Received: 3 March 2019 | Revised: 17 April 2019 | Accepted: 24 April 2019

DOI: 10.1111/jwas.12619

REVIEW ARTICLE

Journal of the World Aquaculture Society

WILEY

U.S. seafood consumption

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Funding information

Gulf States Marine Fisheries Commission, Grant/Award Number: ACQ-210-039-2017-UFL; USDA National Institute of Food and Agriculture through a joint NSF-USDA program on Innovations at the Nexus of Food, Energy and Water Systems (INFEWS), Grant/Award Number: #2018-67003-27408

Abstract

U.S. seafood consumption has changed dramatically in recent decades and has become increasingly dominated by the consumption of a limited number of species that are primarily imported and predominantly sourced from aquaculture. In getting to this point, the United States has been, and still is, at the forefront of some of the most important trends in global seafood markets. Hence, discussing the factors influencing U.S. seafood consumption patterns is an interesting and informative endeavor and will most likely also have strong predictive power for the continued development of seafood markets in the United States. In this article, we will discuss the transitions in the U.S. seafood market, primarily focusing on the period from 1990 to the present, highlighting the main factors that facilitated this development. This article provides an overview of U.S. landings, aquaculture production, exports, and imports and also explores contributing trends in global export and import markets. This will be followed by a discussion of U.S. per capita consumption patterns and an examination of the consolidation of species consumed over time. Finally, implications for future trends in seafood consumption and production are discussed.

KEYWORDS

aquaculture production, exports, global seafood markets, imports, per capita consumption, U.S. seafood market, wild fisheries

1 | INTRODUCTION

U.S. seafood consumption has changed dramatically in recent decades, and currently, it is a market increasingly dominated by a few species that are primarily imported and predominantly sourced from aquaculture. The developments in U.S. seafood consumption, trade, and production in recent decades will be reviewed, and the main factors influencing development will be discussed. Given the prominent role of the United States in several dimensions of the global seafood industry, transitions in the U.S. market will most likely also provide insights into the continued development of seafood markets in the United States and beyond.

The United States, because of its geographical size with long coastlines, is one of the world's largest fishing nations. In 2017, the United States was the world's fourth largest fishing nation, with landings of 5 million m.t. (Food and Agriculture Organization, 2019). These landings have been relatively stable since the late 1980s as most federal fisheries are well-managed and fully exploited, and where there is substantial variation, it is mostly because of natural variability. While a leading aquaculture producer until the 1970s (the United States was the world's third largest aquaculture producer in 1975 (Food and Agriculture Organization, 2019)), the U.S. aquaculture industry largely has not taken part in the “blue revolution,” and its current importance as a supplier to the U.S. market is moderate.[1] Hence, U.S. seafood production has been relatively stable for quite some time and is likely to remain so.

The United States is the largest economy in the world, creating a sizable market opportunity for the producers of any product, including seafood. Imports have always been important for U.S. seafood consumption, and the country was the largest seafood importer in the world in 1976, before being overtaken by Japan as the Japanese distant water fishing fleet was reduced following the adoption of a 200-nautical mile exclusive economic zone (EEZ) by many coastal nations in the late 1970s. In recent years, the United States has again become the world's largest seafood importer in terms of value and the second largest by quantity after China. Moreover, imports now make up 91% of total seafood consumption in the United States, and it is estimated that over half of the imported seafood is farmed (National Marine Fisheries Service, 2018). Given that the U.S. aquaculture industry is dwarfed by the global aquaculture industry in terms of quantity produced, U.S. seafood demand clearly plays an important role well beyond the U.S. borders in providing a market for this industry.[2] The Honduran tilapia farming industry provides one good example of this as virtually its entire production is exported to the United States (Tveteras, 2015). More generally, the significant U.S. imports help facilitate the increasing globalization of the seafood market (Anderson, Asche, & Garlock, 2018; Asche, Bellemare, Roheim, Smith, & Tveteras, 2015).

While it is not a key focus of this article, it is worthwhile to note that exports are also important as the United States is currently the world's fourth largest seafood exporter by quantity and the world's fifth largest seafood exporter by value (Food and Agriculture Organization, 2019). There are several reasons for this, starting with the fact that markets in Japan and China have a closer geographical proximity to the state with the largest fishing industry, Alaska, than the lower 48 states. With regard to China, this proximity also facilitates third-country processing because of high U.S. processing costs (Anderson et al., 2018; Asche, Roheim, & Smith, 2016). Finally, the United States tends to export low-valued species that have a limited demand in the U.S. market. Among the most interesting are California sardines, which the state legislature has prohibited from being reduced to fishmeal. As a consequence, California sardines are mostly exported as frozen product to Australia to be used as tuna feed and to Japan to be used for bait (Pacific Fishery Management Council, 2017).

The large import share together with limited ability to increase capture harvest, in many ways, are the key defining elements for the main trends in the U.S. seafood market. These lead to a significantly higher demand for seafood than what the U.S. seafood-producing sectors are able to supply. U.S. consumers, together with consumers in the European Union and Japan, have a high ability to pay, enabling them to compete for the seafood that is available (Asche et al., 2015). As the world's seafood markets are becoming globalized (Anderson, 2003; Anderson et al., 2018; Tveteras et al., 2012), seafood from around the world is increasingly available for those who can pay, and with few trade barriers, this helps make seafood the most traded food type. While aquaculture production is rapidly increasing, landings of wild seafood have been stagnant since the 1980s. Hence, a significant part of the global seafood trade will be farmed seafood. As aquaculture is a production technology where the producers have greater control over the production process to respond to market signals (Anderson, 2002; Asche, 2008; Kumar & Engle, 2016), U.S. seafood demand is therefore also influencing this development. Again, the example of tilapia from Honduras is pertinent as the Honduran tilapia industry would most likely not exist without the U.S. market.

Another important factor is the trend among food retailers and restaurant chains that provides economies of scale in logistics, transportation, and marketing (Asche & Bjørndal, 2011). This is a trend that gives a competitive advantage to species that are available in large quantities with consistent quality and a high degree of delivery reliability. Again, this gives aquaculture producers an advantage in that production is dominated by much fewer species than wild fisheries and by producers with a much larger production that can be harvested on demand and not when nature makes the resource available.

In this article, we will trace the development of the U.S. seafood market, primarily focusing on the period from 1990 to 2017, discussing the main factors facilitating this development, as well as providing a perspective for the future. We will start with a brief overview of U.S. landings, aquaculture production, exports, and imports. This will be followed by a discussion of U.S. per capita consumption patterns before offering some concluding remarks.

2 | OVERVIEW OF LANDINGS, IMPORTS AND EXPORTS, AND AQUACULTURE PRODUCTION

It is useful to start by placing U.S. seafood consumption in a global context. Generally speaking, seafood is one of the most highly traded food types (Anderson et al., 2018). The most salient features of the global seafood production, excluding aquatic plants and marine mammals, are shown in Figure 1. Until 1970, virtually all the growth in production was caused by increased landings of wild-caught fish, and this growth continued at a slower pace until the end

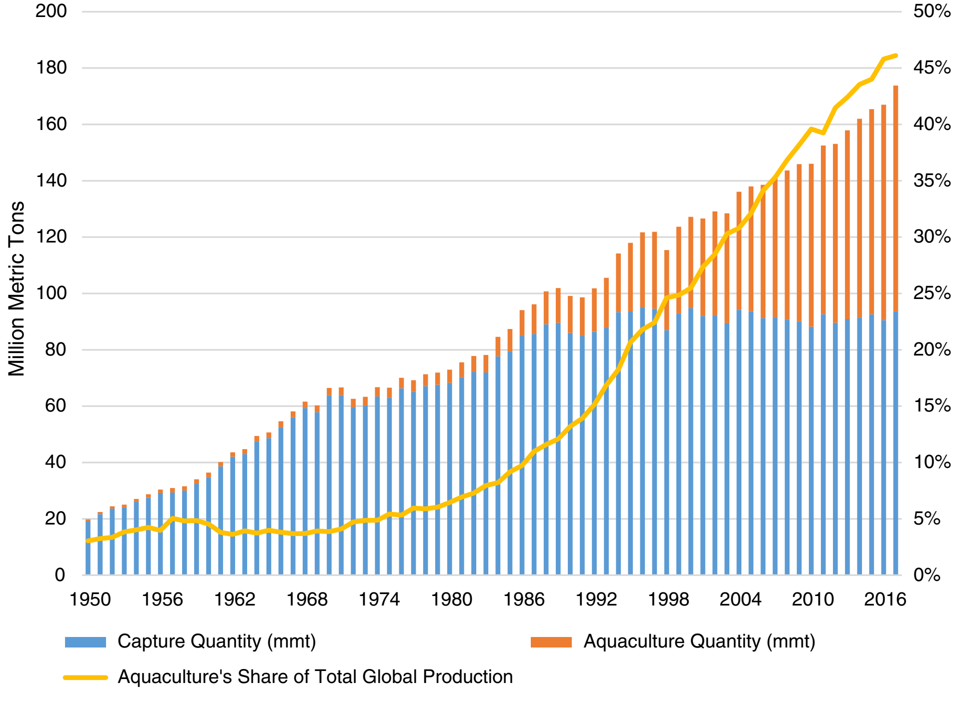


FIGURE 1 Global production of seafood by production technology, 1950–2017

of the 1980s. As the rate of growth in the landings declined after 1970, this created incentives for supplying seafood by other means (Asche & Smith, 2018), and aquaculture production started to grow. However, it was not until the 1990s, when the growth in global landings from capture fishing stagnated, that aquaculture production really took off, and since the 1990s, virtually all the growth in global seafood production is from aquaculture. The production growth in aquaculture is sufficiently fast that total seafood availability in the world is increasing, and it reached 20.3 kg/capita in 2016, a new record high (Food and Agriculture Organization, 2018).

The shift in production modes toward aquaculture implies that any seafood consumer is more likely to consume farmed seafood. This is a feature that is likely to be reinforced by the fact that farmers can choose which species to produce, making them more market-oriented than suppliers of wild fish, producing fish that are better adapted to consumer preferences in various markets (Anderson & Bettencourt, 1993; Asche & Smith, 2018).[3] Hence, an export-oriented fish farmer focusing on markets in developed countries may produce high-valued seafood such as shrimp, while farmers who focus on domestic or developing country markets may focus on lower-valued species. Belton, Bush, and Little (2018) show how this is the case for the 10 largest developing country aquaculture producers.

The production side is also important. Rapid productivity growth has led to reduced production costs for successful aquaculture species, for example, farmed Atlantic salmon, making them even more competitive as this has enabled producers to be profitable at lower prices (Asche, 2008; Kumar & Engle, 2016; Kumar, Engle, & Tucker, 2018). An important feature of aquaculture is that production is much more concentrated geographically than the production of wild fish, with nearly 90% of production taking place in Southeast Asia (Anderson et al., 2018), implying that any net importer of seafood, like the United States, is likely to buy a significant portion of its seafood from this region. The control of the production process also facilitates better utilization of transportation and logistics systems, further reducing supply chain cost and enabling shipments to markets further away to be profitable (Anderson et al., 2018).

While most of the action in terms of production growth takes place in aquaculture, there has also been a shift in the countries responsible for the majority of capture fishery landings. In terms of capture fishery landings, the United States plays a leading role with regard to global landings in contrast to its meager contribution to global aquaculture production. Prior to the establishment of EEZs, distant water fleets were responsible for a large share of global landings. Peru and Chile were the first countries to adopt EEZs in 1947; however, it took until 1976 for the United States to declare its EEZ. Table 1 demonstrates this shift in the top five countries in terms of capture fishery landings over time. The United States was a country with a significant fishing sector in 1950, but it did not to any extent contribute

TABLE 1 Top five countries ranked by capture fishery landings over time

1950		1970		1990		2016	
Country	Quantity (m.t.)	Country	Quantity (m.t.)	Country	Quantity (m.t.)	Country	Quantity (m.t.)
Japan	2,994,435	Peru	12,484,200	Japan	9,771,718	China	17,807,391
United States	2,629,961	Japan	8,747,212	Russian Federation	7,398,958	Indonesia	6,584,419
Union of Soviet Socialist Republics	1,695,224	Union of Soviet Socialist Republics	7,348,875	Peru	6,869,174	India	5,082,332
Norway	1,283,854	Norway	2,982,617	China	6,714,530	United States	4,931,017
Canada	954,072	United States	2,794,298	United States	5,620,405	Russian Federation	4,773,413
Others	9,688,261	Others	29,529,614	Others	49,649,512	Others	52,836,246
Grand total	19,245,807	Grand Total	63,886,816	Grand Total	86,024,297	Grand Total	92,014,817

to the increased global landings from 1950 to 1970. However, the introduction of the EEZ led to a doubling of U.S. landings to over 5 million m.t. in 1990. Salmon, predominantly Pacific salmon (*Oncorhynchus*) from Alaska, and shrimp, mostly harvested from wild fisheries in the Gulf of Mexico, have traditionally been the most valuable fisheries, with New England lobster also entering this group in recent years.[4] One fishery that emerged in earnest in the early 1980s after the establishment of the 200 nm EEZ in the United States was the Alaska pollock fishery. By 1986, this fishery was the largest of all U.S. fisheries in terms of quantity landed, and landings in the fishery are currently approximately double that of the next largest U.S. fishery (gulf menhaden) (Food and Agriculture Organization, 2019).

The United States went from being the world's fifth largest fishing nation in 1990 to the fourth largest in 2016 with relatively stable landings. This can be interpreted as evidence of a well-managed fishing sector, while other leading nations fish less either because their role as a distant water fishing nation has declined (e.g., Japan) or because they were fishing down their stocks when higher landing levels were reported. It is of interest to note that China was not even on the list of top fishing nations in 1970 but, by 1990, was fourth in global landings and was by far the leading country in terms of wild capture landings in 2016. There are several reasons for this, including a rapidly expanding distant water fishing fleet. Other large developing countries like Indonesia and India are new arrivals to the top five list in 2016; while formerly a mainstay on the list, Japan, has fallen out of the top five and was seventh in 2016.

When aquaculture was not very important as a global production technology, the United States was a significant producer. With 218,000 m.t. in 1975, the United States was the fourth largest aquaculture producer in the world.[5] However, as a producer, the United States did not take part in the aquaculture revolution, and today, it is a minor player, accounting for 0.39% of global production in 2017. There are of course several reasons for this, with tight regulations and high regulatory cost receiving the most attention (Chu, Anderson, Asche, & Tudur, 2010; Chu & Tudur, 2014; Engle & Stone, 2013; Knapp & Rubino, 2016; van Senten & Engle, 2017; van Senten & Engle, 2018). The fact of the matter remains that aquaculture production is not significant in the United States and that the landings of wild fish are stable and unlikely to increase; thus, any increase in seafood consumption in the United States has to be based on imports.

It is of interest to take a quick look at the U.S. trade balance given that the country is both a large exporter and importer. In Figure 2, U.S. imports by quantity are shown. In 1976, the United States was a significant importer, but this rapidly changed when the U.S. EEZ was introduced. The export data indicate that a significant part of the increased landings was exported, and as Japan became a main market, a significant amount was exported to former distant water fishing nations that no longer had access to U.S. waters. U.S. wild-caught landings fell as total allowable catches or other management measures were implemented in most fisheries in the late 1980s and 1990s (Shamshak & King, 2015); however, the trend in the quantity of seafood exported was increasing despite stable landings and increased imports. The imports show a relatively steady increase throughout the period, and neither the period when U.S. exports were rapidly increasing in the 1980s or when they were steadily increasing from the 1990s had much of an impact on the quantity imported.

Figure 3 shows the real value of U.S. imports and exports. The most striking difference relative to the quantities in Figure 2 is that import values are always much higher than export values, and this implies that the United States imports much higher-valued fish than it exports. This is not surprising given that wealthy countries in general import higher-valued fish, while poorer countries import lower-valued fish (Asche et al., 2015), independent of whether this is because of the species or if it is because of re-exporting (Asche et al., 2016). However, it does suggest that there are significant quantities of fish landed in the United States that cannot compete in the U.S. market directly, as is the case of California sardines, presumably because U.S. consumers do not want to eat a small oily fish.

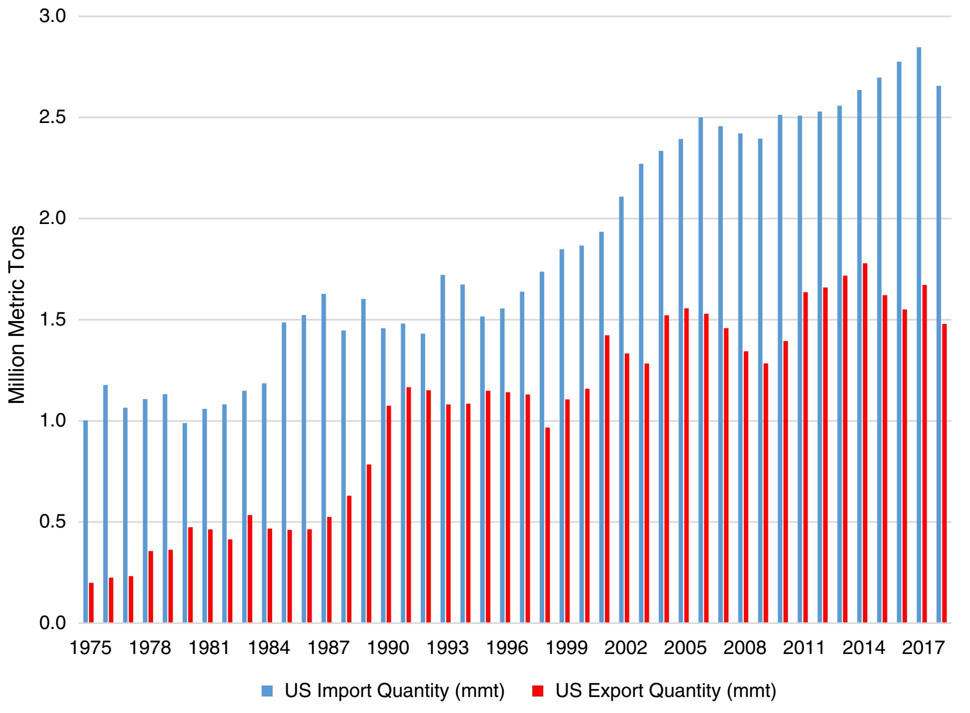


FIGURE 2 U.S. exports and imports by quantity, 1975–2017

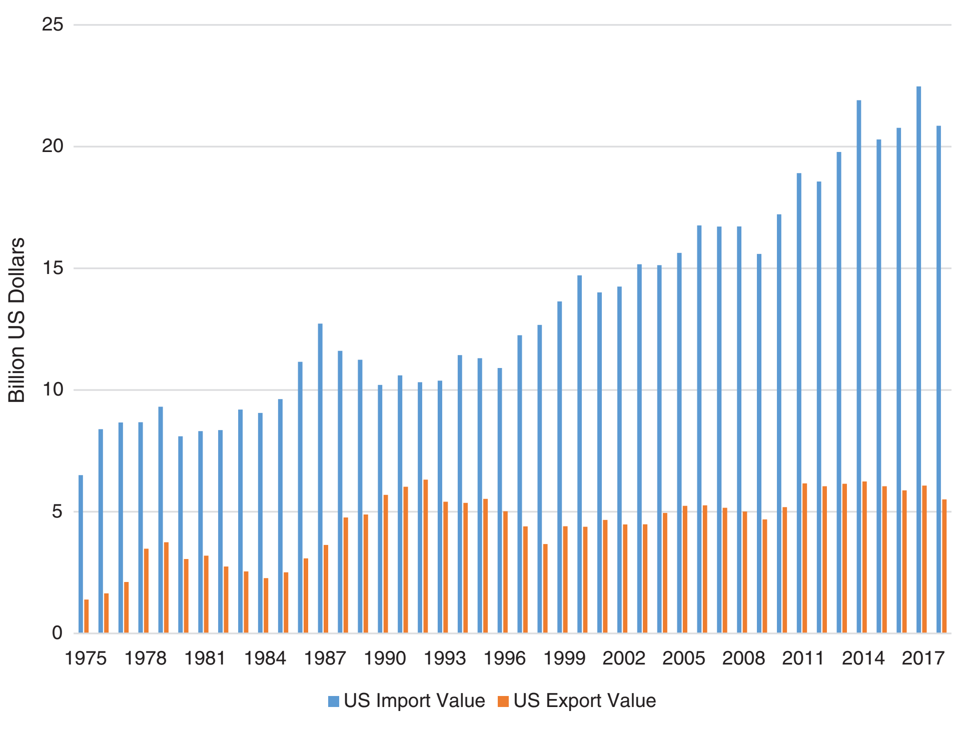


FIGURE 3 U.S. exports and imports by value (2018 constant US dollars), 1975–2017

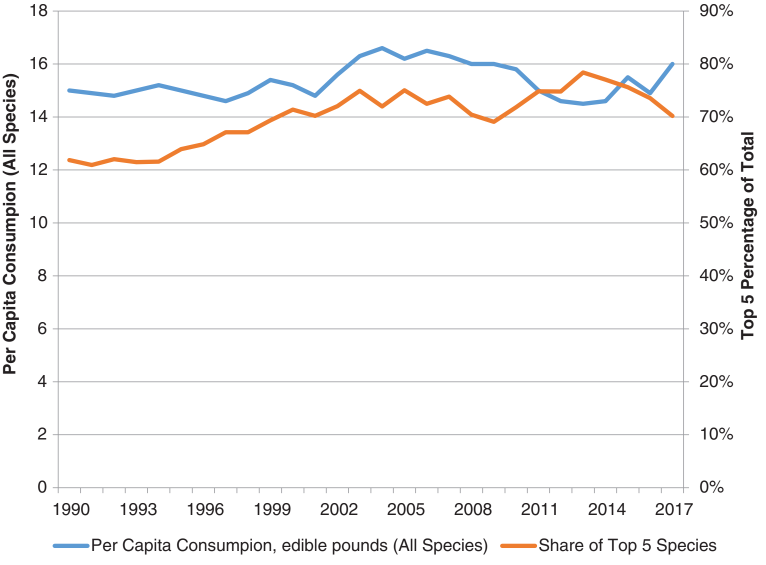


FIGURE 4 Per capita consumption of seafood and share of the top five species consumed, 1990–2017

3 | U.S. SEAFOOD CONSUMPTION

In this section, data originally collected by the National Marine Fisheries Service, and refined by the National Fisheries Institute (National Fisheries Institute, 2018), will be used to describe some patterns in U.S. seafood consumption. All the consumption data are reported in pounds of edible weight.

Figure 4 shows U.S. total per capita seafood consumption since 1990 along with the share of the top five species consumed. As can be seen, per capita consumption has remained relatively stable at about 15 lb/capita over the whole period, although there were a few years where consumption exceeded 16 lb/capita in the early 2000s and most recently in 2017. While this can be interpreted as an indication of a stagnant market, the total consumption and the total market size has a clear positive trend, which is primarily driven by population growth.

The dynamics are more interesting if one examines the consumption of the top five species consumed in a given year. In 1990, U.S. seafood consumption was primarily based on landings of wild fish, largely reflecting the U.S., as well as global, seafood production as described in Section 2. The five leading species in 1990 were canned tuna, shrimp, cod, Alaska pollock, and salmon, where the shrimp and salmon were still primarily sourced from wild fisheries.[6] The top five species were important as they made up 61.8% of total seafood consumption.

By 2017, the top five species consumed had shifted significantly toward aquaculture species as they included shrimp, salmon, canned tuna, catfish (including pangasius), and tilapia, with only canned tuna being primarily a wild species.[7] More importantly, the top five species' share of total consumption had increased to 70.2% (and with a peak of 78.4% in 2013), reflecting a consolidation in the variety of species consumed. Hence, these farmed species are increasingly important in the U.S. market. It is not too surprising that among the farmed species are the two most valuable (salmon and shrimp) and the three most successfully farmed species in terms of growth in trade (salmon, shrimp, and tilapia) (Anderson et al., 2018; Kumar & Engle, 2016).

The methodology used by the National Marine Fisheries Service to calculate per capita consumption is based on a “disappearance” model of seafood in the United States (National Marine Fisheries Service, 2018). The U.S. supply of seafood (imports and landings) is converted to edible weight, and any decreases in supply (exports and industrial uses) are also converted to edible weight and are subtracted from the U.S. supply. The remaining total is divided by the U.S. population to estimate per capita consumption. Because of this methodology, per capita consumption data do not exist on a more detailed basis (e.g., income, gender, or region). As a result, one cannot probe changes in consumption over time by different subpopulations; however, one trend is clear. As per capita income has increased, so has the consumption of higher-valued seafood products (salmon and shrimp vs. cod and Alaska pollock) and product forms (fresh and/or processed and prepared vs. frozen or canned). If one is to obtain more details on the development, other data must be used, and one will typically only focus on a limited number of species or product forms, such as Dey, Surathkal, Chen, and Engle (2017).

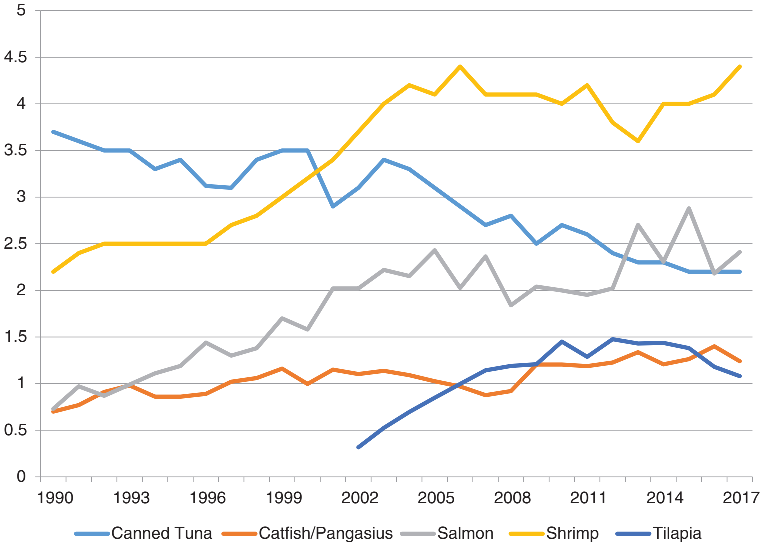
Tuna, the only remaining wild species among the top five, warrants some further comments. It is a species where global landings have increased in recent years, hence providing fewer incentives for aquaculture. The only exception is the high-value bluefin tuna, which is available only in very limited quantities and where a significant effort to farm and ranch exists (Shamshak & Anderson, 2009). In general, the United States exports frozen tuna and imports fresh or chilled tuna based on the most recent import and export statistics (Food and Agriculture Organization, 2019); however, this trend has become more pronounced over the past 30 years. In 1990, 26% of tuna exports in the United States were classified as frozen. By 2016, 83% of U.S. tuna exports were classified as frozen. In 1990, 44% of tuna imports were frozen, but by 2016, only 13% of U.S. tuna imports were frozen, with the majority of the imported product forms being classified as "prepared or preserved" and "fresh or chilled" (Food and Agriculture Organization, 2019). Again, referring back to the overall per capita increase in income, there has been a noticeable shift away from lower-valued and lower-quality seafood products and toward higher-valued and value-added product forms. U.S. landings of tuna declined over the period 1985–2005; however, they have rebounded notably in recent years, returning to levels observed during the 1970s and 1980s. Therefore, shifts in U.S. tuna consumption are not being driven by supply shortages, either in the United States or globally.

Another factor that could partially explain the downward trend in canned tuna consumption could be the joint advisory statement issued in January 2001 by the Food and Drug Administration and the Environmental Protection Agency, which advised women who may become pregnant, pregnant women, nursing mothers, and young children to avoid certain types of fish and to instead eat fish and shellfish with lower mercury concentrations. In particular, the advisory specifically recommended limits for canned tuna consumption.

Oken et al. (2003) noted a decline in consumption of seafood by pregnant women following this 2001 national advisory. Researchers have examined the benefits and risks associated with consumption of raw, cooked, and canned tuna (Afonso et al., 2015), while others have evaluated the concentrations of mercury in three brands of canned tuna in the United States (Gerstenberger, Martinson, & Kramer, 2010). This information, while important to share, also has the potential to create confusion for consumers who are trying to simultaneously balance recommendations to eat seafood for heart health benefits, with recommendations to avoid certain seafood species for certain segments of the population because of concerns about mercury toxicity (Smith & Sahyoun, 2005; Uchida, Roheim, & Johnston, 2017). Awareness campaigns regarding dolphin bycatch could have also contributed to the decline in the consumption of canned tuna, including lingering concerns regarding the effectiveness of dolphin-safe laws and labeling (Joseph, 1994; Watson, 2015). Food scares like the reported polychlorinated biphenyl (PCB) content of salmon in 2004 also influence imports (Sha, Roheim, Insagnaris, & Asche, 2015).

Figure 5 shows the development in consumption for the species that make up the top five in 2017. Shrimp became the most consumed species in 2000, surpassing canned tuna, and has since remained the most consumed seafood in the United States, with consumption doubling from 2.2 lb/capita in 1990 to 4.4 lb/capita in 2017. The increase in shrimp consumption is primarily because of increased imports as U.S. landings have been stable at around 150,000 m.t., and the majority of shrimp imports are farmed. Salmon became the second most consumed species in 2013, and consumption increased from 0.73 lb/capita in 1990 to 2.41 lb/capita in 2017 (with a peak of 2.88 lb/capita in 2015). As U.S. landings have been stable, virtually all the increase in consumption is imported and farmed from Canada and Chile, although there are also some reimports as Alaskan salmon is exported to China for processing. Knapp (2014) estimated that about two thirds of the U.S. salmon consumption is based on imported farmed Atlantic salmon. Canned tuna is the only species in the top five with a long-term declining trend as consumption has been reduced from 3.7 lb/capita in 1990 to 2.1 lb/capita in 2017. In addition, there is also a declining trend for the two wild species that have left the top five list as consumption of cod has declined from 1.4 to 0.7 lb/capita and Alaska pollock has declined from 1.3 to 0.8 lb/capita. The two new species on the list are both farmed. Catfish

FIGURE 5 Annual per capita consumption (edible pounds), selected species, 1990–2017



has, for a long time, been the leading U.S. aquaculture species, and quantities have, after the turn of the century, been augmented by pangasius from Vietnam and channel catfish produced in China. Tilapia, the most traded farmed finfish species (Kumar & Engle, 2016), with the United States as one of the most important markets,[8] has experienced a slight decline in the last few years as a result of weakening demand.

These trends are somewhat surprising given that aquaculture is controversial in the United States. There are several concerns with respect to environmental sustainability (Abate, Nielsen, & Nielsen, 2018; Abolofia, Asche, & Wilen, 2017; Fischer, Guttormsen, & Smith, 2017; Quezada & Dresdner, 2017), even though there is evidence that regulations, when properly implemented and enforced, can address these issues (Osmundsen, Almklov, & Tveterås, 2017; Tveterås, 2002) and that aquaculture is a sustainable food production technology compared to many alternatives (Froehlich, Runge, Gentry, Gaines, & Halpern, 2018). Several studies find a preference for wild seafood (Davidson, Pan, Hu, & Poerwanto, 2012; C. A. Roheim, Bush, Asche, Sanchirico, & Uchida, 2018; C. Roheim, Sudhakaran, & Durham, 2012), although there is some evidence this can be mitigated with ecolabels for some species and in some markets (Bronnmann & Asche, 2017; Bronnmann & Hoffman, 2018). However, the development does reflect the global production patterns (Anderson et al., 2018) and the market development for specific species in specific regions (Dey et al., 2017), as well as the potential competitive advantages of aquaculture products not only with respect to control over the production process but also with control and efficiency in logistics and marketing (Asche, Cojocaru, & Roth, 2018; Landazuri-Tveteraas, Asche, Gordon, & Tveteras, 2018). It may also be important to note that it is far from obvious that there is a clear distinction between wild and aquaculture but that the real question is a matter of control with the production process (Anderson, 2002). For instance, it is not obvious that hatchery-based salmon in Alaska or bait-fed lobster in Maine is wild (Klinger et al., 2013).

4 | CONCLUDING REMARKS

U.S. seafood consumption has changed dramatically since 1990. However, given the basic trends in United States and global seafood production, none of these changes should be surprising as they largely mirror the broad developments in seafood production. While a major seafood producer, U.S. seafood production is fairly constant as it primarily comes from well-managed but fully exploited fish stocks, and regulatory red tape seems to ensure that domestic aquaculture production will not become a significant source of seafood. With a growing and wealthy U.S. population, the demand for seafood is driving an increase in the total quantity of seafood consumed even if per capita consumption remains relatively constant. Hence, imports are increasing, and that growth is largely driven by the global production growth in seafood by focusing on the main traded species that come from aquaculture. The two species that have left the top five list for U.S. seafood consumption since 1990 are both sourced from wild-caught fisheries, cod and Alaska pollock. The two new species are both from aquaculture, tilapia, and catfish/pangasius. In addition, salmon and shrimp have gone from being primarily supplied by domestic fishers to be primarily supplied by foreign fish farmers. Hence, while all five of the most consumed species in 1990 were predominately wild, four are predominately farmed in 2017, with the remaining wild species experiencing a declining trend.

Consumption is also focusing on fewer species. From 1990 to 2017, the top five species' share of the seafood consumption has increased from 62 to 70%. While this partly reflects the focus of the global aquaculture production on relatively fewer species that are produced in large quantities, it also fits the development of large chains in retail, as well as restaurant sales, with a focus on efficient logistics and distribution. Asche and Smith (2018) provide an interesting example with the menu of the restaurant chain Ruby Tuesday, where all but one seafood item is farmed. This seems largely to be dictated by a menu that is identical in all the chain restaurants, which therefore requires the chain to be able to deliver the same product to all of its outlets.

As aquaculture production is expected to continue to increase while wild production remains stagnant (Kobayashi et al., 2015), there is no reason to expect that this development will not continue to influence the consumption of farmed species, both in the United States and globally. Moreover, despite the growth in movements such as local food, there seem to be no reason to expect the retail or restaurant chains or the efficient logistics that supply them to become weaker in any part of the developed world (Asche et al., 2018; Guillotreau, Le Grel, & Simioni, 2005; Murray & Fofana, 2002), and other types of outlets are therefore likely to be niches. Hence, the main trend is that U.S. seafood consumption is likely to become even more concentrated on a few main species, and if the declining trend for canned tuna continues, those species are likely to be predominately imported and sourced from aquaculture production. However, even though the niches combined only make up 30% of the U.S. seafood market, this is a significant quantity, and the niches may be important for specific groups of producers. If anything, while the share of the market may be declining, the quantity in this market is increasing, and it may also be increasing heterogeneously. The U.S. shellfish industry seems to be one of the beneficiaries of this development as new species like clams are thriving, and oyster production is rebounding, with a focus on high-quality shellfish where attributes such as production site and region have value (Brayden, Noblet, Evans, & Rickard, 2018).

ENDNOTES

[1] U.S. aquaculture production as a share of global aquaculture production has fallen steadily from a high of 10% in 1950 to the currently all-time low of 0.39% in 2017. In terms of total U.S. domestic seafood production, aquaculture's share is 8%.

[2] By value, U.S. aquaculture production is approximately 0.5% of the global aquaculture industry.

[3] There are, for instance, no fish farmers that produce low-priced, small, pelagic fish. There is increasing evidence that consumers have a preference for convenient species that are easy to prepare, which again make farmed fish more attractive (Torrissen & Onozaka, 2017).

[4] Since 2006, American lobster landings are up 66% (96 million pounds in 2006 vs. 159 million pounds in 2016). Furthermore, landings in 2016 established an all-time high for American lobster, surpassing the previous high of 150 million pounds in 2012 and 2013.

[5] A good review of the early U.S. aquaculture industry can be found in Parker (1989).

[6] The remaining species in the top 10 list include one farmed species; catfish; and the wild species: clams, flatfish, scallops, and crabs.

[7] In our analysis, Ictalurid catfish and pangasius are treated as one species, while in NFI's data, they are recorded as two different species.

[8] Aquaculture production of several carps are even larger than the tilapia production, but this is primarily consumed in the country where they are produced such as China, India and Bangladesh (Belton et al., 2018).

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How to cite this article: Shamshak GL, Anderson JL, Asche F, Garlock T, Love DC. U.S. seafood consumption. *J World Aquacult Soc*. 2019;50:715–727. https://doi.org/10.1111/jwas.12619