PERSPECTIVES

Market Opportunities for US Aquaculture Producers: The Case of Branzino

Frank Asche, *University of Florida and University of Stavanger*; Taryn Garlock and Edward Camp, *University of Florida*; Jordi Guillen, *European Commission Joint Research Centre*; Ganesh Kumar, *Mississippi State University*; Ignacio Llorente, *University of Cantabria*; Gina Shamshak, *Goucher College*

ABSTRACT

The US is the world's largest seafood importer by value, with an increasing share of imports composed of farmed seafood. Despite numerous policy initiatives, production and growth in the US aquaculture sector is limited, and there is a significant literature discussing potential explanations. In this paper the recent success of imported branzino is used to show that the market is not a constraint. Branzino is a portion-sized white-fleshed fish primarily farmed in the Mediterranean, with no obvious equivalents produced in the US. Since the turn of the century, imports have grown from zero to almost 10,000 metric tons, a quantity that would have made it the fourth-largest farmed fish species if produced in the US, and all is imported fresh. From 2015 when the quantities became more significant, the species entered the large whitefish market, although with a significant price premium relative to tilapia, the largest species in this market, indicating that the opportunity to create separate niches in the seafood market is limited.

Key words: Aquaculture, branzino, market potential, regulations.
JEL codes: Q21, Q22, Q27.

INTRODUCTION

The US is the world's largest seafood importer by value, and imports are rapidly increasing (Shamshak et al. 2019). Even though the US is the world's sixth-largest fishing nation, imports dominate the market as imports are estimated to make up between 65% and 90% of total US

Frank Asche is a professor, Food Systems Institute and School of Forest, Fisheries, and Geomatics Sciences, University of Florida, PO Box 110570, Gainesville, FL 32611 USA (email: frank.asche@ufl.edu), and Department of Safety, Economics, and Planning, University of Stavanger, 4036 Stavanger, Norway. **Taryn Garlock** is a senior research scientist, Food Systems Institute and School of Forest, Fisheries, and Geomatics Sciences, University of Florida, PO Box 110570, Gainesville, FL 32611 USA (email: tgainer@ufl.edu). **Edward Camp** is an assistant professor, School of Forest, Fisheries, and Geomatics Sciences, University of Florida, PO Box 110570, Gainesville, FL 32611 USA (email: edvcamp@ufl.edu). **Jordi Guillen** is a senior research scientist, European Commission Joint Research Centre, Unit D.02 Water and Marine Resources, Via Enrico Fermi 2749, 21027 Ispra (VA), Italy (email: Jordi.guillen@ec.europa.eu). **Ganesh Kumar** is an assistant research professor, Delta Research and Extension Center, Department of Wildlife, Fisheries, and Aquaculture, Mississippi State University, 127 Experiment Station Road, PO Box 197, Stoneville, MI 38776 USA (email: gkk27@msstate.edu). **Ignacio Llorente** is an associate professor, Department of Business Administration, University of Cantabria, Avenida de los Castros 56, 39005, Santander, Spain (email: llorentei@unican.es). **Gina Shamshak** is a professor, Economics Program, Goucher College, 1021 Dulaney Valley Road, Baltimore, MD 21204 USA (email: Gina.Shamshak@Goucher.edu).

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seafood consumption (Gephart, Froehlich, and Branch 2019). US fisheries landings have been relatively stable for decades, and as most stocks are well managed but fully exploited there is little opportunity for increased supply from this sector (Shamshak et al. 2019; Smith 2019; Hilborn et al. 2020). This is particularly true for fresh fish, as limited quantities of domestic wild-caught fish are marketed fresh. The increase in imports suggests strong seafood demand, which in general creates good conditions for aquaculture production to grow (Asche and Smith 2018). Globally, the aquaculture sector has grown rapidly as the landings of wild fish have stagnated. However, this has not impacted the US aquaculture sector very much (Garlock, Asche, et al. 2020), indicating that the opportunity created by increased seafood demand is not being exploited by US aquaculture producers. In this paper we will use the developments in the imports of one niche species, European sea bass (*Dicentrarchus labrax*), which is marketed as branzino in the US, to show that the market is not one of these constraints.

While there are numerous barriers to aquaculture production in the US (Knapp and Rubino 2016), increased production is a priority. The NOAA Fisheries Priorities and Annual Guidance calls "increasing marine aquaculture production" a high-priority objective (NOAA 2019), and the White House issued an executive order on May 7, 2020, calling for the aquaculture permitting process to be streamlined and unnecessary regulations to be removed (*Federal Register* 2020). These are the latest in a number of attempts to support increased aquaculture production in the US. However, the sector is controversial because of its environmental impacts and perceived competition with the commercial fishing industry, and an extremely complicated permitting system has contributed to making it very difficult for aquaculture producers to succeed (Engle and Stone 2013; Chu and Tudur 2014; Knapp and Rubino 2016; Anderson, Asche, and Garlock 2019; Van Senten et al. 2020).

The US was well positioned to benefit from the blue revolution as the world's third-largest aquaculture producer until the mid-1970s. US producers, however, have largely not participated in the blue revolution on the production side, and the country is now the 17th-largest aquaculture producer (Garlock, Asche, et al. 2020). However, US contributes significantly to the blue revolution globally by providing capital, technologies, and input factors to the industry elsewhere (Chu et al. 2010; Kumar et al. 2021), and also by being a major importer of farmed seafood, creating a market for export-oriented producers in other countries (Anderson, Asche, and Garlock 2019; Garlock, Asche, et al., 2020). Four of the five most consumed seafood species (shrimp, salmon, tilapia, and pangasius/catfish) are primarily imported and from aquaculture, with tuna as the only top five species primarily supplied from wild fisheries (Shamshak et al. 2019; Love et al. 2020).

Figure 1 shows US aquaculture production by main species groups from 1980. Production has an increasing trend from 168,000 metric tons (mt) in 1980 to 490,000 mt in 2019. Production was declining in the years 2004–11, primarily due to a reduction in US catfish production during that period, and 2004 is so far the peak year for total production with 607,000 mt. The two most important species groups are mollusks and freshwater fish, which make up 43.5% and 33.7% of the production, respectively. Mollusks are primarily oysters, although there are also smaller quantities of farmed clams, while freshwater fish species are mostly composed of catfish. The crustacean group is dominated by crayfish production, and diadromous species contains two species, Atlantic salmon and rainbow trout, with trout having a slightly larger share than salmon. US production of marine fish is minor at 4,317 mt and is primarily red drum. It is also notable that these species are dominating their categories throughout the period, and accordingly, there has been no new successful species. With the exception of Atlantic salmon, these industries consist of

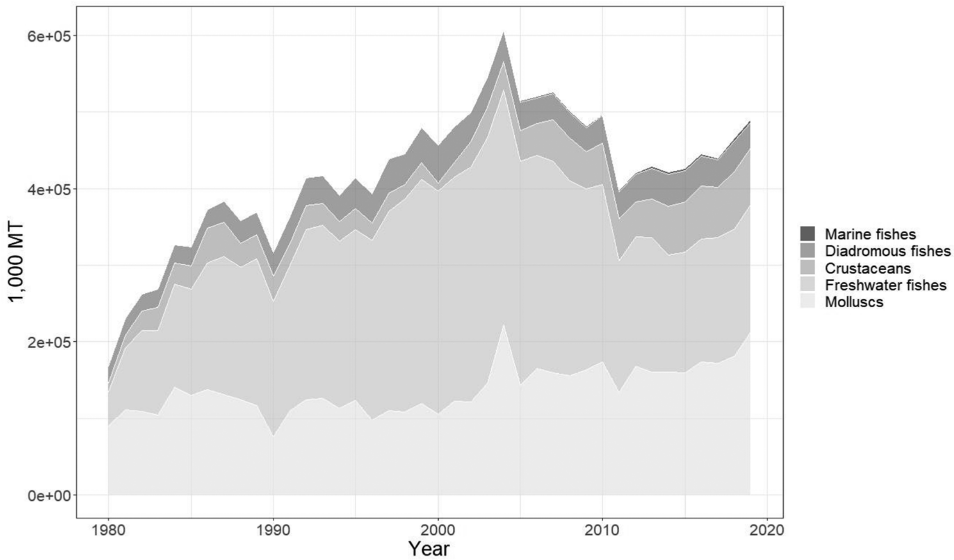

Figure 1. US Aquaculture Production, 1980–2019. A color version of this figure is available online.
Source: FAO (2021).

many small companies (Van Senten, Engle, and Smith 2021). This implies that the US aquaculture industry is in general not operating on a scale that would allow it to compete on cost with imports of global commodities like shrimp, salmon, and tilapia, as economies of scale and productivity growth leading to cost reductions are the main drivers for the competitiveness of the global aquaculture industry (Asche 2008; Kumar and Engle 2016).

There is an extensive literature on consumer preferences for seafood showing that in general wild fish is preferred to farmed fish, domestic to imported, and certified sustainable to not certified. This can be nuanced somewhat by species (Garlock, Nguyen, et al. 2020). Brayden et al. (2018) show that farmed species are preferred for shellfish, and Kecinski et al. (2017) show that frequent oyster consumers prefer farmed oysters. Anderson and Bettencourt (1993) show that even if there is a preference for wild over aquaculture, this can be overcome if farmed fish score better than wild fish on quality attributes. In general, fresh and relatively unprocessed fish provides higher value to the producer (Asche and Smith 2018), suggesting that US producers may have a competitive advantage in such high-quality segments because of higher transportation costs and shorter travel time that is required for fresh delivery. This is supported by the fact that fresh tilapia imports are primarily from Central America while frozen imports are from Asia (Norman-López and Asche 2008), and whole fresh salmon tend to be imported from Canada while more processed and frozen forms travel farther distances (Xie and Zhang 2014). More generally, in international trade fresh product forms are more responsive to distance than are more storable or shelf-stable product forms (Straume et al. 2020; Yang, Anderson, and Asche 2020).

US imports of fresh sea bass have gone from basically zero to nearly 10,000 mt product weight in about 10 years. In this paper, we will show that sea bass provides an interesting illustration of how strong the US demand for high-quality seafood is when it can be supplied with the right characteristics. The key characteristics for sea bass appear to be delivery reliability of fresh never frozen products, not low price, sustainability certification, a strong resemblance to popular species, or any of the attributes that most often are investigated when studying competition in the seafood market. However, when quantities become large enough, the sea bass market becomes integrated with one of the larger species categories, although with a price premium.

The paper is organized as follows: In the next section, we give a brief overview of the production of European sea bass in the Mediterranean before we show the development of US imports. This is followed by a discussion and concluding remarks.

SEA BASS AQUACULTURE IN THE MEDITERRANEAN

European sea bass is the most important farmed fish in the Mediterranean region. Sea bass is grown in marine sea-pens, and reaches a market size of 300–500 g in 15–18 months (Llorente et al. 2020). According to the FAO (2021), farmed sea bass production reached 263,215 mt in 2019. Turkey is the main producer with 52% of the production, followed by the EU with 32% and Egypt with 12% (figure 2). The share of Turkish production of sea bass has been rapidly increasing since the early 2000s, as Turkish sea bass production has been increasing much faster. In the EU, the main farmed sea bass producers are Greece (16% of the total sea bass production), followed by Spain (10%) and Croatia (2%). Wild sea bass catches are minor, accounting for 5,206 mt in 2019.

Total sea bass production has grown at an annual rate of 7.6% but this varies considerably by country, with the highest annual growth rate of 12.5% in Turkey and a much lower growth rate of 4.0% in the EU. Aquaculture production in the EU has increased slightly, despite significant investment aimed to boost aquaculture production (Guillen et al. 2019). Lower growth in the EU aquaculture sector can be mainly explained by heavy regulatory burden in terms of both time and impact assessments required, difficulties in access to space and water with competing sectors contributing to higher costs (Abate, Nielsen, and Tveterås 2016), together with keen market

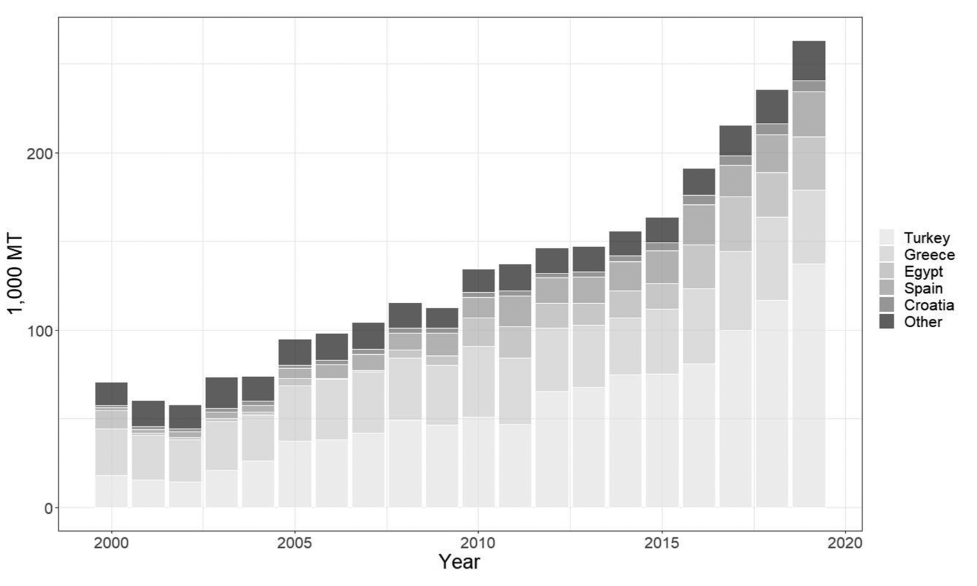

Figure 2. Global Farmed Production of Sea Bass by Country. A color version of this figure is available online. Source: FAO (2021).

competition as increased imports from Turkey put downward pressure on prices (Guillen et al. 2019). The sea bass aquaculture in Turkey has lower production cost and is more profitable than in the EU (Bjørndal, Guillen, and Rad 2019).

There appear to be well-integrated markets for sea bass and its cousin sea bream in the sense that the law of one price holds for fish from different producer countries (Bjørndal, Guillen, and Rad 2019; Fernández-Polanco, Llorente, and Asche 2021). Real global prices of farmed sea bass reached a bottom in 2001 and 2002, mainly because of major production increases from 2000. Average global ex-farm prices for farmed European sea bass fell to $4.3 per kg in 2002, thereby stabilizing afterward at around $6 per kg, and seeing a decrease below $5 per kg in 2018. Profitability in the sector varies with significant price oscillations, due to cyclical mismatches between supply and demand (Fernández-Polanco and Llorente 2019). These mismatches often lead to overproduction, resulting in prices falling below production costs, and more so and for longer periods in the western European countries, where there is little or no production growth. These challenges have been exacerbated by the fact that limited product development is possible with the portion-sized fish that is the main output (Asche et al. 2011). This has caused major economic crises in the sea bass aquaculture sector and has resulted in consolidation of the industry (Llorente et al. 2020) as well as a search for new markets.

There are three differentiated types of countries from a sea bass production and consumption point of view. Egypt and Tunisia produce to supply their domestic demand; Greece and Turkey produce for both their domestic market and export markets; while the remaining producing countries in Southern Europe with more modest productions (Italy, Spain, France, and Portugal) produce for their local markets but are increasingly being supplied by imports from Greece and Turkey. Sea bass is mainly consumed fresh, and frozen consumption is almost negligible. The Russian embargo on certain food products (including fish) from several countries and regions (including the EU) following the Crimea War discontinued EU sea bass exports to Russia, which was the main extra-EU destination, and led to a significant increase of Turkish sea bass exports to Russia. About 10% of Turkish sea bass exports are currently going to Russia (Llorente et al. 2020). In recent years, the US has become the main extra-EU destination for sea bass exports.

THE US MARKET FOR SEA BASS

European sea bass is commonly marketed by US chefs under its Italian name, branzino. It is a fish with white, flaky meat and a mild, sweet flavor, and it is popular on menus of upscale restaurants in the Northeast US and Southern California (Love et al. 2021). In the 1990s, a US market for European sea bass was almost nonexistent, with as little as 37 mt imported annually (figure 3) and virtually all of this was frozen. As aquaculture of sea bass gained momentum in the Mediterranean and producers there faced increasing competition and lower prices (Llorente et al. 2020), they started looking for new markets. The US became one of these as imports of sea bass slowly increased in the 2000s.

In the US import data, sea bass is not separately identified until 2012. However, there are limited imports of any other species from Greece, Italy, and Spain. Hence, it is reasonable to assume that fresh imports of sea bass from Greece, Italy, and Spain are classified as nonspecified marine fish prior to 2012 in the US trade data. As shown in figure 3, this provides an almost seamless transition between 2011 and 2012. It was not until the early 2010s that fresh sea bass markets in the US became better established, as illustrated by the rapid increase in fresh imports (figure 3). Imports of sea bass increased more than threefold from 2,977 mt in 2012 to 9,650 mt in 2019.

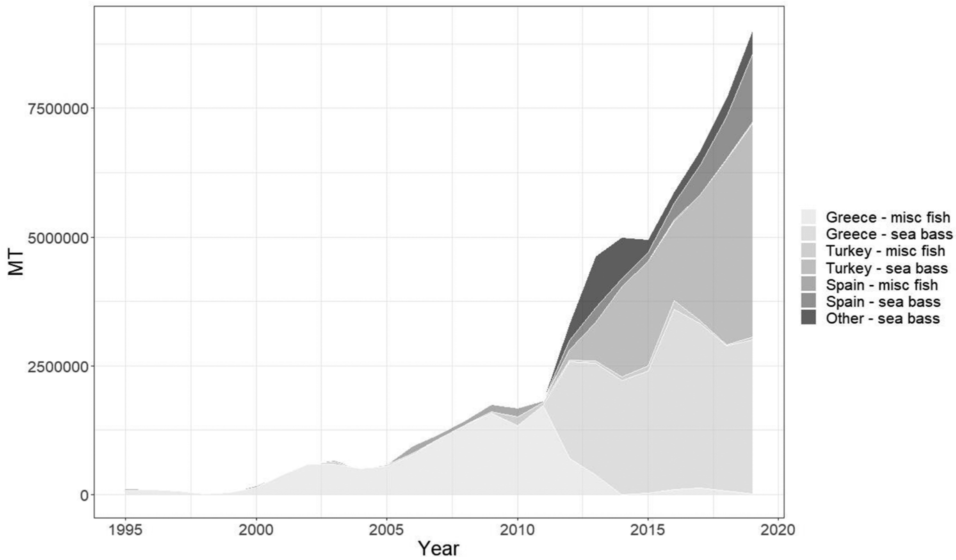

Figure 3. US Imports of Fresh Sea Bass and Nonspecified Marine Fish by Exporting Country. A color version of this figure is available online.
Source: NOAA (2021).

Nearly 90% of sea bass imports were whole fresh, gutted fish at so-called portion size (1lb to 1.5 lb). Using a live weight conversion factor of 1.12, this is equivalent to 10,005 mt live weight of fresh sea bass. This is significant, as it is comparable to US farmed Atlantic salmon production (16,107 mt) and about half of US rainbow trout production (22,370 mt). Similarly, fresh imports of sea bass were valued in 2019 at $52.4 million, which is slightly less than the value of US farmed salmon production ($67.3 million) and more than half of the value of US farmed rainbow trout ($95.7 million). This is a quantity and value that would make sea bass the fourth-largest farmed finfish species by value if it had been produced domestically in the US.

The trends in US imports of sea bass largely reflect where the production takes place as well as market competition. The increase in exports to the US was led by Greece, whose producers faced increasingly keen competition from Turkish producers targeting the EU market. In 2004, Turkey overtook Greece as the largest producer of sea bass. As Turkey's total production has increased, Turkey has steadily taken market share from Greece, including in the US, and in 2018 Turkey became the largest supplier of sea bass in the US market. The rapid development of the US sea bass market is indicative of the strong demand for fresh fish in the US. Moreover, being sold as portion-sized fish is a clear indication that the market is open to nonstandard product forms as long as the product is competitive on price and quality.

Many authors have noted how aquaculture producers increase their competitiveness in the supply chain by being able to supply products of stable quality with a high degree of reliability (Asche, Roll, and Tveterås 2007; Kvaløy and Tveterås 2008; Olson and Criddle 2008; Asche and Smith 2018; Oglend, Asche, and Straume 2022). Birkenbach et al. (2020) provide a model that shows how the market demand for stable supply depends on the demand elasticity, which tends to be more inelastic for fresh products. Figure 4 shows the average import volume of sea

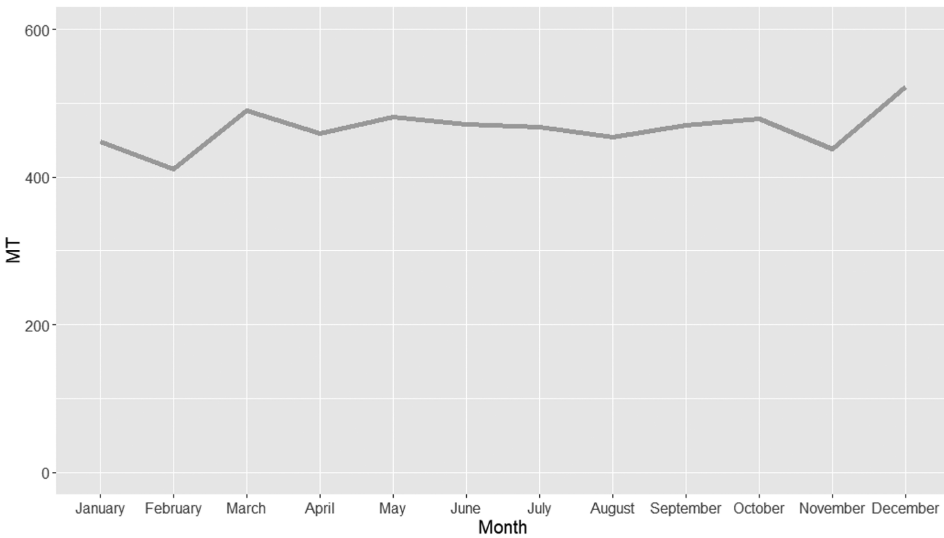

Figure 4. Average Monthly Import Volume of Fresh Sea Bass from 2012 to 2019. A color version of this figure is available online.

bass per month to the US for the period 2012 to 2019. The figure shows a steady supply of fresh products with virtually no seasonal variation. Hence, it is the market and not the natural production cycle that is determining the supply profile, and the exporters can deliver the same volume year-round. This is often a challenge for aquaculture producers in the US, where the harvest is dependent on the growth cycle (Surathkal and Dey 2020; Hanson 2020). The parallel to fisheries with a race to fish is obvious (Anderson 2002; Homans and Wilen 2005).

Garlock, Nguyen, et al. (2020) discuss in the case of US aquaculture production how potential production faces three competitive scenarios: it can create new market segments, it can win market share from domestic wild fish, and it can win market share from imports. In the first scenario, the price determination process for the species is independent of other species, but price will tend to decline rapidly with increasing supply. In the other two scenarios, the competitive situation is impacted by the degree of substitutability and production cost relative to the species one competes with. If the species are perfect substitutes or the law of one price holds, any change in production cost will translate into changes in market shares, which can be an advantage for new species as this limits the price decline when supply is increasing. In an international trade setting, the competitiveness will also be impacted by exchange rates.

A potential importer faces similar scenarios. Figure 5 shows the price development for sea bass together with the price development for tilapia, the most consumed farmed whitefish species in the US market (Shamshak et al. 2019). Two features are apparent. There is a sharp decline in unit price of imported sea bass between 2012 and 2019. The average unit price in 2012 was $10.00 per kg, which fell to $5.90 per kg in 2019. This is steeper than the price decline in Europe (Llorente et al. 2020), suggesting that exchange rates have been beneficial in addition to productivity growth for the competitiveness of sea bass in the US. The declining trend in the sea bass price follows a very similar pattern as the price of fresh imported tilapia fillets from 2015, indicative of market integration. However, while the price of sea bass averaged $5.90 per kg in 2019, which is similar

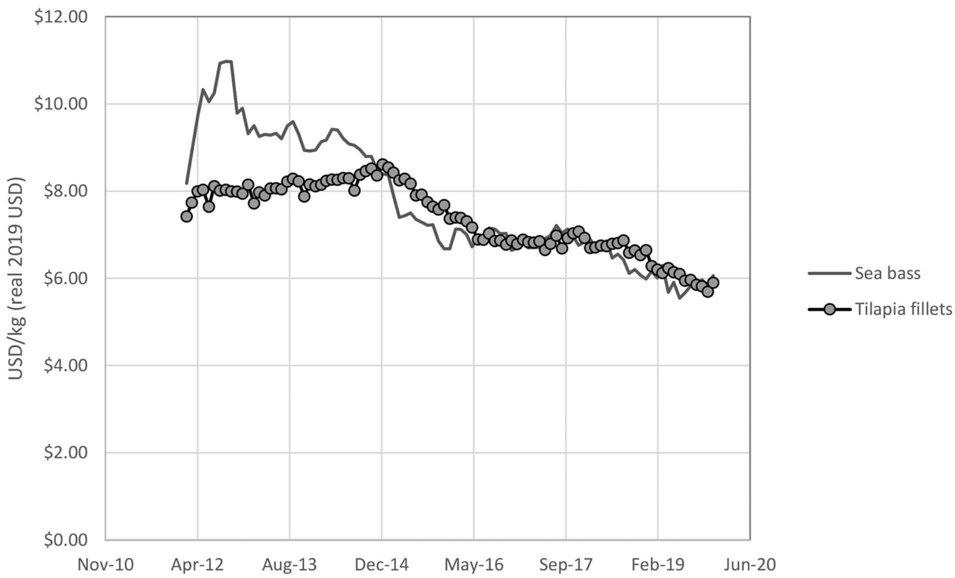

Figure 5. Monthly Unit Price for Imported Whole Fresh Sea Bass and Fresh Tilapia Fillets. Unit prices are adjusted for inflation. A color version of this figure is available online.

to the average price of $6.02 per kg for tilapia fillets, this implies a significantly higher price for round sea bass as it is head-on fish.[1]

In recent decades, increased trade has made the seafood market global for most species, as seafood has become the most highly traded food category (Anderson, Asche, and Garlock 2018). Several studies investigating market integration for specific species or groups of species report that there is a global market for most species groups, but that the markets for different species groups are not integrated (Anderson, Asche, and Garlock 2018), with Landazuri-Tveteraas et al. (2021) and Salazar and Dresdner (2021) as some recent examples. In a global market, the price development over time is similar in all regions, even though there may be differences in price levels because of transportation costs and quality differences, as a shortage in one region is corrected by increases in imports from other regions. However, there are exceptions as discussed by Bjørndal and Guillen (2017) in the case of wild relative to farmed fish for some species. Factors that may prevent market integration include high transportation costs leading to a lack of trade, or differences in product characteristics.

The main tool used in the literature to investigate the degree of market integration is to investigate the relationship between the prices of different markets (Asche, Bremnes, and Wessells 1999). The basic equation to be estimated is the following:

$$\ln P_{1,t} = \alpha + \beta \ln P_{2,t} + e_t, \tag{1}$$

where $P_{1,t}$ and $P_{2,t}$ are the prices of two different goods at time t, 1 and 2. The parameter α is a constant term that captures transportation cost and/or quality differences. Other factors that

1. While the US imports significant quantities of fresh tilapia fillets from South America, most of the imports are frozen fillets from Southeast Asia at lower prices (Norman-López and Asche 2008).

influence price are assumed random with expectation zero and are captured in the error term, e_t. The main interest is related to the parameter β (Asche, Gordon, and Hannesson 2004). Perfect or full market integration implies that $\beta = 1$, so that the two prices move proportionally over time and the relative price is constant. This is often labeled as the law of one price. If $\beta = 0$, there is no relationship between the prices and the price determination processes for the two products are independent. If $0 < \beta < 1$, there is a relationship between the prices, indicating that the two prices influence each other, but not completely. Hence, there is market integration, but it is incomplete; alternatively, the two products are imperfect substitutes.

The results of market integration tests are reported in table 1 using data starting in January 2015.[2] The results indicate that one cannot reject the null hypothesis of one cointegration vector. Moreover, as one cannot reject the law of one price hypothesis, the two species share the same price determination process from 2015. Hence, a successful new aquaculture product does not seem to be able to maintain a separate niche for very long but seems to be rapidly driven into an established market segment, where the best it can do is to obtain a premium associated with quality or other characteristics that consumers prefer.[3] However, the premium can be significant. This is potentially of great importance for US aquaculture producers.

Asche, Bjørndal, and Young (2001) argue that entering an established market segment is positive, as the larger quantity in this segment limits the price impact of the increased supply for the producers in question. However, entering established markets also links the competitiveness of the product to the cost and price development of the competitors. Bronnmann, Ankamah-Yeboah, and Nielsen (2016) show that farmed species like pangasius and tilapia compete with traditional whitefish species like cod and pollock in the German market. However, this is the first time to our knowledge that sea bass is linked to the larger whitefish market, and it will be an interesting future research topic as to whether this is also the case in Europe. There is evidence of productivity growth in sea bass production (Fernández-Sánchez, Llorente-García, and Luna 2020; Nielsen, Ankamah-Yeboah, and Llorente 2021), but the continuous economic crises in the industry (Llorente et al. 2020) may make the task of maintaining productivity growth on par with that of tilapia a real challenge.

The local food movement provides a potential market opportunity for US producers to achieve such premiums while also lowering transportation cost and travel time required for fresh delivery to high-quality market segments. There exists a significant literature on consumer willingness to pay for locally or domestically produced seafood. For instance, Fonner and Sylvia (2015) show that consumers in the Pacific Northwest indicate a willingness to pay higher prices for locally produced chinook salmon and Dungeness crab in niche markets; Shamshak, Tookes, and Yandle (2020) identify price premiums for locally caught Georgia seafood; and Davidson et al. (2012) find that consumers in Hawaii are willing to pay higher prices for locally produced tilapia than for imported fish. Garlock, Nguyen, et al. (2020) show that US wholesale buyers prefer domestic fish to imported fish, and there is no preference for wild fish to farmed fish among buyers. The tendency for US consumers to prefer domestically produced fish to imports, and with

2. The dataset contains 54 observations. Following standard practices, the market integration tests are carried out on the logarithms of the prices. As with most price series, Dickey-Fuller tests indicate that the prices are nonstationary in levels and stationary in first differences. Cointegration tests are then the appropriate statistical tool, where the trace test for cointegration is the most commonly reported. The number of lags is chosen using Akaike's information criterion, and in all cases, the null hypothesis of no autocorrelation in the system is not rejected using an LM test (p-value 0.148).

3. Price premiums in an integrated market can be found in different product attributes, such as freshness, that can have value (Pettersen and Asche 2020).

Table 1. Johansen Cointegration Tests for Market Integration between Branzino and Tilapia

	Test Statistic	*P*-value	Law of One Price	*P*-value
H_0: No cointegration	26.74**	0.005	0.325	0.568
H_0: One cointegration vector	7.63	0.098		

Note: ** significant at the 5% level.

a limited preference for wild fish, is important if domestically farmed seafood is to be competitive and maintain a price premium relative to imports.

CONCLUDING REMARKS

Sea bass is a recent addition to the US seafood market, and the species appears to have been well received given the rapid increase in imports. This strongly suggests that there is still room for new species in the market, and it is not too hard to introduce them if the price and quality point is reasonable. Hence, demand does not appear to be a significant constraint for potential US aquaculture producers. Moreover, it strongly suggests that it is possible to develop niches for new species and product forms even in a market that is dominated by a few, mostly imported, species. However, at a relatively moderate quantity, imported sea bass started to compete in the larger whitefish market where tilapia is the leading species, although obtaining a premium. This shows that there is relatively little room to develop new independent market segments, as most products in the US get pulled into one of the large species groups for which there are global markets. For an expanding industry this may be an advantage, though, as the price effect is limited by the larger quantity in the market that one enters (Asche, Bjørndal, and Young 2001).

The result that foreign aquaculture producers of a new species can create a new market segment in the US with relative ease suggests that this is also an avenue that is open to US aquaculture producers. One company in Connecticut has started US production of sea bass in recirculating aquaculture systems, which are arguably more environmentally friendly than the sea-cage farming used to produce imported sea bass, but production is minor. That US producers are not able to exploit this opportunity is a strong indication that their main challenges are to be found in other places in the supply chain. Knapp and Rubino (2016) strongly suggest that the regulatory system is the main culprit, and this is substantiated in recent work (Van Senten et al. 2020). However, this does not appear to be an easy issue to solve, and Guillen et al. (2019) show how the EU struggles with similar challenges in relation to its aquaculture industry and similarly ends up with increasing demand being served by imports. Hence, while increased aquaculture production is an economic opportunity, as observed by Garlock, Asche, et al. (2020), it is an opportunity that developed countries fail to exploit despite struggling coastal communities and increasing demand for sustainably produced protein.

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