Supermarket trends for rainbow and steelhead trout products: Evidence from scanner data

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ARTICLE INFO

ABSTRACT

Farm-raised trout is the second-largest foodfish sector of United States (U.S.) aquaculture, with the first trout farms established more than a century ago. Given its importance to both U.S. and global aquaculture, there is surprisingly little research on critical markets and marketing for trout in the U.S. Scanner data (AC Nielsen ScanTrack) were used for the time period from September 2016 through August 2021 to compare retail sales of the trout products sold across years at national, regional, and city levels to provide information on sales revenue, volumes sold, and prices. Supermarket sales of trout increased from $100 to $135 million from 2016 to 2021; the average annual growth rate of sales was 8.3%. Trout prices were relatively stable over the study period in contrast to the generally increasing trends for seafood generally. The South Atlantic region was found to be the largest region for trout products and experienced a 13% average annual growth in sales, but the fastest growth rate of sales (15%) was observed in the West North Central region. The two top market regions for trout sales overall were Seattle/Tacoma and Portland Oregon, followed by Atlanta. Seventy-two percent of trout sales were of steelhead trout, with 26% of rainbow trout. Rainbow trout prices increased by 12% annually in contrast to those for steelhead trout that were relatively constant. This study highlighted the complexities of the U.S. retail trout market, with increasing volumes of imported steelhead and rainbow trout capturing the growing market demand for trout. Additional attention is needed to reduce barriers to expansion for U.S. trout farmers. Future studies that measure the substitutability of steelhead for rainbow trout in key markets as well as greater attention to food service sales to restaurants would provide useful marketing information for trout farmers.

1. Introduction

Farmed trout is the 15th-most produced finfish species globally (FAO, 2022). Rainbow trout (*Oncorhyncus mykiss*) is the most prominent of the various trout species raised. Rainbow trout are native to the western United States (U.S.) (Hinshaw et al., 2004), and trout is the second-most produced finfish species raised in the U.S., following another native species, catfish (*Ictalurus punctatus*). The global supply from trout farming has been led by Norway despite its origin in the U.S., followed by Chile, and then the U.S. (FAO, 2021).

The earliest reports of successful trout farming date back to California (U.S.), in 1870–1873 (Needham and Behnke, 1962; Behnke, 1992). International shipments of rainbow trout eggs from the U.S.

began in 1877, following the successful development of techniques for reliable production of eggs (Hardy et al., 2000); thus, most of the rainbow trout cultured worldwide likely originated from California as a combination of rainbow and steelhead trout (rainbow trout raised in seawater) genetic stocks (Hinshaw et al., 2004). European production of trout likely developed from an 1885 shipment of rainbow trout eggs to England from which breeding stock were subsequently used to develop the first trout farm in Denmark. Early trout culture in both the U.S. and Europe focused primarily on stock enhancement, with major growth of foodfish production developing much later in the mid-1950 s with the first major trout processing facility constructed in Idaho (U.S.) (Brannon and Klontz, 1989). The availability of processing capacity, combined with the development of lower-cost, pelleted feeds became the

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foundation of the ensuing development of a farmed trout sector in the U. S. and elsewhere around the world.

Rainbow trout farming in Europe has historically been important in England, Denmark, and Germany (Statista, 2015), and grew rapidly in the 1980 s (Shaw and Gabbott, 1992). Trout farming subsequently grew to become the most widely farmed species in Italy (D'Agaro et al., 2022), a valued foodfish in Germany (Risius et al., 2017), France (Bazoche and Poret, 2021), Japan (Sone, Nortvedt, 2009), and in other countries around the world.

Despite its importance as an aquatic farmed species for more than a century, there is surprisingly limited research on demand, supply chains, prices, volumes, and other critical market and marketing information for trout. Early marketing studies performed in the 1990 s found that trout fillets in Italy were priced similarly to beef fillet steaks (Shaw and Gabbott, 1992) and that Canadian consumers found both brown and rainbow trout generally acceptable, with acceptance varying by the water body of origin (Rounds et al., 1992).

More recent marketing studies have examined consumer preferences for various attributes. In Germany, "production method", "organic," "appearance of product," "produce processing," "branding and certification," and "taste" were found to be important attributes (Risius et al., 2017), while Ankamah-Yeboah et al. (2019) found greater willingness-to-pay higher prices for trout labeled as "organic" as compared to "non-organic" among German consumers. In Japan, Sone, Nortvedt (2009)) evaluated consumer preferences for raw rainbow trout, finding that the choice of meat cut ("body part") had the greatest effect on preferences of Japanese consumers. Effects of perceptions and expectations of consumers as related to use of insect meals in trout diets were examined in France (Bazoche and Poret, 2021) and in Spain (Llagostera et al., 2019). D'Agaro et al. (2022) reported that 57% of European salmon and trout farms participated in at least one environmental certification program.

Norway has surpassed the early European trout production in England and Denmark to become a world leader in trout production as a result of diversification of salmon production with rainbow trout raised in marine net pens (also referred to as "salmon trout" or "steelhead trout"). An analysis of Norwegian export prices, however, showed that salmon and steelhead trout prices were cointegrated, suggesting that farmed Norwegian Atlantic salmon and steelhead trout were close substitutes (Landazuria et al., 2020). Thus, export prices do not explain what has driven the diversification into steelhead trout production in Norway. In the U.S., however, steelhead trout have been viewed largely as a distinct "species" or product in markets (Crouse et al., 2018), largely because of their differing life history that results in a larger size at harvest. The life history of steelhead trout includes several years in freshwater followed by several more years in the ocean (National Wildlife Foundation, 2022) during which they reach a larger size at harvest than do freshwater rainbow trout.

In the U.S., national survey results from the late 1980 s did not include trout in the top-10 list of fish and seafood products by consumers, grocery stores, or restaurants (Engle et al., 1990). When responses were disaggregated by region, however, trout were rated as the #1 favorite finfish of consumers in the Mountain Region,[1] #2 in the West North Central and the South Atlantic regions, and #3 in the West South Central region. Unfortunately, study reports did not disaggregate supermarket or restaurant responses by region.

Subsequent surveys in the North Central Region reported that most seafood marketing businesses (other than brokers) in Michigan sold primarily catfish and rainbow trout (Chopak, 1992) and that farmed trout had high market presence in the north central U.S., with 72% of wholesalers, 68% of specialty retail stores, and 75% of grocery retail stores listing trout as one of the top three best-selling seafood products in the region (Hushak et al., 1993). Additional surveys of supermarket and restaurant operators in the North Central region in 1996–1997 showed that 14% of supermarket managers listed trout as one of their top-selling products (Riepe, 1999a), but trout were not included in the list of top-selling products by restaurant operators (Riepe, 1999b). Other studies compared consumer preferences in Chicago and Los Angeles for whole trout as compared to value-added trout products (Foltz et al., 1999) and sought to identify consumer segments that might have a preference for trout steaks (Dasgupta et al., 2000).

In a 2020 survey of consumers in the West North Central region (U. S.), 32% of respondents indicated that they would have purchased rainbow trout (more than any other species) if it had been available (Valle de Souza et al., 2021), suggesting that there may be consumer demand to support expansion of U.S. farmed trout production. Further analysis revealed that while willingness to pay for yellow perch and walleye was estimated to be greater inside the North Central region, that of trout was greater outside the North Central region (Athnos et al., 2022), indicating that demand for trout extends beyond the North Central region.

The availability of supermarket scanner data over the past several decadeshas provided the basis for examining revealed preferences in supermarket retail sales. Early studies on revealed supermarket preferences for aquaculture products found that product form, packaging type and size, and promotion affected both quantities purchased and retail prices (Capps and Lambregts, 1991; Wessells, Wallström, 1999; Chidmi et al., 2012). Several decades later, other studies pointed to the need for marketing strategies that were specific to geographic markets (Singh et al., 2014; Surathkal et al., 2017). The scanner data studies of the 2010 s focused primarily on frozen products in supermarkets (Dey et al., 2014, 2017; Singh et al., 2012). Trout did not appear among the top 16 finfish species sold in the analysis of Dey et al. (2014) and only appeared as a lower-priced finfish product in the list of the top unbreaded seafood products in Dey et al. (2017). In the 2017 study, trout was priced lower than tilapia, catfish, swai, salmon, and various types of shellfish products.

The COVID-19 pandemic and ensuing economic shutdowns introduced substantial uncertainty and market volatility into seafood markets. Engle et al. (2023a) found that overall seafood consumption did not appear to increase in contrast to the speculation that the pandemic induced greater consumption of seafood by U.S. consumers. Some respondents to the 2022 survey conducted by Engle et al. (2023a) reported decreased consumption of seafood because of its high price, reduced household income during the pandemic, and unwillingness to prepare fish at home.

Sun et al. (2022a) used scanner data for the period September 2016 through August 2021 to broadly examine U.S. retail market trends for seafood. Results showed continuous increases in sales over the study period and further examined trends in volumes and sales by geographic region, cities, and the top 15 seafood species sold. Trout was not among the top 15 seafood species sold and, hence, trends in sales of trout were not presented in that study. A subsequent scanner data analysis focused on catfish retail market trends (Sun et al., 2022b).

Review of the literature on U.S. trout markets suggests that there is unmet market demand for trout that appears to be attracting increasing volumes of imported trout, much of which is steelhead trout imported from Norway and Chile (Fig. 1; Fig. 2). There has been little guidance provided on the dynamics of U.S. trout markets despite U.S. farms that produce and sell both rainbow and steelhead trout. This paper takes a step to fill gaps in knowledge of supermarket retail store sales of trout products by providing an analysis of five-year trends from a national supermarket scanner dataset (September 2016 through August 2021). Specific objectives were to: 1) identify overall national and regional

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[1] Mountain Region includes Idaho, Colorado, Wyoming, Montana, Utah, Arizona, New Mexico, and Nevada; West North Central Region includes: Missouri, Nebraska, Kansas, Iowa, Minnesota, North Dakota, South Dakota; South Atlantic includes Maryland, West Virginia, Virginia, Delaware, North Carolina, South Carolina, Georgia, and Florida; West South Central includes Texas, Oklahoma, Arkansas, and Louisiana.
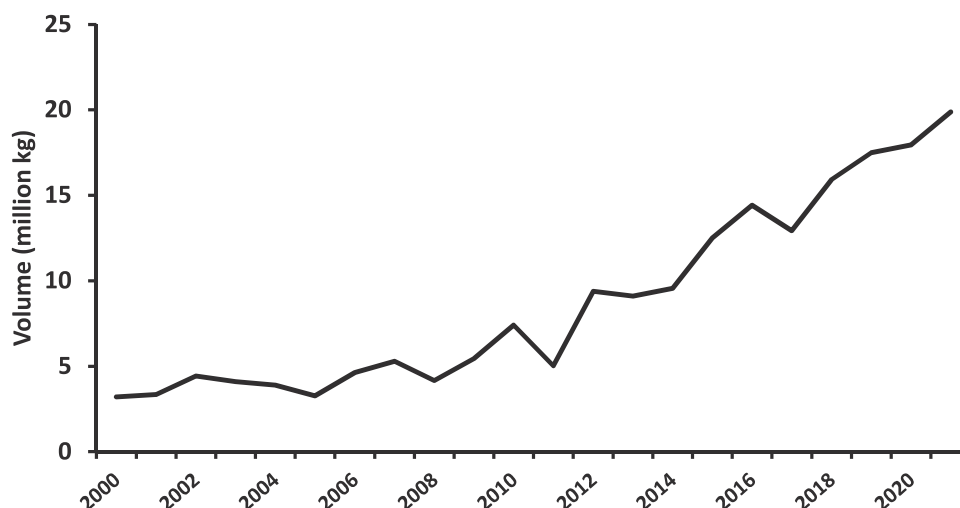
Fig. 1. Volumes (kg) of trout imported into the U,S. from 2000 to 2021.
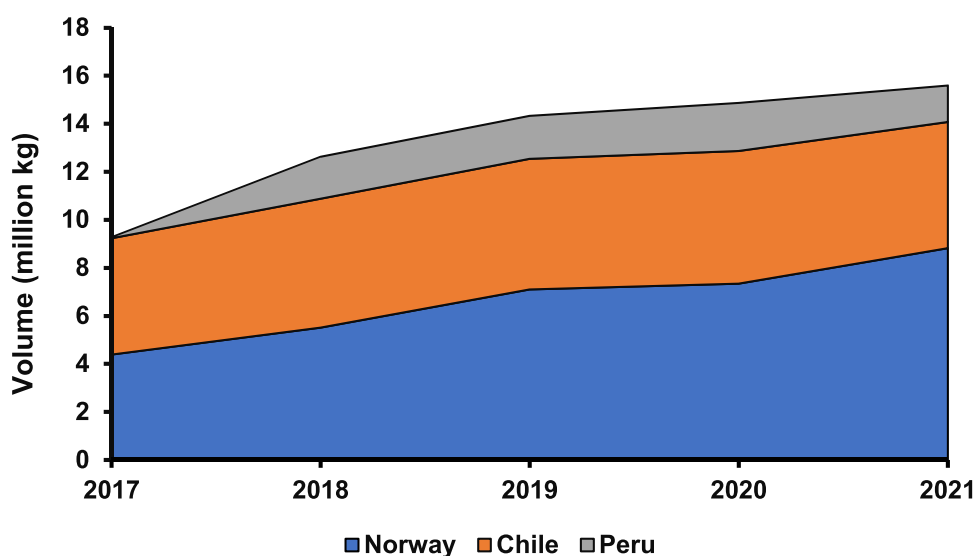SOURCE: NOAA (2022).

Fig. 2. Volumes of trout imported into the U.S. from 2017 to 2021 from the top three exporting countries Norway, Chile, and Peru.
SOURCE: NOAA (2022).

trends in supermarket sales and volumes of trout; 2) identify product-specific sales and volume trends at the national, regional, and city level; 3) examine the trends in prices for popular trout products; and 4) compare merchandising, prices, and volumes of rainbow and steelhead trout.

2. Methods

A descriptive analysis of trends in U.S. retail trout sales was developed based on a dataset of retail Scantrack data purchased from AC Nielsen Consumer LLC (New York City, New York, USA) for the five-year period from September 1, 2016 through August 31, 2021. The data included U.S. retail sales from more than 67,200 participating stores (including major retailers such as Walmart, Sam's Club, Kroger, food stores, drug stores, mass merchandisers, military stores, and dollar stores) in eight regional markets and 54 cities across the 48 continental states. The data is exclusively of retail sales and does not include data on restaurant sales. Absent from the data are sales by Costco, Amazon, small local grocery stores, and ethnic markets which do not participate in the AC Nielsen program. The complete dataset consists of 53 million

rows with 1.53 billion cells of weekly seafood purchase data on sales ($) and volumes (kg and counts). Some products sold in supermarkets do not include weight information and are sold by "count", without sufficient conversion information to convert to weight. Products sold by weight accounted for 94% of all sales of seafood; thus, this analysis focused on the observations with weight information and excluded the 6% of datapoints of products sold as "counts".

The data are based on Universal Product Codes (UPCs), or bar codes that are scanned when checking out of stores. The bar codes in the dataset contain information on 53 major seafood categories, the form and type of the product, size and material of the package, the label, and whether sold under a promotional offer at the time of purchase. Label categories are either "private" (sold under a store brand), "company" (that includes the brand of the supplier), or "other" (sold with only a broad descriptor such as "fish").

The data were cleaned, organized into a format appropriate for analysis and observations of various forms of trout disaggregated from the remaining data. The "trout-only" dataset included 750,000 rows with 27 million cells. The trout data were assembled by year to examine trends in sales and volumes (kg) for comparison across geographic

regions (South Central, South Atlantic, New England, Pacific, East North Central, West North Central, and Mountain), cities (Table 1), and nationally over the five-year period of the data. Given that data became available as of September 1, 2016, the five-year periods consisted of: 2016–2017; 2017–2018; 2018–2019; 2019–2020; and 2020–2021. Trends over time were further compared by type and size of packaging, product form (frozen and refrigerated/entrée/shelf stable), cut (fillet, whole), whether value-added, by label type, and whether sold with a promotional incentive.

The dataset revealed a large number of different names used for supermarket sales of trout. The various names were divided into the following categories of types of trout for subsequent analyses: rainbow trout, steelhead trout, marine trout, and other freshwater trout (Table 2). Sales and volumes were compared across the various types of trout. The analyses developed were descriptive and presented in a way that the identified trends would be accessible to trout producers, the stakeholders for this analysis.

While rates of inflation reached 40-year highs in 2022, the rate of inflation over the period of study of this dataset was only 1.88% for a majority (90%) of the months in the study and 2.16% over the entire dataset (United States Census Bureau, 2022). The data show trends of slightly increasing prices in both nominal and real prices over the study period, but the trendline of the difference between nominal and real prices is flat (Sun et al., 2022a). Because the stakeholders of this project rely primarily on nominal rather than real, prices, and the trends of nominal and real prices were similar, this analysis focused on trends in nominal prices and sales for ease of interpretation by stakeholders.

3. Results

3.1. National trends

The greatest proportion of sales of trout in U.S. retail markets (95–97%) were sold by weight, with only 3–5% of trout products sold by count (Fig. 3). The higher percentage of trout products that were sold by weight combined with the lack of label information that would be required to convert product sold by count to weight (kg), led to a focus on the weight information for this analysis.

Retail sales of trout in the U.S. grew from 2016 to 2017 to a plateau of $135 million in 2018–2019 (Fig. 4). The volume of trout sold at retail also grew for the first two years of the study period and then plateaued for the last three years (Fig. 5). Price declined somewhat from 2018 to 2019–2020–2021. Average annual growth in sales, volume, and price over the study period were 8.3%, 8%, and 0.75%, respectively (Fig. 6).

Table 2

Types of trout included in the A.C. Nielsen Scantrack retail database and how each was classified in the analysis.

Rainbow	Steelhead	Marine	Other freshwater
Trout	Steelhead	Sea trout	Brook trout
Rainbow trout	Steelhead trout	Speckled sea trout	Brown trout
Golden trout	Chilean steelhead	Silver sea trout	Italian trout
Golden rainbow trout	Chilean steelhead trout	Spotted sea trout	Lake trout
Idaho trout	Columbia River steelhead	Grey trout	Pan trout
Idaho rainbow trout	Norwegian steelhead	Sand trout	Red trout
Red rainbow trout	Norwegian steelhead trout	Speckled trout	
Ruby trout	Red steelhead trout	Bay trout	
Ruby red trout	Scottish steelhead trout	Ocean trout	
Ruby red rainbow trout	Steelhead salmon	Scottish ocean trout	
Butterfly trout	Salmon trout	White trout	
Rainbow butterfly trout	Steelhead salmon trout		
Andean rainbow trout	Steelhead lox		
Winter trout	Steelhead nova lox		
Rainbow trout salmon			
Not applicable			

3.2. Regional trends

The greatest regional sales of trout were in the South Atlantic region, followed in descending order by the Pacific, South Central, East North Central, Middle Atlantic, Mountain, West North Central, and New England with the lowest sales (Fig. 7). The top three regions (South Atlantic, Pacific, and South Central) accounted for 63% of total trout sales in the U.S. Sales were similar in the East North Central, Middle Atlantic, and Mountain regions, accounting for 27% of national sales. Sales in the South Atlantic region were nine times greater than those in New England.

The greatest average annual growth rate of trout sales was in the West North Central region, followed by the South Atlantic and South Central regions (Table 3). The average annual growth rate was negative (−1%) in both the Middle Atlantic and New England regions. By volume, average annual growth rates were similar in rank and magnitude to those of sales revenue (Table 4).
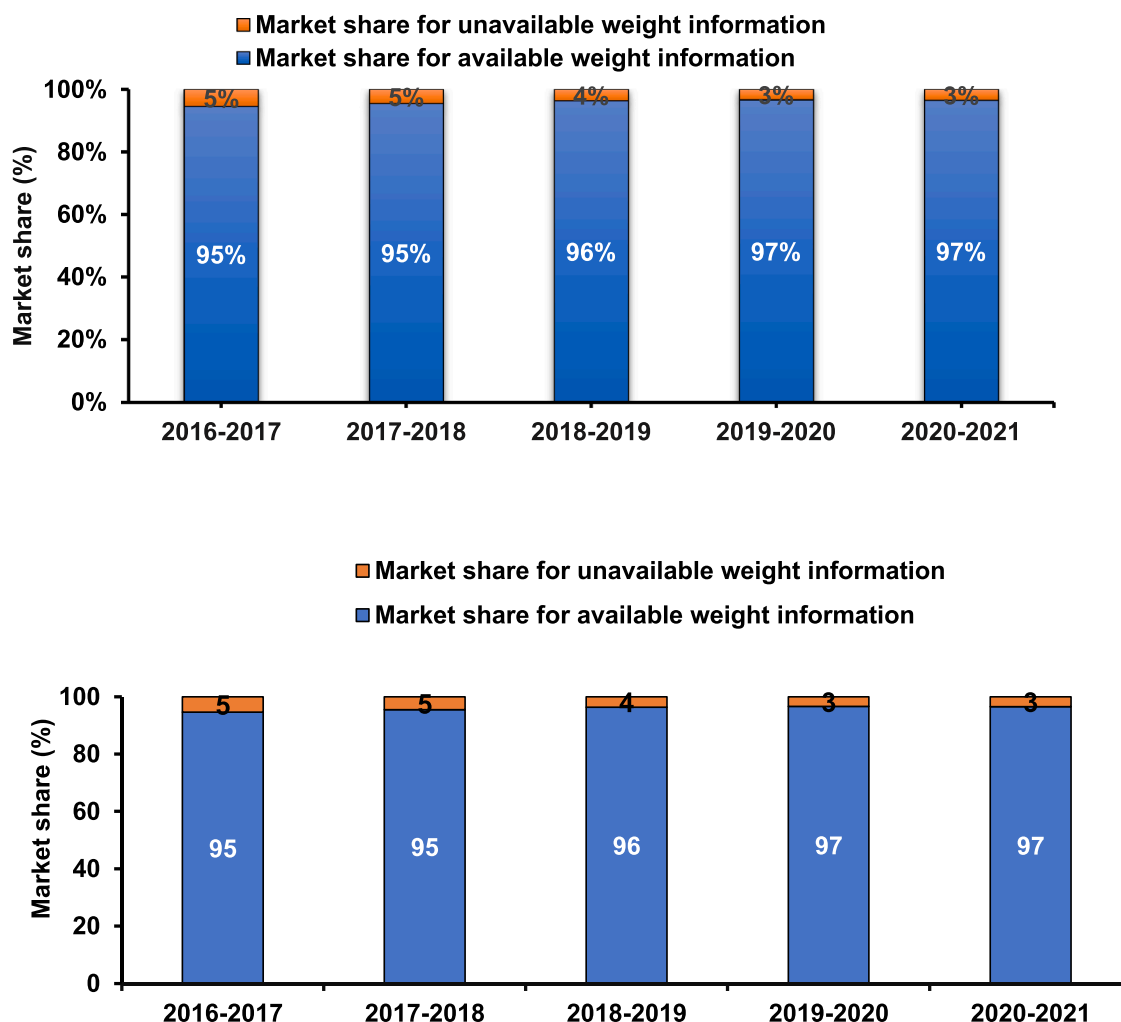
Table 1

U.S. cities in each U.S. geographic region as classified in the AC Nielsen Scantrack retail database.

East North Central	Middle Atlantic	Mountain	New England	Pacific	South Atlantic	South Central	West North Central
Chicago	Albany	Denver	Boston/ Manchester,	Fresno	Atlanta	Austin	Kansas City
Cincinnati	Buffalo	Las Vegas	Hartford/ New Haven	Los Angeles	Baltimore	Birmingham/ Tuscaloosa	Minneapolis
Cleveland	Harrisburg/ Lancaster	Phoenix	Providence/ New Bedford	Portland, OR	Charlotte	Dallas/ Fort Worth	St. Louis
Dayton	New York	Salt Lake City		Sacramento	Greensboro	Houston	
Detroit	Philadelphia			San Diego	Greenville	Knoxville	
Grand Rapids	Pittsburgh			San Francisco/ Oakland/ San Jose	Jacksonville	Louisville	
Indianapolis				Seattle/Tacoma	Miami	Memphis	
Milwaukee					Norfolk/ Newport News	Mobile/ Pensacola	
					Orlando	Nashville	
					Raleigh/ Durham	New Orleans	
					Tampa/Fort Myers	San Antonio	
					Washington District of Columbia		

Fig. 3. Market share (%) of sales of trout products by whether weight information was reported, 2016–2017–2020–2021, AC Nielsen Scantrack retail market database.
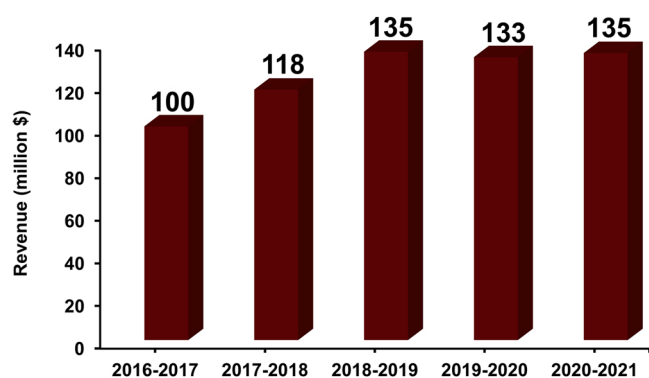

Fig. 4. Total national retail trout sales (in million US$), 2016–2017–2020–2021, AC Nielsen Scantrack retail market database.

Prices for trout exhibited an average annual growth rate of 0.4% nationally, but across regions ranged from − 1.2–1.9% (Table 5). The greatest percentage increase in trout prices was in New England, the region with the lowest overall sales of trout, followed by the Pacific region, the second-greatest regional market for trout, and then the West North Central region, one of the regions with lower overall sales. The two regions with declining average annual prices, the Mountain and East North Central regions, were two of the regions with lower overall sales

and lower growth rates of sales over the study period.

3.3. Trends in major cities

By city, the greatest annual sales for trout in 2020–2021 were in Seattle/Tacoma (5.3% market share), followed by Portland, Oregon (4.4% share), Atlanta (3.9% share), and then New York (3.4% share) (Fig. 8). Other cities in the top 10 for sales of trout were, in descending order, Tampa/Fort Myers, Los Angeles, Washington District of Columbia (DC)/Hagerstown, Denver, Miami/West Palm Beach, and San Francisco/Oakland/San Jose.

Over the 5-yr study period, the cities of Atlanta, Tampa/Fort Myers, and Miami/West Palm Beach had the greatest average annual growth rate in sales, 3% (Table 6) and by volume (million kg), 14%, 14%, and 12%, respectively (Table 7). Only one city, New York, had a negative average annual sales growth rate, but by volume, both New York and Washington DC/Hagerstown had negative average annual growth rates.

In 2019–2020, the data year that included the onset of the COVID-19 pandemic, several cities showed double digit percentage increases in sales revenue, including Seattle/Tacoma, Portland, Oregon, and Los Angeles (Table 6), and in volume (Table 7); but in most cities, growth rates declined in the following data year (2020–2021). In contrast, average annual growth rates of sales revenue were negative in 2019–2020 in New York, Tampa/Fort Myers, Denver, Miami/West Palm Beach, and Dallas/Fort Worth.
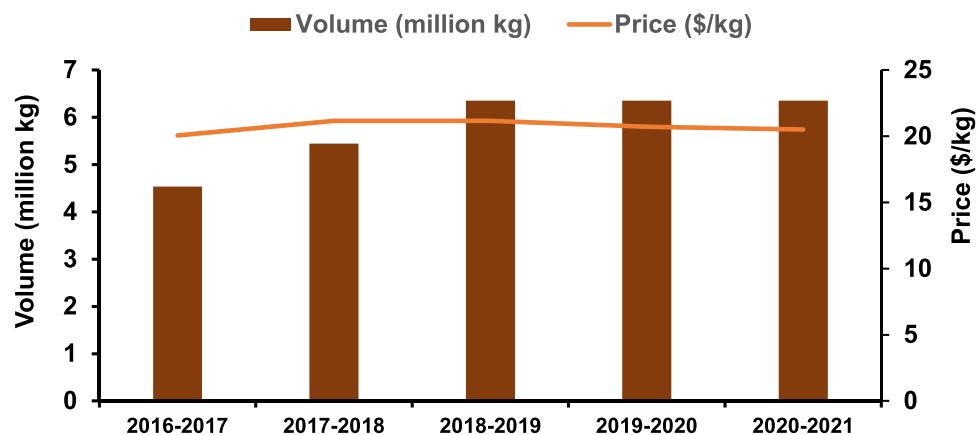
Fig. 5. Volumes (million kg) and prices (US$/kg) of trout products sold nationally in U.S. retail markets, 2016–2017–2020–2021, AC Nielsen Scantrack retail market database.
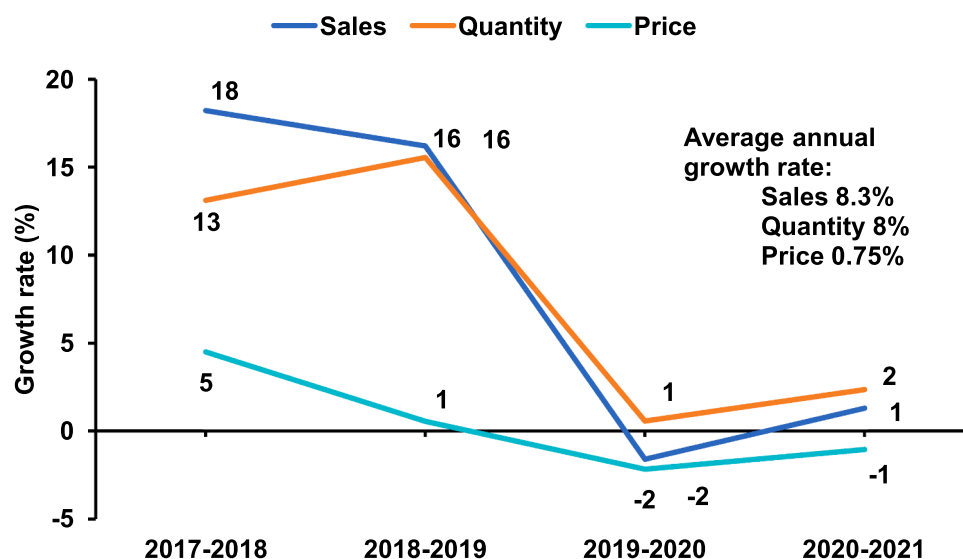

Fig. 6. Annual growth rate for trout sales, quantity and price, in U.S. retail markets, 2016–2017–2020–2021, AC Nielsen Scantrack retail market database.
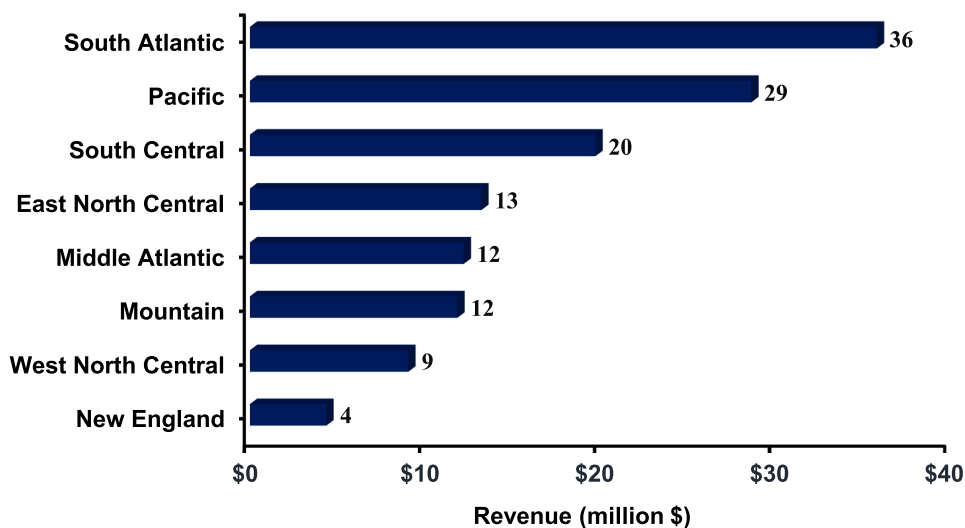

Fig. 7. Regional sales (million U.S. $) of trout products sold in U.S. retail markets, 2020–2021, AC Nielsen Scantrack retail market database.

Table 3
Regional average annual growth rate of trout retail sales (in million US$), 2016–2017–2020–2021,AC Nielsen Scantrack retail market database.

| Regions	2016–2017 (million $)	2017–2018 (million $)	2018–2019 (million $)	2019–2020 (million $)	2020–2021 (million $)	Average annual growth rate (%)
West North Central	5	7	9	8	9	15
South Atlantic	23	30	38	37	36	10
South Central	13	18	22	20	20	10
Mountain	9	10	11	11	12	7
Pacific	22	22	22	27	29	5
East North Central	11	20	6	-11	4	4
Middle Atlantic	13	12.5	14	13	12	-1
New England	5	4	4	4	4	-1
U.S. retail market	100	118	135	133	135	6

Table 4
Regional average annual growth rate of retail volume (in million kg) of trout sold, 2016–2017–2020–2021, AC Nielsen Scantrack retail market database.

Regions	2016–2017	2017–2018	2018–2019	2019–2020	2020–2021	Average annual growth rate (%)
West North Central	0.23	0.32	0.41	0.36	0.41	14
South Atlantic	1.09	1.09	1.36	1.77	1.77	10
South Central	0.59	0.82	1.00	0.95	0.95	10
Mountain	0.41	0.45	0.50	0.54	0.59	8
Pacific	1.00	0.95	1.00	1.22	1.32	6
East North Central	0.54	0.64	0.68	0.59	0.64	4
Middle Atlantic	0.64	0.59	0.64	0.64	0.59	-1
New England	0.23	0.18	0.18	0.18	0.18	-2
U.S. retail market	4.72	5.35	6.17	6.21	6.35	6

Table 5
Annual prices (US$/kg) of trout in regional markets, 2016–2017–2020–2021, AC Nielsen Scantrack retail market database.

Regions	2016–2017	2017–2018	2018–2019	2019–2020	2020–2021	Average annual growth rate (%)
South Atlantic	20.7	21.6	21.2	20.9	21.2	0.5
Pacific	19.4	19.8	21.2	20.7	20.5	1.1
Middle Atlantic	20.3	20.7	21.6	21.2	20.5	0.3
South Central	19.8	21.4	21.2	20.5	19.8	0
East North Central	20.3	20.5	20.5	19.8	19.8	-0.3
Mountain	20.7	22.3	21.4	20.5	19.4	-1.2
West North Central	19.6	21.2	20.7	20.5	20.5	1.0
New England	20.3	21.4	22.7	22.3	22.3	1.9
U.S. retail market	20.1	21.2	21.2	20.7	20.5	0.4
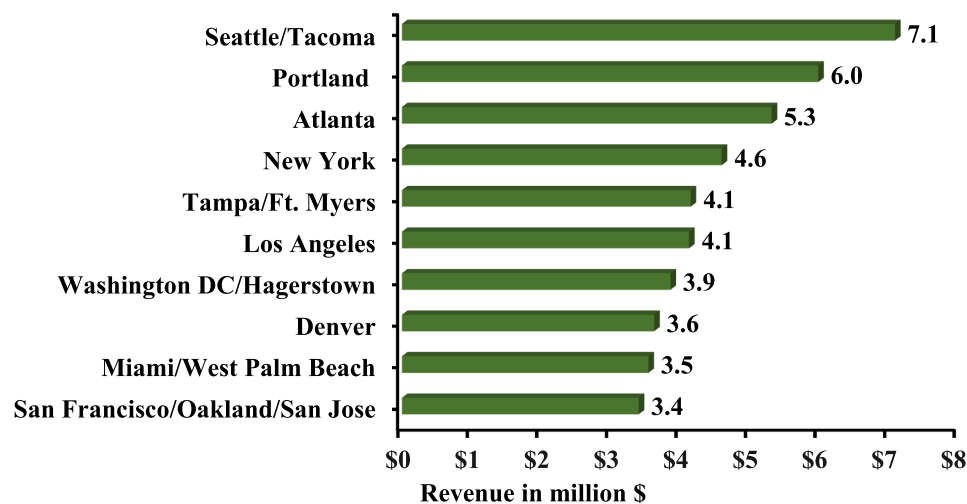
Fig. 8. Top 10 cities for annual sales (million U.S. $) of trout in U.S. retail markets, 2020–2021, AC Nielsen Scantrack retail market database.

The average annual price of trout decreased in 7 of the 12 top cities for trout (Table 8). The cities that showed an average increase in price over the study period were: Seattle/Tacoma, Los Angeles, Washington DC/Hagerstown, San Francisco/Oakland/San Jose, and Philadelphia.

3.4. Package Sizes and Materials

Ninety percent of the trout sold was packaged in 454-g packages, followed by 3.5% sold as "1-count" and 3.4% sold in 227-g packages

Table 6

Annual growth rate of sales revenue (million US$) for top 12 cities for trout sales, 2016–2017–2020–2021, AC Nielsen Scantrack retail market database.

Top cities for trout sales	2016–2017 (million $)	2017–2018 (million $)	2018–2019 (million $)	2019–2020 (million $)	2020–2021 (million $)	Average annual growth rate (%)
Seattle/Tacoma	6.1	6.0	5.7	7.2	7.1	1
Portland, Oregon	4.5	4.5	4.7	5.3	6.0	1
Atlanta	3.1	4.2	4.9	4.9	5.3	3
New York	6.4	5.3	5.9	5.3	4.6	-1
Tampa/Fort Myers	2.5	3.2	4.5	4.3	4.1	3
Los Angeles	3.0	2.6	3.3	4.0	4.1	2
Washington District of Columbia/Hagerstown	3.7	4.5	5.1	5.4	3.9	1
Denver	3.4	4.3	4.1	3.9	3.6	1
Miami/West Palm Beach	2.3	2.9	3.8	3.5	3.5	3
San Francisco/Oakland/San Jose	2.5	2.5	2.8	2.0	3.4	2
Philadelphia	3.1	3.1	3.6	3.6	3.3	0
Dallas/Fort Worth	2.4	3.3	3.9	3.5	3.3	2

Table 7

Annual growth rate of volume (million kg) for top 12 cities for trout sales, 2016–2017–2020–2021, AC Nielsen Scantrack retail market database.

Top cities for trout sales	2016–2017	2017–2018	2018–2019	2019–2020	2020–2021	Average annual growth rate (%)
Seattle/Tacoma	0.28	0.29	0.25	0.34	0.32	3
Portland, Oregon	0.21	0.22	0.21	0.26	0.30	9
Atlanta	0.13	0.17	0.20	0.21	0.23	14
New York	0.30	0.25	0.27	0.24	0.22	-6
Los Angeles	0.16	0.11	0.15	0.18	0.20	5
Tampa/Fort Myers	0.11	0.14	0.20	0.20	0.19	14
Washington District of Columbia/Hagerstown	0.17	0.21	0.24	0.25	0.16	-1
Dallas/Fort Worth	0.11	0.15	0.18	0.17	0.16	9
Denver	0.14	0.16	0.17	0.16	0.16	3
Miami/West Palm Beach	0.10	0.12	0.17	0.16	0.16	12
San Francisco/Oakland/San Jose	0.10	0.10	0.10	0.10	0.12	4
Philadelphia	0.15	0.14	0.16	0.17	0.15	1

Table 8

Annual prices (US$/kg) for trout for top 12 cities for trout sales, 2016–2017–2020–2021, AC Nielsen Scantrack retail market database.

Top cities for trout sales	2016–2017	2017–2018	2018–2019	2019–2020	2020–2021	Average annual change in price (%)
Seattle/Tacoma	21.22	20.53	22.07	21.04	22.09	0.8
Portland, Oregon	20.00	18.58	20.34	20.12	19.78	-0.2
Atlanta	22.22	23.19	22.69	22.30	22.09	-0.1
New York	20.77	20.88	22.15	22.28	20.69	-0.1
Los Angeles	17.19	20.53	20.96	19.90	18.86	1.9
Tampa/Fort Myers	22.41	23.55	21.76	21.45	21.64	-0.7
Washington District of Columbia/Hagerstown	21.37	21.19	21.31	21.50	23.20	1.7
Dallas/Fort Worth	20.71	22.14	21.72	20.98	20.07	-0.6
Denver	23.92	26.43	24.64	23.87	22.27	-1.4
Miami/West Palm Beach	23.01	24.11	22.79	21.93	22.05	-0.8
San Francisco/Oakland/San Jose	17.95	21.61	21.86	22.69	22.81	5.4
Philadelphia	20.86	21.17	22.04	21.12	21.14	0.3

(data not shown). Most trout sales (93%) did not indicate whether trout were sold in a bag, can, tray pack or box (data not shown). For those few that did, 4.1% were sold in a bag, 1.5% in a can, 0.6% in a tray pack, and 0.5% in a box (data not shown).

3.5. Product Forms

Trout products sold in supermarkets were sold primarily (95–97%) in the "frozen and refrigerated seafood" category across all study years (data not shown), with 2.7% sold as entrées and 1.5% sold as a shelf stable product. Moreover, high percentages (87–91%) of trout were sold without value-addition. In 2020–2021, for example, 89% of trout sold were not value-added, with 5% sold as smoked, 1.3% seasoned, 1.5% canned, and 3% other value added such as boxed, breaded, or in a canister (data not shown). By product cut, 64% of trout were sold as fillets, with only 4% sold whole, and 32% were sold without specifying the product cut (data not shown).

3.6. Labels

Of the trout sold over the study period, 88–92% were sold without a brand listed (sold as "other", with only a broad descriptor such as "fish") (data not shown). Trout sold with a "company" label (supplier brand name included) accounted for 6% of sales in 2020–2021, while those sold with a "private" label (store brand) accounted for 2% of sales in that year.

3.7. Promotional sales

The proportion of trout sold under some type of promotion ranged from a low of 20% in 2018–2019 to highs of 29% and 28% for 2016–2017 and 2017, 2018, respectively (Fig. 9). The extent of promotion varied substantially by region (Fig. 10). The Pacific region led all other regions in 2020–2021 with the greatest percentage of trout sold under promotion, (41%), followed by the West North Central region at 30%. The remaining regions all had proportions of trout sold under
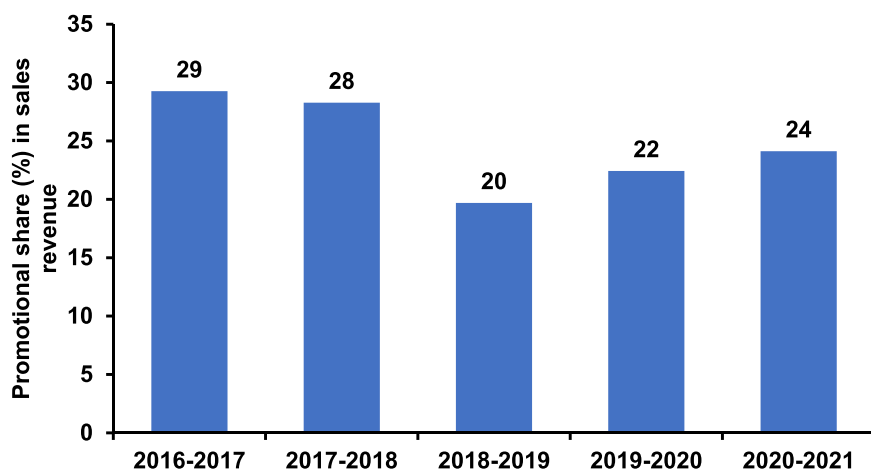
Fig. 9. Share (%) of trout products sold under promotion in U.S. retail markets, 2016–2017–2020–2021, AC Nielsen Scantrack retail market database.
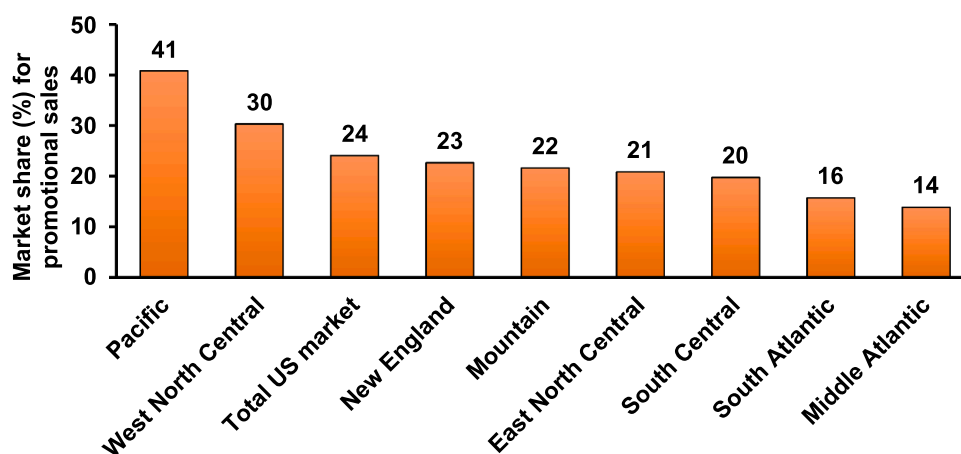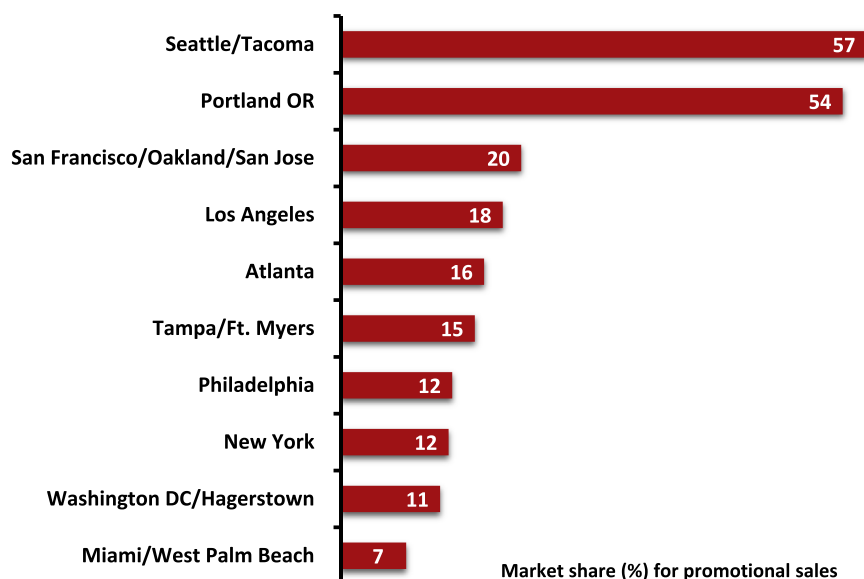

Fig. 10. Shares (%) of trout products sold under promotion by region in U.S. retail markets, 2020–2021, AC Nielsen Scantrack retail market database.

promotion that were less than the national average of 24%. The lowest percentages of trout sold under some type of promotion were found in the South Atlantic (16%) and Middle Atlantic (14%) regions. The top

four cities for promotional shares of trout were in the Pacific region and included: Seattle/Tacoma (57%), Portland, Oregon (54%), San Francisco/Oakland/San Jose (20%), and Los Angeles (18%) (Fig. 11). In

Fig. 11. Shares (%) of trout products sold under promotion by city in U.S. retail markets, 2020–2021, AC Nielsen Scantrack retail market database.

contrast, Miami/West Palm Beach had promotional market shares of only 7% in 2020–2021.

3.8. Comparisons by types of trout

Of the various types of trout sold in U.S. supermarkets, steelhead trout accounted for the greatest market share (72%), with $97.2 million in sales, followed by rainbow trout (26% market share; $35.5 million in sales), freshwater trout (1% market share; $1.6 million in sales), and marine trout (0.4% market share; $0.6 million in sales) (Table 9). However, the highest average prices in 2020–2021 ($/kg) were for rainbow trout, followed by those for steelhead, marine, and freshwater trout. By region, rainbow prices exceeded those of steelhead trout by 5.4–22.2%; with the greatest differential in the West North Central, followed by the East North Central, the South Atlantic, and South Central regions, with a 9.9% overall differential in prices (data not shown).

Nearly all (99%) steelhead and marine trout were sold without value addition, as compared to 60% for rainbow trout and 90% of freshwater trout (Table 9). Smoked trout was the most common form (16%) of value addition for rainbow trout, followed by canned, seasoned, breaded, and boxed. Twelve percent of rainbow trout was sold as an "other" (unspecified) type of value-added product.

The most common package size of all trout products sold was a 454-g package for 98% of steelhead trout, followed by 86% of marine trout, 70% of rainbow trout, and 62% of freshwater trout (Table 9). The next most important package size for rainbow trout was a 270-g package that was exclusive to rainbow trout. The only other "size" sold was that of "1 count" which accounted for 38% of freshwater trout sold, 14% of marine trout, 7% of rainbow trout, and 2% of steelhead trout.

Annual supermarket sales revenue of steelhead trout increased rapidly from 2016 to 2017–2018–2019 but then decreased through 2020–2021 (Fig. 12). Rainbow trout sales revenue was relatively constant from 2016 to 2017 through 2019–2020, but then increased to a five-year high in 2020–2021.

The most important regional market for both steelhead and rainbow trout was the South Atlantic region (Fig. 13). For steelhead trout, the next most important regions were the Pacific and South Central regions; whereas for rainbow trout, the second most important region was the Middle Atlantic region, followed by the Pacific region. For steelhead trout, the South Atlantic, Pacific, and South Central regions were of much greater importance to sales than the other regions. A closer examination of steelhead trout sales over the five-year study period shows sales growth only in the Pacific and Mountain regions (Fig. 14).

Per-capita consumption ($/person) of steelhead trout was greatest in the Pacific, South Atlantic, and Mountain regions; three of the top four sales regions for steelhead trout sales. The South Central region was the 3rd-greatest by overall sales, but per-capita consumption ranked relatively much lower than in other regions (Table 10). For rainbow trout, the top two regions for per-capita consumption were the same as those for overall sales (South Atlantic and Middle Atlantic, respectively), but the third-most important region by per-capita consumption was the New England (rather than the Pacific) region.

The top cities for sales of steelhead trout differed from those of rainbow trout (Table 11). The top four cities for steelhead trout sales were: Seattle/Tacoma, Portland, Oregon, Atlanta, and Tampa/Fort Myers whereas for rainbow trout, the top cities were: Washington DC/Hagerstown, New York, Los Angeles, and Philadelphia. The only city in which rainbow trout showed a greater market share than steelhead trout was Washington DC/Hagerstown; New York showed similar market shares of rainbow (49%) and steelhead (51%) trout (Table 12).

Greater percentages of steelhead trout were sold under some type of promotional incentive than were rainbow trout, with relative proportions of trout sold under promotion lower in the later years of the study as compared to the earlier years (Fig. 15). Percentages of steelhead trout sold under promotion ranged from 22% to 36% over the study period, increasing from a low of 22% in 2018–2019–28% in 2020–2021 for steelhead trout. Rainbow trout percentages sold under promotion ranged from 11% to 16% over the study period, increasing from the low of 11% in 2019–2020–14% in 2020–2021.

3.9. Imports as compared to U.S. production

The volumes of trout fillets have been relatively constant from 2018 through 2021, following a 30% increase from 2017 to 2018 (Fig. 16), and were consistent with the findings from the retail market scanner data in this study. However, the volume of whole trout imports has grown steadily since 2017, with an average annual increase of 26%. Given that the scanner data shows that only 6% of the trout sold in supermarkets were sold as whole trout, it is likely that the increased volumes of whole trout imports were sold to restaurants, not the retail market.

Some trout are exported from the U.S., but in relatively small volumes, 900,000 kg of whole trout in 2021 and 300,000 kg of trout fillets in 2021 (data not shown). Thus, net import trends largely reflect those of gross imports, with little effect of exported trout volumes. Net imports of trout fillets have been variable, but declined from 2019 to 2021, with a − 4% average annual growth rate from 2017 to 2021 (Table 13). Net imports of whole trout were even more variable, but averaged 8% growth annually.

4. Discussion

Trout is an important foodfish sector of U.S. aquaculture, but expansion of this mature sector of U.S aquaculture has been challenging (Fornshell, 2002). Various reports by trout producers have suggested unmet demand for trout in the U.S. as a result primarily of regulatory constraints to expansion (Engle et al., 2005, 2019, 2021). Increasing volumes of imported steelhead and rainbow trout from Norway, Chile, and Peru substantiate assertions of unmet market demand. Understanding the trends in sales and prices of various trout products and potential substitutes is critical. Moreover, given that preferences for specific species of seafood have tended to vary by geographic region (Singh et al., 2014; Surathkal et al., 2017; Engle et al., 2017; Engle, 2019), the ability to disaggregate marketing data geographically is important to understand trends for each sector of U.S. aquaculture. This paper provides a descriptive analysis of disaggregated trends of supermarket sales by region and by cities across the U.S. as a basis for developing hypotheses for subsequent quantitative analyses to provide additional insight into appropriate marketing strategies for U.S. trout producers in various markets.

Table 9
Sales revenue, volumes, and price by type of trout sold, 2020–2021, AC Nielsen Scantrack retail market database.

	Steelhead	Rainbow	Freshwater	Marine
Sales revenue				
Revenue (million US$)	97.2	35.5	1.6	0.6
Market share (%)	72	26	1	0.4
Volume (million kg)	4.8	1.5	0.0	0.0
Price (US$/kg)	20.06	22.05	14.55	19.84
Market share of value added				
Non-value added (%)	99	60	90	99
Smoked (%)	0.53	16	10	0
Canned (%)	0	6	0	0
Seasoned (%)	0	5	0	0
Breaded (%)	0	1.2	0	0
Box (%)	0	0.1	0	0
Other (%)	0	12	0	0
Package size[a]				
454 g	98	70	62	86
270 g	n.a.	13	n.a.	n.a.
1 count	2	7	38	14

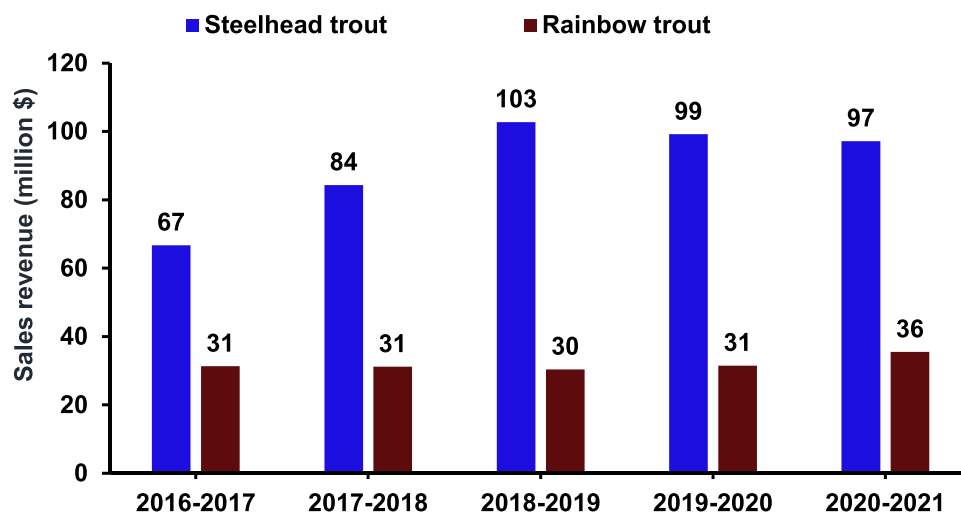[a] Other sizes reported included 113 g (3.5%), 680 g (2%), 142 g (1%), 340 g (1%).

Fig. 12. Annual revenue (million $) over time of steelhead and rainbow trout in U.S. retail markets, AC Nielsen Scantrack retail market database.
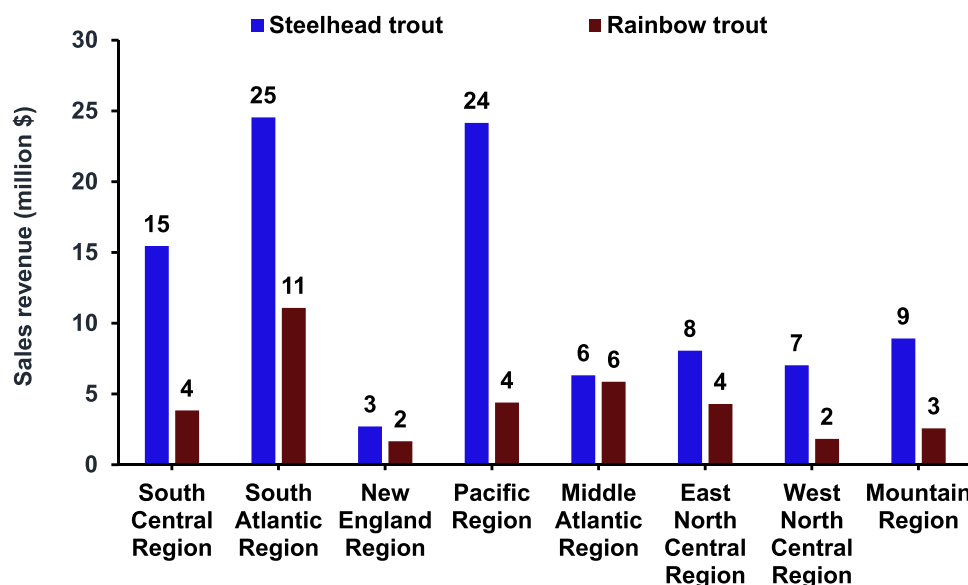

Fig. 13. Revenue (million $) for steelhead and rainbow trout products by region in U.S. retail markets, 2020–2021, AC Nielsen Scantrack retail market database.

The decreased trout sales found in this study in the 2019–2020 and 2020–2021 data years contrast sharply with the growth of supermarket sales observed in these same years across seafood sales generally (Sun et al., 2022a) and for most individual seafood products, including catfish (Sun et al., 2022b). While trout is the second-most farmed finfish species in the U.S., it ranked 20th among the top seafood species sold at retail in the U.S. (Table 13). The decrease in prices for trout from 2018 to 2019–2019–2020 also contrasts with the respective increases in prices for the top seafood products, including catfish. The data years of 2019–2020 and 2020–2021 include months following the onset of the COVID-19 pandemic and the subsequent economic shutdowns. The economic shutdowns resulted in severe disruptions to sales of aquaculture products in the U.S. (van Senten et al., 2020, 2021) and around the world, as many U.S. aquaculture producers were forced to attempt to pivot to supermarket from restaurant sales. It appears from the results of this study, that trout sales and prices were affected negatively to a greater extent than those of seafood generally and catfish specifically. Additional research is needed to examine what factors contributed to this apparent differential effect.

The expected regional preferences for trout as compared to catfish and other products was observed clearly in this analysis. For example,

the Pacific region (especially the cities of Seattle/Tacoma and Portland, Oregon) was of much greater importance for trout, as compared to general seafood (South Atlantic; but New York among cities) (Sun et al., 2022a) and catfish (South Central; Dallas/Fort Worth and Chicago by city) (Sun et al., 2022b).

Data on sales of trout were complicated by the wide array of differing types of trout, from marine to freshwater species; but also in that rainbow trout can be grown in either freshwater or marine environments. Steelhead trout (rainbow trout grown in marine environments) have by far the greatest market share of trout sales, perhaps competing to some degree with salmon in size and fillet color. The increased volumes of steelhead trout sold in U.S. supermarkets from 2017 to 2018 have been accompanied by a gradual decrease in its price, whereas rainbow trout prices appear to have remained relatively stable (Fig. 17). Rainbow trout appear to occupy a slightly different position in the marketplace, as a smaller fillet that is preferred in cities and regions where native populations of rainbow trout have commonly been caught from wild mountain streams for centuries.

While Landazuria et al. (2020) found strong integration of salmon and steelhead export prices from Norway, it may be that steelhead occupies somewhat of a different market niche in the U.S. than either
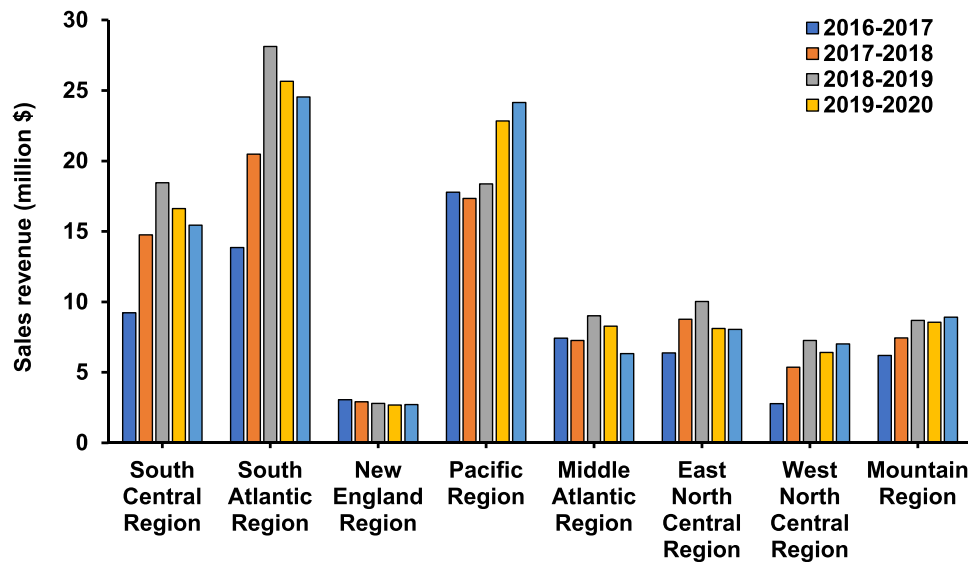
Fig. 14. Steelhead trout revenue (million $) in U.S. retail markets by region, 2016–2017–2020–2021, AC Nielsen Scantrack retail market database.

Table 10

Total retail rainbow and steelhead trout sales per capita by region (US$/person), 2021. Calculated by dividing the total sales of trout reported in the AC Nielsen Scantrack retail market database by the population in each region.

Regions	Steelhead trout	Rainbow trout
Pacific	0.45	0.08
South Atlantic	0.39	0.17
Mountain	0.36	0.12
West North Central	0.32	0.09
South Central	0.25	0.07
New England	0.20	0.13
East North Central	0.17	0.08
Middle Atlantic	0.14	0.14
U.S. retail market	0.29	0.11

Table 11

Top cities for steelhead trout and for rainbow trout by sales (million US$), 2020–2021, AC Nielsen Scantrack retail market database.

Steelhead trout		Rainbow trout	
Cities	Sales (million US $)	Cities	Sales (million US $)
Seattle/Tacoma	6.8	Washington District of Columbia/Hagerstown	2.6
Portland Oregon	5.8	New York	2.3
Atlanta	3.8	Los Angeles	1.6
Tampa/Fort Myers	3.4	Philadelphia	1.6
Miami/West Palm Beach	3.1	Atlanta	1.5
Dallas/Fort Worth	2.8	San Francisco/Oakland/San Jose	1.3
Orlando/Daytona Beach	2.6	Denver	1.0
Denver	2.6	Chicago	1.0
Minneapolis/St. Paul	2.6	Baltimore	0.9
Sacramento/Stockton/Modesto	2.5	Detroit	0.8

Table 12

Market share of different types of steelhead and rainbow trout in the top 10 cities by sales, 2020–2021, AC Nielsen Scantrack retail market database.

Top cities for trout sales	Steelhead trout (%)	Rainbow trout (%)
Atlanta	71	29
Denver	71	29
Los Angeles	59	40
Miami/West Palm Beach	88	12
New York	51	49
Portland Oregon	98	2
San Francisco/Oakland/San Jose	61	37
Seattle/Tacoma	95	5
Tampa/Fort Myers	83	17
Washington District of Columbia/Hagerstown	33	67

salmon or rainbow trout, perhaps explaining the diversification of Norwegian and Chilean farms into steelhead production. Additional research is needed to determine the degree to which markets for salmon, steelhead, and rainbow trout are integrated in the U.S. cities that are most important for steelhead and rainbow trout sales.

While the volume of farmed steelhead trout has grown in the U.S., so have the volumes of steelhead trout imports from Norway and Chile, notably the two largest salmon producers worldwide. Much of the growth of imports has been of whole trout, not fillets. More detailed information on imported trout product cuts is not available in trade databases nor company names/country of origin specified for 90% of the trout products listed in the scanner dataset.

The growth of trout imports has occurred despite clear strengths of U.S. trout farming that include its profitability (Engle et al., 2020) and a high efficiency of use of resources (Engle et al., 2021). For example U.S. trout farming used land, water, and energy resources more efficiently than did many other species and production systems. Moreover, the environmental sustainability of U.S. trout production is evident in its green, "Best Choice," rating by Seafood Watch. In this, there appear to be some parallels between the U.S. trout and catfish industries in the recent growth of imported, competing products. Fig. 18 shows that the live weight equivalents of imported trout appear to be increasing while those of domestic trout production have decreased.

The growth of imports may also reflect the constraints to growth of U.S. trout and salmon production as a result of the regulatory framework. Previous studies have estimated that the direct regulatory compliance burden adds $2.71/kg to the cost of producing trout in the U.S., constituting 12% of total direct costs (Engle et al., 2019), similar to the 15% found for tilapia (Engle et al., 2023a; Engle et al., 2023) and redfish (Engle and van Senten, in press). Studies on regulatory costs of other sectors of U.S. aquaculture show similarly high levels, from a low of 8.4% of catfish production costs (Hegde et al., 2023) to a high of 22%
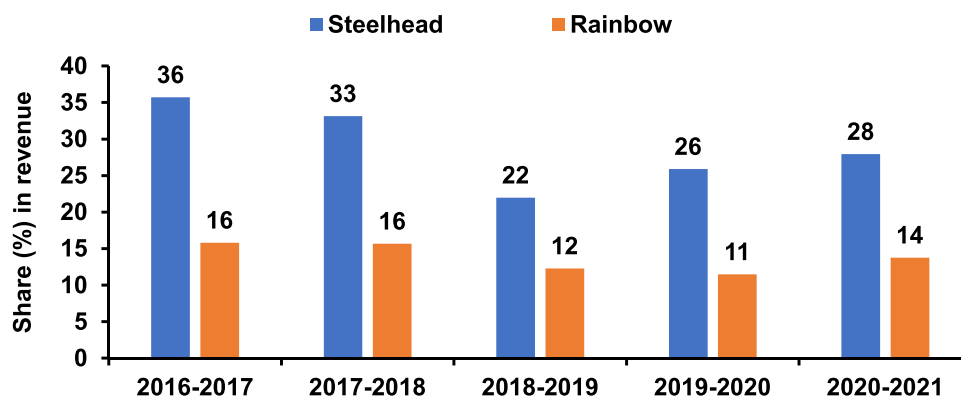
Fig. 15. Share (%) of steelhead and rainbow trout products sold under promotion in U.S. retail markets, AC Nielsen Scantrack retail market database.
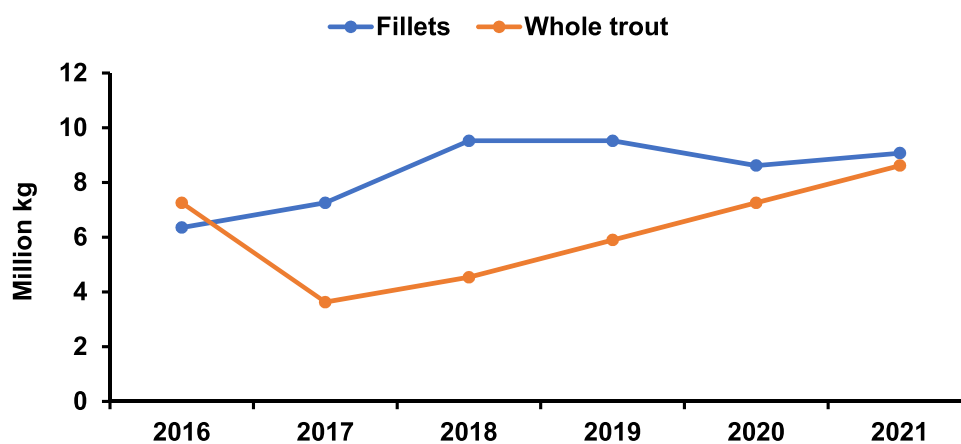

Fig. 16. Volume (million kg) of net imports (total imports minus total exports) of fillet and whole trout, 2016–2021. SOURCE: NOAA (2022).

Table 13

Growth rates of trout sales revenue from 2018 to 2019–2019–2020 with other top species sold in supermarkets, by change in sales volume (US$) and percentage change, AC Nielsen Scantrack retail market database.

Species	million $	% change
Shrimp	839	23
Salmon	476	18
Tuna	304	17
Crab	445	48
Tilapia	72	13
Cod/scrod	43	11
Lobster	103	36
Catfish	58	22
Pollock	54	21
Scallops	67	29
Anchovy/sardine	29	17
Clams	24	19
Trout	- 2.5	-2

for hybrid striped bass (Engle and van Senten, in press). On baitfish/-sportfish farms, regulatory costs exceed the value of profits on more than a third of the farms (van Senten and Engle, 2017). In addition, studies have shown a disproportionately negative economic effect on smaller as compared to larger farms that likely exacerbates economies of scale and competitiveness of smaller farms (van Senten et al., 2020; Boldt et al., 2022). Constraints to trout farmers have included prescriptive requirements for production practices (Engle et al., 2005), with lost market sales of $7.1 million/year, value of lost production of $5.3 million/yr; but perhaps more importantly, respondents estimated the value of expansion attempts that have been thwarted by regulatory action of

$40.1 million/yr. Reduction of the frequency of required testing for effluents and fish health, for farms with many years of test results showing no non-conformities, have been shown to have potential to reduce on-farm regulatory costs (van Senten et al., 2018; Engle et al., 2021). Regulatory reform that would remove barriers to expansion of U. S. trout production would not only meet growing consumer demand for locally raised food, but would contribute to economic development in many rural areas that would stimulate secondary business development (Kaliba and Engle, 2004; Hegde et al., 2022) and provide employment in rural trout-producing areas with few job opportunities (Kaliba et al., 2004). Sustainable aquaculture, such as U.S. trout production, has the potential to enhance the resilience of communities in areas of aquaculture clusters, but only if not regulated in ways that prevent its growth and expansion (Engle and van Senten, 2022).

5. Summary and conclusions

Sales of trout in supermarkets in the U.S. increased from $100 million to $135 million from 2016 to 2021, with an annual average growth rate of 8.3% for sales and 8% for volume (kg). Overall, trout prices remained relatively constant over the five-year study period in contrast to the behavior of sales and prices for seafood generally.

This study has further highlighted the importance of the use of disaggregated data for various geographic areas. Sales and price trends identified for trout differed substantially from those of catfish, likely because of differences in regional preferences for trout, catfish, and swai seafood. The largest regional retail market for trout was the South Atlantic region, with an average annual growth rate of 13%. The fastest percentage growth in sales was 19%, in the West North Central region.
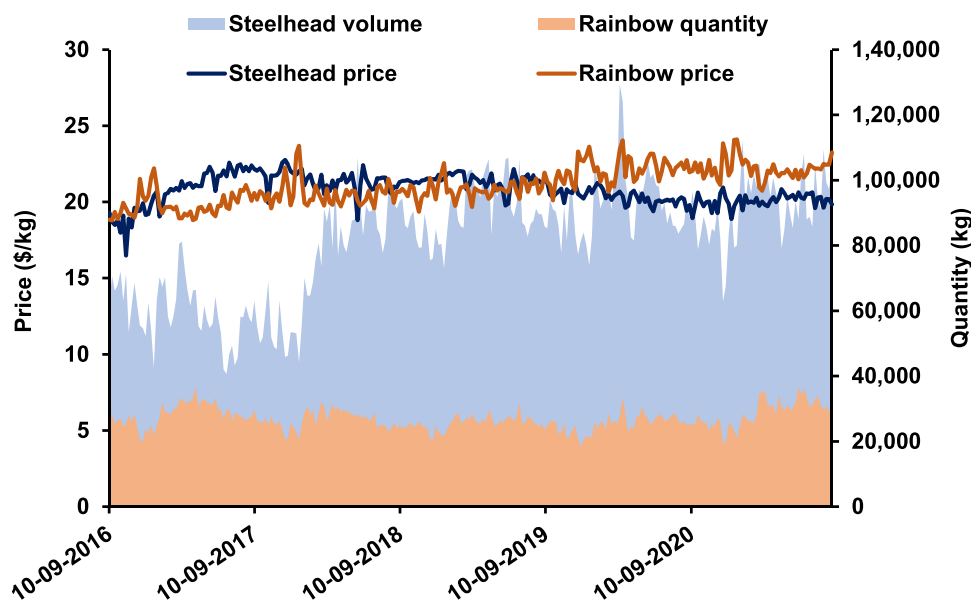
Fig. 17. Quantity (kg) and price (US$/kg) trends for steelhead and rainbow trout products sold in U.S. retail markets, September 1, 2016 to August 31, 2021, AC Nielsen Scantrack retail market database.
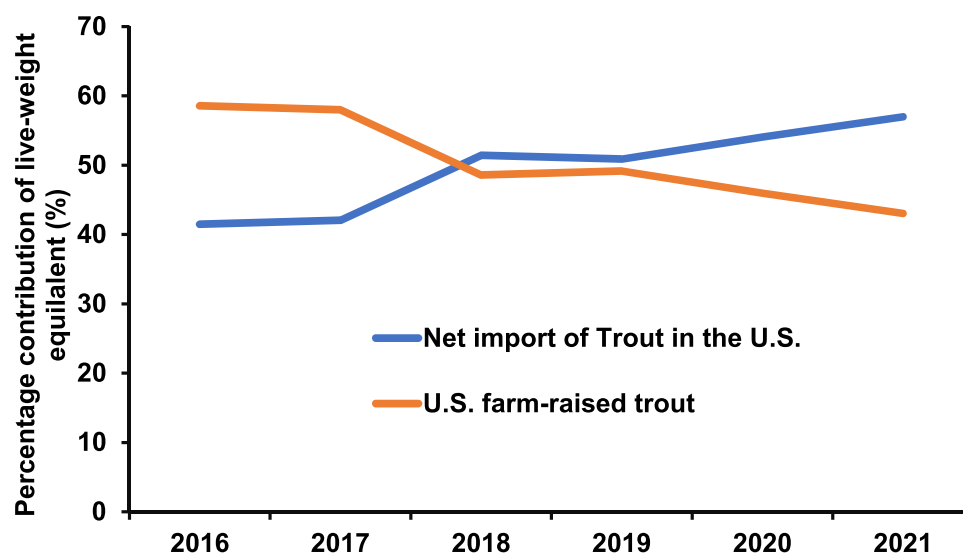

Fig. 18. Percentage share of the live-weight equivalent of imported trout products as compared to U.S. farmed trout products. Net imports equals total imports minus total exports.
SOURCE: NOAA (2022) and USDA (2022).

Despite the importance of sales in the South Atlantic region, the top cities for trout sales overall were Seattle/Tacoma and Portland, Oregon, followed by Atlanta that exhibited the fastest average annual growth rate among all cities in the study.

Steelhead trout accounted for nearly three-fourths (72%) of the trout market share, while rainbow trout sales accounted for 26% of the market share. Prices of rainbow trout increased by 12% annually, whereas prices of steelhead trout were relatively constant over the five-year study period with a slight decline after 2019.

The U.S. retail market for trout is complex. This study provides insights into important trends in market preferences. With much of the increasing demand for trout being met by imports, additional attention is needed to seek to remove the barriers to expansion that have been identified in previous studies for U.S. trout producers to capture the growing interest in their products. To do so, additional research is needed on the degree to which steelhead and rainbow trout substitute

for salmon in retail markets and whether the markets for these various salmonid products are integrated. Additional research is needed on food service sales to restaurants to identify key opportunities to meet consumer demand for steelhead and rainbow trout.

CRediT authorship contribution statement

Lansing Sun: Conceptualization, data curation, formal analysis, investigation, methodology, validation, visualization, writing: review and editing. Carole Engle: Conceptualization, funding acquisition,

investigation, methodology, writing: original daft. Ganesh Kumar: Conceptualization, funding acquisition, investigation, methodology, project administration, resources, supervision, writing: review and editing. Jonathan van Senten: Conceptualization, funding acquisition, investigation, methodology, writing: review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

The authors do not have permission to share data.

Acknowledgments

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