter estimates for multivariable regressions on product form shares by state.

Dependent variable	Fresh share		Frozen share		Shelf-stable share	
	Coefficient	<i>p</i> value	Coefficient	<i>p</i> value	Coefficient	<i>p</i> value
Intercept	0.045	(0.466)	0.661*	(<0.001)	0.294*	(<0.001)
East Coast ^a	-0.069*	(0.011)	0.078*	(0.004)	-0.009	(0.590)
Inland ^a	-0.107*	(<0.001)	0.095*	(0.001)	0.012	(0.476)
Gulf ^a	-0.068*	(0.026)	0.089*	(0.004)	-0.021	(0.255)
HH income	<0.001*	(0.005)	>-0.001*	(0.028)	-0.000	(0.235)
Percent urban	0.003*	(0.002)	-0.002*	(0.018)	-0.001	(0.115)
Population	<0.001	(0.809)	>-0.001	(0.655)	<0.001	(0.756)
Landings	>-0.001	(0.348)	<0.001	(0.879)	<0.001	(0.216)
R ²	0.873		0.829		0.467	

*Statistically significant at the 5% level.

^aReference category is West Coast.

cross-sectional data by state for the 31 states represented in the dataset. States were grouped into four regions: East Coast (Connecticut, Georgia, Maryland, Massachusetts, New Jersey, New York, North Carolina, South Carolina, Virginia), West Coast (California, Oregon, Washington), Gulf Coast (Alabama, Florida, Louisiana, Mississippi, Texas), and Inland (Arizona, Colorado, Illinois, Indiana, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nevada, Ohio, Pennsylvania, Tennessee, Wisconsin). In addition to regional dummies (D_i) for West Coast (base category), East Coast, Inland, and Gulf regions, the regression contains variables for average household income in the state (HHI in \$), the percentage urban population

($Urban$), total population (Pop) (Census Bureau n.d.), and total seafood commercial landings (lbs), which includes some aquaculture production ($Landings$) (NOAA Fisheries n.d.), and an error term e_j . The regression equation is given as:

$$S_j = a + \sum_i b_i D_i + c_1 HHI + c_2 Urban + c_3 Pop + c_4 Landings + e_j$$

The results of these multivariable regressions are reported in Table 5 and bivariate regression for each explanatory variable in Supplemental data, Table A2. In the equations for fresh and frozen seafood, the

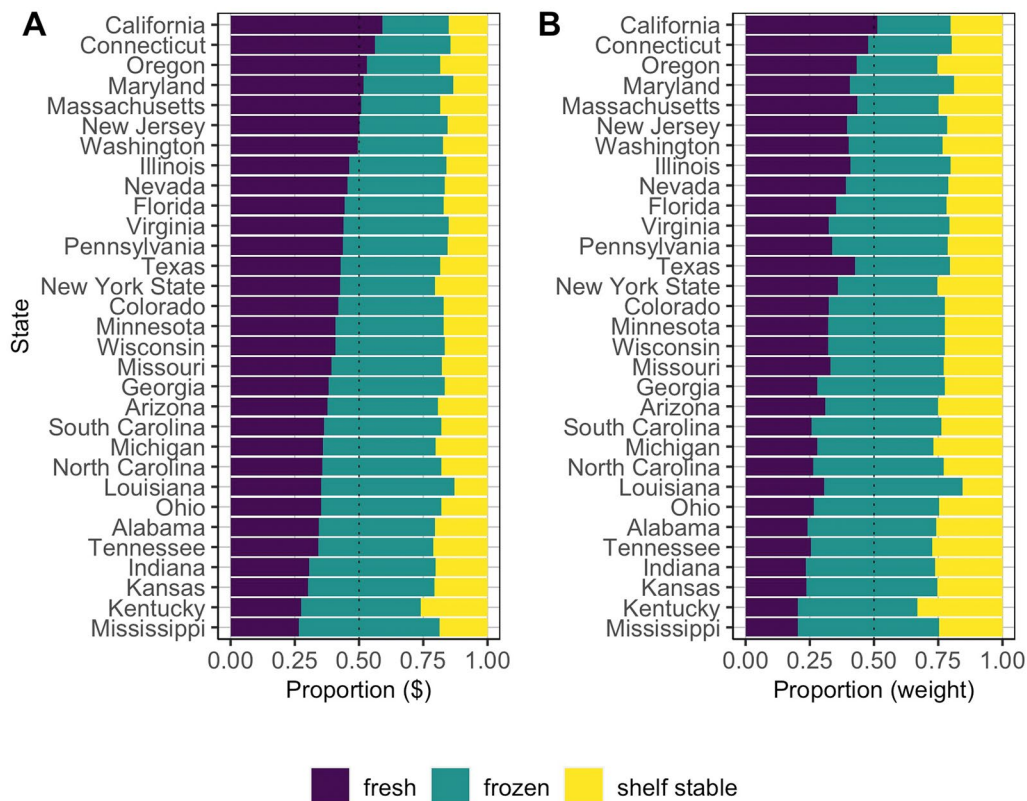
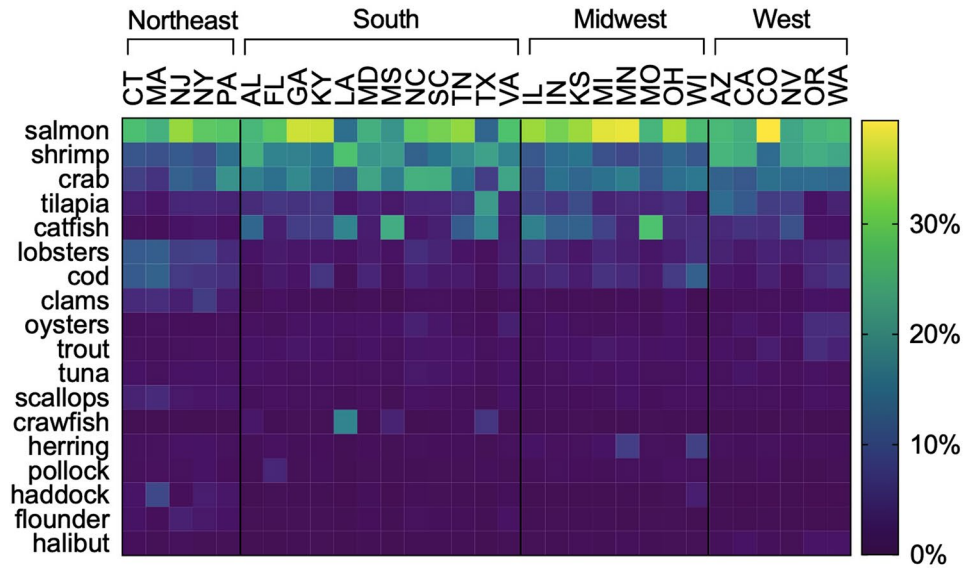
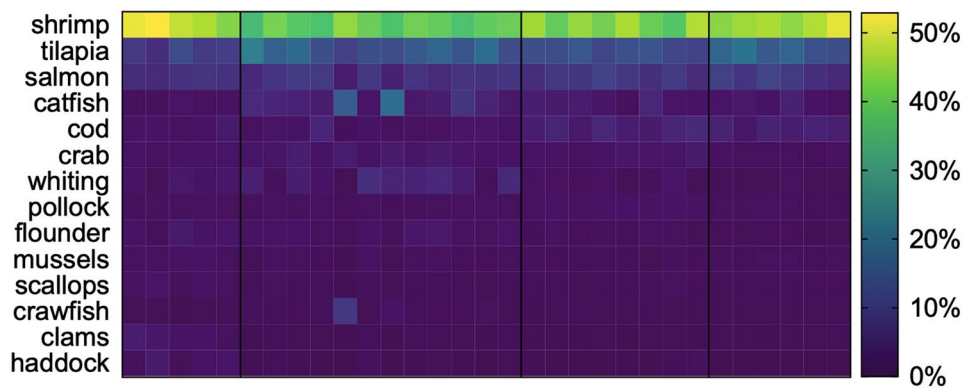


Figure 4. Average proportion of sales by (A) revenue and (B) volume for states ($n=31$) and product categories in US retail seafood, Nielsen 2017–2019. Dotted vertical line at $x=0.5$ for comparison purposes.

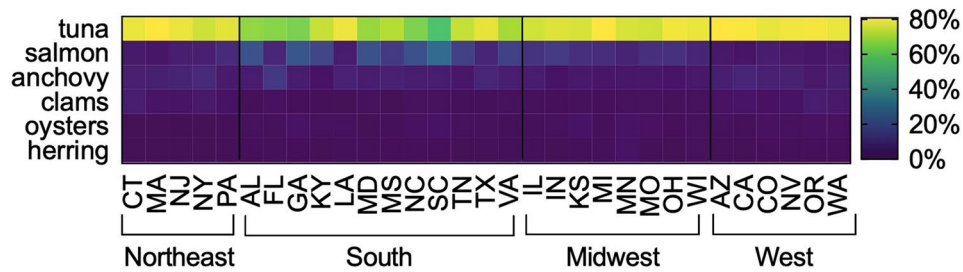
A. Fresh



B. Frozen



C. Shelf-stable



↑
 ↓
 Column proportion

Figure 5. Average proportion of sales within a state of (A) fresh, (B) frozen, and (C) shelf-stable seafood, Nielsen 2017–2019. Calculations are based on all species groups, however, only the top-20 species groups are presented for simplicity.

models have good explanatory power with an R^2 over 0.8, while the equation for shelf-stable is much lower at $R^2 = 0.47$, although an F -test indicates that the parameters are still jointly statistically significant at a 5% level with a p value of 0.032.

For fresh seafood, the sales share is lower in all regions relative to the West Coast, and it is the lowest in the Inland region. The sales share of fresh seafood increases with household income and percent urban population but is independent of the states' total population and seafood commercial landings. All the coefficients that are statistically significant in the equation for fresh seafood are also significant in the equation for frozen seafood, but with the opposite sign. Hence, the sales share of frozen seafood is higher in the other three regions than in the West Coast, and also higher in states with lower household income and less urbanization. The sales share of shelf-stable is independent of all variables. Hence, there are regional differences in sales for fresh and frozen, but not for shelf-stable seafood. Moreover, sales of fresh seafood increase with household income indicating that wealth matters, and it increases with degree of urbanization, indicating that logistics and infrastructure matter. It is also notable that on average, total commercial fisheries landings do not have a significant impact on sales. This is not too surprising given the high share of imports. Another way to visualize the shift between fresh and frozen sales is to plot sales proportion by product category and state (Figure 4). This plot also shows that the frequency of shelf-stable sales remains fairly constant across all states.

Given that there were regional sales for fresh and frozen categories, regional preferences were explored by species group. Fresh species sales (Figure 5(a)) had more state-to-state variability than frozen (Figure 5(b)) or shelf-stable species sales (Figure 5(c)). This makes sense if logistics limit distribution of some fresh products. Some products had large variation in price from state-to-state, such as fresh and frozen halibut, fresh and frozen lobster, fresh and frozen oysters, fresh anchovy, fresh whiting, frozen trout, and frozen herring (Table 4). In some cases, lower prices were observed close to production centers for halibut, lobster, flounder, and oysters, while the highest prices of fresh lobster were far from production sites in inland states. The top species-product category combinations – fresh salmon, frozen shrimp, and shelf-stable tuna – acted more like food commodities as they were widely consumed in all states with little variation in price (Table 4).

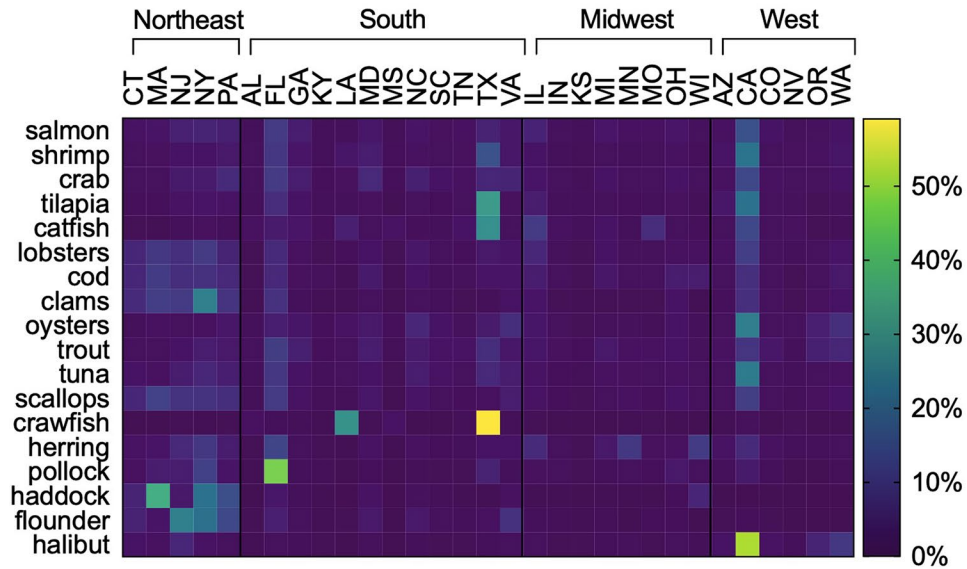
With a few notable exceptions, the variation in species purchased by region is low. There are strong cultural traditions for certain species, however, that may impact seafood sales in some regions. Fresh and frozen shrimp, catfish, and crawfish made up a larger share of seafood sales in Louisiana than in other states (Figure 5). The same was true for the following species-state pair: fresh catfish in Mississippi, Missouri, Texas, and Illinois; fresh cod, lobster, and haddock in Massachusetts and Connecticut; and canned salmon in many southern states (Figure 5). The quantity of top species groups consumed by a state relative to other states is presented in Figure 6. Northeast states consumed more fresh and frozen haddock, flounder, clams and scallops, and fresh lobster compared to other states (Figure 6(a,b)). Maryland, Virginia, North and South Carolina, and Georgia consumed more frozen whiting (Figure 6(b)); Minnesota, New York, and Wisconsin consumed more fresh and shelf-stable herring (Figures 6(a,c)); and California, Florida, and Texas consumed more of all seafood types due to their larger population size (Figure 6(b,c)).

4. Conclusions

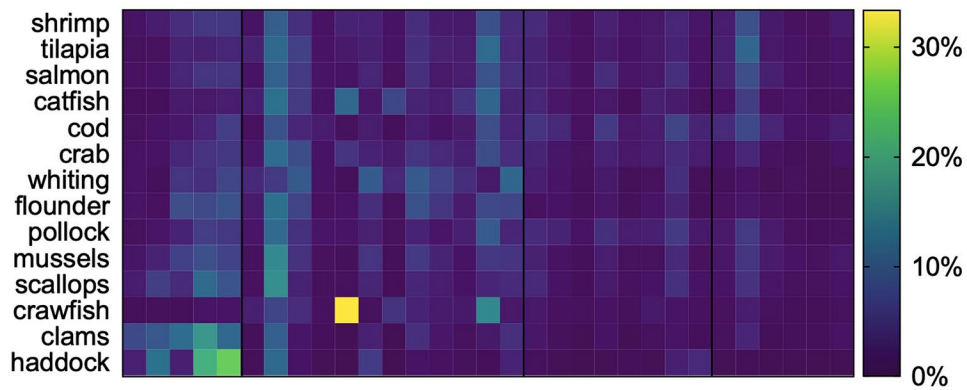
The US retail sector has a wide diversity of seafood species, product categories, brands, and regional sales, which makes it both complex and interesting to study. Purchases are highly focused on a handful of commodity products sold through mainstream supply chains with national distribution. Despite the diversity in seafood, which is a function of natural diversity in aquatic life (Metian et al. 2020), the retail sector is fairly homogeneous and does not reflect the full diversity of species caught and farmed in US waters. Sales for fresh seafood vary by region, as well as by household income and urban population percentage. This suggests that better logistics and infrastructure in urban areas support fresh seafood distribution, and higher incomes allow consumers to purchase fresh products that are often at higher price points than frozen products. The opposite was true for frozen seafood, which was associated with lower household income and lower share of urban population. Shelf-stable seafood had no association with region, income, or urbanization. The Nielsen dataset does not provide insights into other food sources such as food service or self-caught seafood; however, other studies have done so (Love et al. 2020).

Retail sales data including the fresh category have not been available previously, so this study sheds new light on a major component of the seafood market.

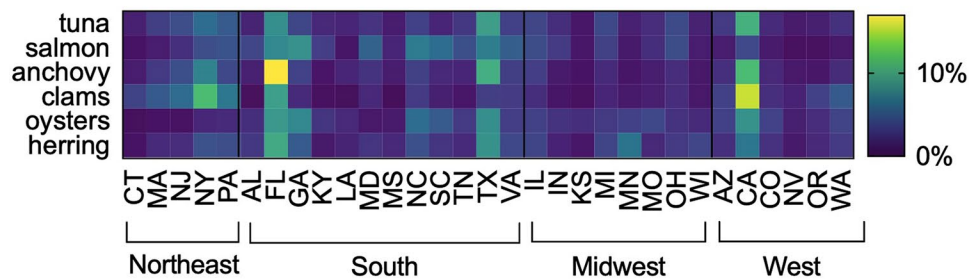
A. Fresh



B. Frozen



C. Shelf-stable



Row proportion



Figure 6. Average proportion of sales across states of (A) fresh, (B) frozen, and (C) shelf-stable seafood, Nielsen 2017–2019. Calculations are based on all species groups, however, only the top-20 species groups are presented for simplicity.

Fresh products made up the majority of retail seafood revenue and many top species are sold mainly fresh. Atlantic salmon is one of the largest products sold as majority fresh and an example of an industry that can produce, process, and globally distribute large quantities of perishable fish (Asche et al. 2018). Fresh salmon has a higher degree of price transmission to retail than processed or packaged salmon (Asche et al. 2018), and firms have decided that selling fresh seafood is more profitable. As such, 84% of Atlantic salmon imports are fresh, including 77% of Chilean Atlantic salmon (48,000 metric tons/yr) by air freight and 99.8% of Canadian Atlantic salmon (57,000 metric tons/yr) by truck (US Census n.d.). An argument has been made that farmed salmon producers opened up Midwestern markets for fresh seafood (Anderson 2002; Anderson et al. 2019) with their better logistics and pinbone out fillets.

The fresh category also has low market concentration and higher unit prices, which makes it an appealing market for domestic fisheries and aquaculture products with enough quantity and sufficient logistics. Farmed trout is an excellent example of the ability of domestic producers to capture market share in the fresh category. Domestic trout production has increased 5.9% from 2013 to 2018 (USDA 2019). The success of domestic farmed trout has received little attention, and it is almost exclusively sold as fresh and available all over the country.

Decisions about which product category to market have a bearing not only on sales but also on their underlying supply chains, as well as environmental sustainability and food waste. Fresh seafood spoils faster than frozen or shelf-stable forms and requires different modes of transport, including by air when the distance to market is large, which has a larger environmental footprint (Ziegler et al. 2013). Consumers have different strategies related to food acquisition and meal planning for fresh seafood compared to more stable forms. Retail is the main outlet where consumers access seafood in the USA (Love et al. 2020), and seafood is wasted at higher rates at the retail and consumer stages than in other parts of the supply chain (Love et al. 2015), making this an important avenue for waste prevention. Fresh seafood waste is thought to be higher than frozen or shelf-stable seafood waste (Buzby et al. 2009; Muth 2011), but more work is needed to characterize waste by product category. Reducing seafood waste is critical because there are higher environmental costs of wasting seafood and meat compared to other foods due to their larger environmental footprint (Conrad and Blackstone 2020). There is also an economic argument

for reducing waste – wasted seafood costs more for consumers than other foods (Conrad 2020). By examining the most common product categories and species consumed fresh at retail, this study can help inform the targeting of interventions for seafood waste among consumers and retail seafood managers.

Lastly, regional markets for seafood were explored with mixed findings. In the regression, an association between average domestic commercial seafood production and retail sales was not found. This can be explained by the fact that imports represent such a large share of the market, and also by the fact that the USA is a major seafood exporter (Gephart et al. 2019; Shamshak et al. 2019). At the species group level, however, there were examples of regional markets, such as states that consume a larger share of a particular species, or where price was influenced by distance to market. It is unknown if products with regional markets were majority import or domestic, however. There is a growing body of work on domestic seafood sold *via* direct sales (Stoll et al. 2015; O'Hara 2020). More work is needed to account for origin and production within the retail supply, both analytically and through traceability, including product labeling and mislabeling (Roheim et al. 2018; Kroetz et al. 2020). The serious mislabeling issues associated with seafood as documented by Kroetz et al. (2020) increases the importance of this issue, particularly since generic categories like whitefish are increasingly important in the international seafood trade (Asche et al. 2009; Anderson et al. 2018). The importance of a few globally sourced species also facilitates addressing market shocks. For instance, during the COVID-19 pandemic, USA retail seafood sales are up significantly from the previous year, and up more in frozen and shelf-stable than fresh, while restaurant sales are down (Love et al. 2021).

Our own analyses and calculations are based in part on data reported by Nielsen through its Nielsen Service for the Seafood category for the week period ending December 31, 2019, for the US and 31 state market and xAOC channel. Copyright © 2020, The Nielsen Company. The conclusions drawn from the Nielsen data are those of the authors and do not reflect the views of Nielsen. Nielsen is not responsible for and had no role in analyzing and preparing the results reported herein.

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References

- Anderson JL. 2002. Aquaculture and the future: why fisheries economists should care. *Mar Resour Econ.* 17(2):133–151. doi:10.1086/mre.17.2.42629357
- Anderson JL, Asche F, Garlock T. 2019. Economics of aquaculture policy and regulation. *Annu Rev Resour Econ.* 11(1):101–123. doi:10.1146/annurev-resource-100518-093750
- Anderson JL, Asche F, Garlock T. 2018. Globalization and commoditization: the transformation of the seafood market. *J Commod Mark.* 12:2–8. doi:10.1016/j.jcomm.2017.12.004
- Anderson JL, Bettencourt SU. 1993. A conjoint approach to model product preferences: the New England market for fresh and frozen salmon. *Mar Resour Econ.* 8(1):31–49. doi:10.1086/mre.8.1.42629045
- Asche F, Cojocaru AL, Roth B. 2018. The development of large scale aquaculture production: a comparison of the supply chains for chicken and salmon. *Aquaculture* 493:446–455. doi:10.1016/j.aquaculture.2016.10.031
- Asche F, Roll KH, Trollvik T. 2009. New aquaculture species—the whitefish market. *Aquac Econ Manag.* 13(2):76–93. doi:10.1080/13657300902881641
- Asche F, Smith MD. 2018. Induced innovation in fisheries and aquaculture. *Food Policy* 76:1–7. doi:10.1016/j.foodpol.2018.02.002
- Buzby JC, Wells HF, Axtman B, Mickey J. 2009. Supermarket loss estimates for fresh fruit, vegetables, meat, poultry, and seafood and their use in the ERS loss-adjusted food availability data. doi:10.22004/ag.econ.58313
- Census Bureau. n.d. US Census.
- Conrad Z. 2020. Daily cost of consumer food wasted, inedible, and consumed in the United States, 2001–2016. *Nutr J.* 19:35. doi:10.1186/s12937-020-00552-w
- Conrad Z, Blackstone NT. 2020. Identifying the links between consumer food waste, nutrition, and environmental sustainability: a narrative review. *Nutr Rev.* nuaa035. doi:10.1093/nutrit/nuaa035.
- Dey MM, Surathkal P, Chen OL, Engle CR. 2017. Market trends for seafood products in the USA: implication for Southern aquaculture products. *Aquac Econ Manag.* 21(1):25–43. doi:10.1080/13657305.2017.1266710
- Garlock T, Asche F, Anderson J, Bjørndal T, Kumar G, Lorenzen K, Ropicki A, Smith MD, Tveterås R. 2020a. A global blue revolution: aquaculture growth across regions, species, and countries. *Rev Fish Sci Aquac.* 28(1):107–116. doi:10.1080/23308249.2019.1678111
- Garlock T, Nguyen L, Anderson J, Musumba M. 2020b. Market potential for Gulf of Mexico farm-raised finfish. *Aquac Econ Manag.* 24(2):128–142. doi:10.1080/13657305.2019.1691676
- Gephart JA, Froehlich HE, Branch TA. 2019. Opinion: to create sustainable seafood industries, the United States needs a better accounting of imports and exports. *Proc Natl Acad Sci U S A.* 116(19):9142–9146. doi:10.1073/pnas.1905650116
- Kroetz K, Luque GM, Gephart JA, Jardine SL, Lee P, Moore KC, Cole C, Steinkruger A, Donlan CJ. 2020. Consequences of seafood mislabeling for marine populations and fisheries management. *Proc Natl Acad Sci U S A.* 117(48):30318–30323. doi:10.1073/pnas.2003741117
- Landazuri-Tveteraas U, Asche F, Gordon DV, Tveteraas SL. 2018. Farmed fish to supermarket: testing for price leadership and price transmission in the salmon supply chain. *Aquac Econ Manag.* 22(1):131–149. doi:10.1080/13657305.2017.1284943
- Love DC, Allison EH, Asche F, Belton B, Cottrell RS, Froehlich HE, Gephart JA, Hicks CC, Little DC, Nussbaumer EM, et al. 2021. Emerging COVID-19 impacts, responses, and lessons for building resilience in the seafood system. *Glob Food Secur.* 28:100494. doi:10.1016/j.gfs.2021.100494
- Love DC, Asche F, Conrad Z, Young R, Harding J, Nussbaumer EM, Thorne-Lyman AL, Neff R. 2020. Food sources and expenditures for seafood in the United States. *Nutrients* 12(6):1810. doi:10.3390/nu12061810
- Love DC, Fry JP, Milli MC, Neff RA. 2015. Wasted seafood in the United States: quantifying loss from production to consumption and moving toward solutions. *Glob Environ Change.* 35:116–124. doi:10.1016/j.gloenvcha.2015.08.013
- Metian M, Troell M, Christensen V, Steenbeek J, Pouil S. 2020. Mapping diversity of species in global aquaculture. *Rev Aquacult.* 12(2):1090–1100. doi:10.1111/raq.12374
- Muth MK. 2011. Consumer-level food loss estimates and their use in the ERS loss-adjusted food availability data. DIANE Publishing.
- NMFS. 2020. Fisheries of the United States, 2018. Current Fishery Statistics.
- NOAA Fisheries. n.d. Fisheries landings.
- O'Hara JK. 2020. Farmers markets and seafood: where is it feasible? *Mar Resour Econ.* 35(4):411–426. doi:10.1086/710051

- R Core Team. 2021. R: A Language and Environment for Statistical Computing. [WWW Document]. <https://www.R-project.org/>
- Roheim C, Bush S, Asche F, Sanchirico J, Uchida H. 2018. Evolution and future of the sustainable seafood market. *Nat Sustain.* **1**(8):392–398. doi:10.1038/s41893-018-0115-z
- Roheim CA, Gardiner L, Asche F. 2007. Value of brands and other attributes: Hedonic analysis of retail frozen fish in the UK. *Mar Resour Econ.* **22**(3):239–253. doi:10.1086/mre.22.3.42629557
- Shamshak GL, Anderson JL, Asche F, Garlock T, Love DC. 2019. US seafood consumption. *J World Aquacult Soc.* **50**(4):715–727. doi:10.1111/jwas.12619
- Singh K, Dey MM, Surathkal P. 2014. Seasonal and spatial variations in demand for and elasticities of fish products in the United States: an analysis based on market-Level scanner data. *Can J Agric Econ Can Agroeconomie.* **62**(3):343–363. doi:10.1111/cjag.12032
- Singh K, Dey MM, Surathkal P. 2012. Analysis of a demand system for unbreaded frozen seafood in the United States using store-level scanner data. *Mar Resour Econ.* **27**(4):371–387. doi:10.5950/0738-1360-27.4.371
- Sogn-Grundvåg G, Asche F, Zhang D, Young JA. 2019. Eco-labels and product longevity: the case of whitefish in UK grocery retailing. *Food Policy.* **88**:101750. doi:10.1016/j.foodpol.2019.101750
- Stoll JS, Dubik BA, Campbell LM. 2015. Local seafood: rethinking the direct marketing paradigm. *Ecol Soc.* **20**(2).
- Surathkal P, Dey MM, Engle CR, Chidmi B, Singh K. 2017. Consumer demand for frozen seafood product categories in the United States. *Aquac Econ Manage.* **21**(1):9–24. doi:10.1080/13657305.2017.1265020
- US Census. n.d. USA trade.
- US EPA. 2014. Estimated fish consumption rates for the US population and selected subpopulations (NHANES 2003–2010). Office of Water Washington, DC.
- USDA, 2019. 2018 census of aquaculture. Volume 3, Special Studies, Part 2. AC-17-SS-2.
- Wessells CR, Wallström P. 1999. Modeling demand structure using scanner data: implications for salmon enhancement policies. *Agribus Int J.* **15**(4):449–461. doi:10.1002/(SICI)1520-6297(199923)15:4<449::AID-AGR2>3.0.CO;2-9
- Ziegler F, Winther U, Hognes ES, Emanuelsson A, Sund V, Ellingsen H. 2013. The carbon footprint of Norwegian seafood products on the global seafood market. *J Ind Ecol.* **17**(1):103–116. doi:10.1111/j.1530-9290.2012.00485.x