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Trond Bjørndal, Department of International Business, NTNU in Ålesund

Jordi Guillen, European Commission, Joint Research Centre, Ispra, Italy.

Department of International Business, NTNU in Ålesund, 6025 Ålesund, Norway

NTNU
Norwegian University of Science and Technology

MARKET COMPETITION BETWEEN SELECTED WILD AND FARMED SPECIES IN MEDITERRANEAN FISH MARKETS

By

Trond Bjørndal[1] and Jordi Guillen[2]

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The report investigates the competition between wild and farmed fish species in Mediterranean fish markets.

[1] NTNU in Ålesund, trond.bjorndal@ntnu.no
[2] European Commision, Joint Research Centre,Ispra, Italy

EXECUTIVE SUMMARY

The aim of this report is to provide an overview of the market interactions (competition) between wild and farmed species in Mediterranean fish markets. The interactions between wild fisheries and aquaculture have been widely detailed by Soto *et al.* (2012) and Knapp (2015). While, Bjørndal and Guillen (2016) analysed the existing literature on market interactions between wild and farmed fish.

The existence of market competition between wild fisheries and aquaculture implies that there is substitutability between wild and farmed species. So, market competition between wild fisheries and aquaculture can be observed mostly when increased aquaculture supply leads to decreases in wild-caught seafood prices (Anderson, 1985). If two products (wild and farmed) are close substitutes, and considering that aquaculture is probably the fastest growing food-producing sector, farmed produce will win market share from the wild produce. If demand is not perfectly elastic, the price of both products will decline, as will the income of fishermen. In an extreme case, buyers would make no distinction between both products, considering that they are the same product. However, if the two produces are not substitutes, so that there are no market effects, the increase in the supply of the farmed produce will only lead to a price decrease for farmed produce and not affect the price of wild-caught produce (Asche *et al.*, 2001).

Previously available studies on competition interactions between wild and farmed species in the Mediterranean are based on a rather limited number of cases with no general trends detected. The differences in the outcomes obtained could be based, at least in part, in the different data sources employed and time periods analyzed. In fact, market integration results can be sensitive to the period investigated since fish markets are dynamic and are continuously evolving.

Therefore, this study is a detailed and wide-ranging investigation on the existence of market interactions between wild and farmed species in different Mediterranean countries. Unfortunately, only data from Southern European markets and Turkish exports are available. Our results show that there is no market integration between wild and farmed products in Mediterranean countries for gilthead seabream, European seabass, nor for the other species analysed (turbot, sole, blackspot red seabream, Atlantic cod, meagre and clams). This lack of integration between farmed and wild products has been explained in the literature by the traditional consumption (knowledge) of fish in

the area, a preference for local products, the use of different market chains (e.g. fine restaurants normally only serve wild products), and a still persisting negative perception of farmed products in the area.

Results also show that there are few cases where prices of farmed gilthead seabream and European seabass are related (i.e., prices move together overtime). This happens between farmed gilthead seabream and European seabass in the Paris wholesale market, and at the retail level in Italy where seabream prices seem to benchmark seabass prices. But there is no market integration between gilthead seabream and European seabass in the Spanish wholesale markets.

Finally, results show that there is a limited degree of integration between different markets for farmed species; but there is no market integration between wild species from different markets in all cases analysed. Prices of farmed turbot in Barcelona and Madrid wholesale markets are integrated. While prices of farmed European seabass in Barcelona and Paris wholesale markets are related to the prices of farmed European seabass imported from Turkey into the EU.

ABBREVIATIONS AND ACRONYMS

ADF: Augmented Dickey-Fuller.

C: constant.

CE: Cointegration Equations.

e.g.: from the Latin *exempli gratia*, meaning “for the sake of example”.

et al.: from the Latin *et alii*, meaning “and others”.

EU: European Union.

EUMOFA: EUropean Market Observatory for Fisheries and Aquaculture.

FAO: Food and Agriculture Organisation of the United Nations.

i.e.: from the Latin *id est*, meaning “that is” or “in other words”.

IID: Independent and Identically Distributed.

Info: information.

Kg.: Kilogram.

Km.: Kilometre.

L.R.: Likelihood ratio.

No.: Number.

OLS: Ordinary Least Squares.

Prob: Probability.

S.D.: Standard Seviation.

S.E.: Standard error.

Std.: Standard.

US: United States.

USD or U$D: United States Dollar.

VAR: Vector Autoregression.

1. INTRODUCTION

The aim of this report is to provide an overview of the market interactions (competition) between wild and farmed species in Mediterranean fish markets. The interactions between wild fisheries and aquaculture have been widely detailed by Soto *et al.* (2012) and Knapp (2015). Whilst, Bjørndal and Guillen (2016) analysed the literature on market interactions between wild and farmed fish.

The existence of market competition between wild fisheries and aquaculture means that there is substitutability between wild and farmed species. Market competition between wild fisheries and aquaculture can be observed, for the most part, when increased aquaculture supply leads to decreases in wild-caught seafood prices (Anderson, 1985).

The existence of market competition (substitutability) between wild fisheries and aquaculture implies that wild and farmed products behave as substitutes. If two products (wild and farmed) are close substitutes, and considering that aquaculture is probably the fastest growing food-producing sector, farmed produce will win market share from the wild produce. If demand is not perfectly elastic, the price of both products will decline, as will the income of fishermen. However, if the two produces are not substitutes, so that there are no market effects, the increase in the supply of the farmed produce will only lead to a price decrease for farmed produce and not affect the price of wild-caught produce (Asche *et al.*, 2001).

Price interactions operate at a global level and can have serious consequences for wild fisheries and aquaculture producers when the imported produce price is lower than the domestic price (e.g. produce comes from countries with significantly lower production costs). Less efficient domestic aquaculture firms and wild fisheries may experience decreases in profits, compromising their future. In some instances, this has given rise to dumping complaints and the introduction of anti-dumping measures (Asche and Bjørndal, 2011).

Therefore, the introduction of aquaculture has led to a higher total seafood supply, lower seafood prices and lower price volatility (Dahl & Oglend, 2014; Asche, Dahl & Steen, 2015). Through this contribution to the decrease in the prices of seafood and the increase of total supply, aquaculture has accelerated the globalisation of trade and increased the concentration and integration of the seafood industry worldwide (Schmidt, 2003; Guillotreau, 2004). Quality improvements and new product developments have been boosted and logistics improved so that international airfreight is commonplace, changing the way of doing business with a stronger market orientation and risk reduction due to decreased price volatility. Aquaculture also has a positive influence on the development of new markets and the promotion of seafood consumption in general (Valderrama & Anderson, 2008).

Current knowledge on market competition between aquaculture and wild fish is based on a small number of species and markets. Studies have mostly focused on salmon, shrimp, tilapia, and seabass and seabream, which are the most traded species, and the US and EU markets, the two main consumer markets (Bjørndal and Guillen, 2016). In particular, when it comes to the Mediterranean area, existing knowledge on competition interactions between wild and farmed species in the Mediterranean is more limited, and it is based solely on studies investigating gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*) in Spain, France and Italy. As we shall discuss later, some of the results may appear to be contradictory.

For Spain, Alfranca *et al.* (2004) found that farmed gilthead seabream (*Sparus aurata*) prices determined the evolution of wild gilthead seabream (*Sparus aurata*) prices more directly than the wild gilthead seabream prices in the Barcelona wholesale market. However, Rodríguez *et al.* (2013) have shown that wild and farmed gilthead seabream (*Sparus aurata*) are two heterogeneous products and consequently are not substitutes in the Madrid wholesale market.

In French households, Regnier and Bayramoglu (2014) have found that fresh whole wild seabream (consisting of *Sparus aurata*, *Spondyliosoma cantharus*, *Pagellus bogaraveo*, *Coryphaena hippurus*, *Sebastes mentella*, *Sebastes marinus*, and *Lithognathus mormyrus*) and farmed gilthead seabream (*Sparus aurata*) are partially integrated and that their price relationship is led by farmed seabream; while, those for whole wild seabass (*Dicentrarchus labrax* and *Anarhichas lupus*) and farmed European seabass (*Dicentrarchus labrax*) are not integrated. On the other hand, Brigante and Lem (2001), using a much older data set, concluded that wild and farmed conspecifics are not substitutes for gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*) in Italy.

In addition, Alfranca *et al.* (2004) found that the influence on farmed and wild gilthead seabream (*Sparus aurata*) prices of wild sole, farmed Atlantic salmon (*Salmo salar*), farmed European seabass (*Dicentrarchus labrax*), and wild European seabass (*Dicentrarchus labrax*) prices are rather weak and not very significant in the Barcelona wholesale market.

Therefore, available studies on competition interactions between wild and farmed species in the Mediterranean are based on a limited number of cases with no general trends observed. The differences in the outcomes obtained could be, at least in part, due to the different data sources employed and the time periods analysed. Therefore, in this study we investigate in more detail and in a more homogeneous approach the existence of market interactions in the area and with recent data sets spanning more or less the same period.

This study is organised as follows. In section one, we provide an overview of aquaculture and capture fisheries in the Mediterranean with a characterisation of the main producing and consuming countries. Section two introduces the methodology to estimate the existence of market competition interactions: the Johansen cointegration test. Data used for the analysis is presented in section three. Section four shows the results obtained, while section five provides a discussion and interpretation of the results.

2. CAPTURE FISHERIES AND AQUACULTURE IN THE MEDITERRANEAN

In the Mediterranean and Black Sea[3], capture fisheries production in 2013 was 1.2 million tonnes, of which 1061 thousand tonnes were fish, 129 thousand tonnes were mollusks and 52 thousand tonnes were crustaceans (FAO, 2015). The main capture species in 2013 (see Table 1) are European anchovy, which represents 26 percent of the total production, European pilchard (15%) and sardinellas and striped venus, (3%). While quantity data are available for both aquaculture and capture fisheries, value data are only available for aquaculture.

Marine aquaculture production in the Mediterranean and Black Sea reached 466 thousand tonnes in 2013, with 310 thousand tonnes coming from fish and 156 from mollusks (FAO, 2015). Marine aquaculture production in the Mediterranean and Black Sea is concentrated on gilthead seabream and European seabass, and the two species combined represent 63 percent in weight and 80 percent in value of the total Mediterranean and Black Sea aquaculture production. Other farmed species in terms of quantity are Mediterranean mussel (24%) and Japanese carpet shell (6%), which represented 5 and 7 percent in terms of value, respectively (see Table 1).

[3] The Mediterranean Sea is located between Europe and Africa, as well as Asia in the East. It is connected to the Atlantic Ocean thorught the 14km wide Gibraltar Strait it is and almost completely enclosed by land: on the north by Southern Europe and Anatolia, on the south by North Africa, and on the east by the Levant. The Mediterranean Sea covers an area of over 2.5 million square kilometers (950,000 square miles).
The Black Sea is a sea between Southeastern Europe and Western Asia. It is bounded by Europe, Anatolia and the Caucasus. The Black Sea is an inland sea connected to the Marmara Sea by the narrow and shallow Bosporus Strait, while the Strait of Dardanelles further connects the Marmara Sea to the Aegean Sea region of the Mediterranean Sea. The Black Sea is also connected to the Sea of Azov by the Strait of Kerch. The Black Sea (not including the Sea of Azov) covers an area of 436,400 square kilometers (168,500 square miles).
Marine biodiversity differs significantly between the Mediterranean Sea and the Black Sea, in great part explained by the Black Sea reduced salinity. In the Mediterranean Sea there are two to five times more species in various benthic taxa than in the Black Sea. There are twice as many macroalgal varieties in the Medierranean as in the Black Sea, and planktonic biodiversity is about 1.5 times higher. In the Black Sea there are no corals, no octopuses and squids, no seastars, sea urchins - of all echinoderms only several small ophiuran and holothurian species are adapted to the Black Sea habitat.

Table 1. Top ten species and total production from aquaculture and wild fisheries in weight (tonnes) and aquaculture value ('000 U$D) in the Mediterranean and Black Sea (2013).

Capture fisheries production volume	tonnes	Aquaculture production volume	tonnes	Aquaculture production value	'000 USD
European anchovy	321115	Gilthead seabream	152376	Gilthead seabream	947746
European pilchard(=Sardine)	192507	European seabass	140659	European seabass	917538
Marine fishes nei	55915	Mediterranean mussel	113814	Japanese carpet shell	157570
Sardinellas nei	42834	Japanese carpet shell	30194	Mediterranean mussel	122165
Striped venus	42798	Rainbow trout	5190	Atlantic bluefin tuna	67191
Jack and horse mackerels nei	32926	Sea mussels nei	4591	Rainbow trout	22484
European sprat	29930	Pacific cupped oyster	4260	Pacific cupped oyster	22479
Mediterranean horse mackerel	27411	Atlantic bluefin tuna	3445	Meagre	12524
Bogue	23621	Meagre	1764	Sciaenas nei	11405
European hake	23115	Grooved carpet shell	1608	Grooved carpet shell	8761
Total general	1243876	Total general	465628	Total general	2337670

Source: FAO, 2015.

The main fishing nations in the Mediterranean and Black Sea are Turkey accounting for 27 per cent of the total catches followed by Italy (14%), Tunisia (9%) and Algeria (8%) (see Table 2). Marine aquaculture production is more concentrated, with Greece responsible for 31 percent of the total quantity produced followed by Italy (27%), Turkey (24%) and Spain (7%) (see Table 2).

Table 2. Top ten countries and total production from aquaculture and wild fisheries in weight (tonnes) and value ('000 U$D) in the Mediterranean and Black Sea (2013).

Capture fisheries production volume	tonnes	Aquaculture production volume	tonnes	Aquaculture production value	'000 USD
Turkey	339053	Greece	142240	Greece	839363
Italy	174118	Italy	123765	Turkey	602548
Tunisia	109899	Turkey	110845	Italy	375700
Algeria	100058	Spain	30764	Spain	178829
Spain	82496	France	19535	Tunisia	82543
Ukraine	78424	Tunisia	11186	France	71554
Croatia	75286	Croatia	8784	Croatia	62685
Egypt	63028	Cyprus	5284	Cyprus	38119
Greece	62200	Malta	3939	Malta	37202
Libya	36004	Israel	3374	Israel	30477
Total general	1,243,876	Total general	465,628	Total general	2,337,670

Source: FAO, 2015.

Production from capture fisheries and aquaculture in the Mediterranean and Black Sea do not match with the production from Mediterranean countries[4] because in the latter we do not include production from countries with a coastline only in the Black Sea[5], or production from third countries (e.g. Japan and Republic of Korea), which have historically been fishing in Mediterranean waters. In addition, Mediterranean countries also fish in other waters, especially those countries that also have coastlines in different water basins (e.g. France, Morocco, Spain), the existence of long-distance fishing (e.g. fishing in the Pacific and Indian oceans), and freshwater and inland water fisheries. The Mediterranean coast is about 46,000 km long, with 15,000 km suitable for aquaculture production on the northern shore (from Spain to Turkey) and 4,000 km on the southern shore (Lacroix, 1995).

Table 3. Total production from aquaculture and wild fisheries in weight (tonnes) and value ('000 U$D) for Mediterranean countries by fishing area (2013).

Fishing area	Capture fisheries production volume	Aquaculture production volume	Aquaculture production value
Africa - Inland waters	266212	1101721	2100068
Asia - Inland waters	38705	147211	393401
Europe - Inland waters	15742	104047	400874
Mediterranean and Black Sea	1111339	462722	2332881
Atlantic Ocean	2336716	321048	943665
Indian Ocean	276485		
Pacific Ocean	132536		
Total	4177735	2136750	6170890

Source: FAO, 2015.

Capture fisheries production represents two thirds of the total seafood production, including capture and aquaculture production, in Mediterranean countries. Capture fisheries catches in the Mediterranean and Black Sea by Mediterranean countries represent 27 percent of all their catches; while most catches come from the Atlantic Ocean, mainly by Morocco, Spain and France which

[4] Albania, Algeria, Bosnia & Herzegovina, Croatia, Cyprus, Egypt, France, Gibraltar (a self-governing British Overseas Territory), Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Montenegro, Morocco, Palestine Occupied Tr., Slovenia, Spain, Syrian Arab Republic, Tunisia, and Turkey.

[5] Bulgaria, Georgia, Romania, Russia, and Ukraine. Turkey is considered in this study as a Mediterranean country because it has part of the coastline in the Mediterranean Sea.

accounts for 56 percent of all catches. Other capture fisheries areas are inland waters[6], the Indian Ocean and the Pacific Ocean.

Marine aquaculture production represents 37 percent in quantity and 53 percent in value of all aquaculture production by Mediterranean countries. Twenty-two percent in quantity and 38 percent in value of all aquaculture production come from the Mediterranean and Black Sea, while the other 15 percent in quantity and value comes from the Atlantic Ocean. Inland aquaculture (freshwater and brackishwater) represents 63 percent in quantity and 47 percent in value for Mediterranean countries, mostly from Africa, which represents 52 percent in quantity and the 34 percent of all aquaculture production.

The main Mediterranean fishing nations are Morocco with 30 per cent of the total catches followed by Spain (25%), France (13%), Turkey (4%) and Egypt (4%) (Table 4). Marine aquaculture production is more concentrated, with Egypt being responsible for 51 percent of the total quantity produced followed by Turkey (11%), Spain (10%), France (9%) Italy (8%), and Greece (7%) (Table 4).

[6] Asia – inland waters refers to inland production in Turkey.

Table 4. Capture and aquaculture production in weight (tonnes) and value ('000 U$D) by Mediterranean country (2013), including also other areas than the Mediterranean Sea.

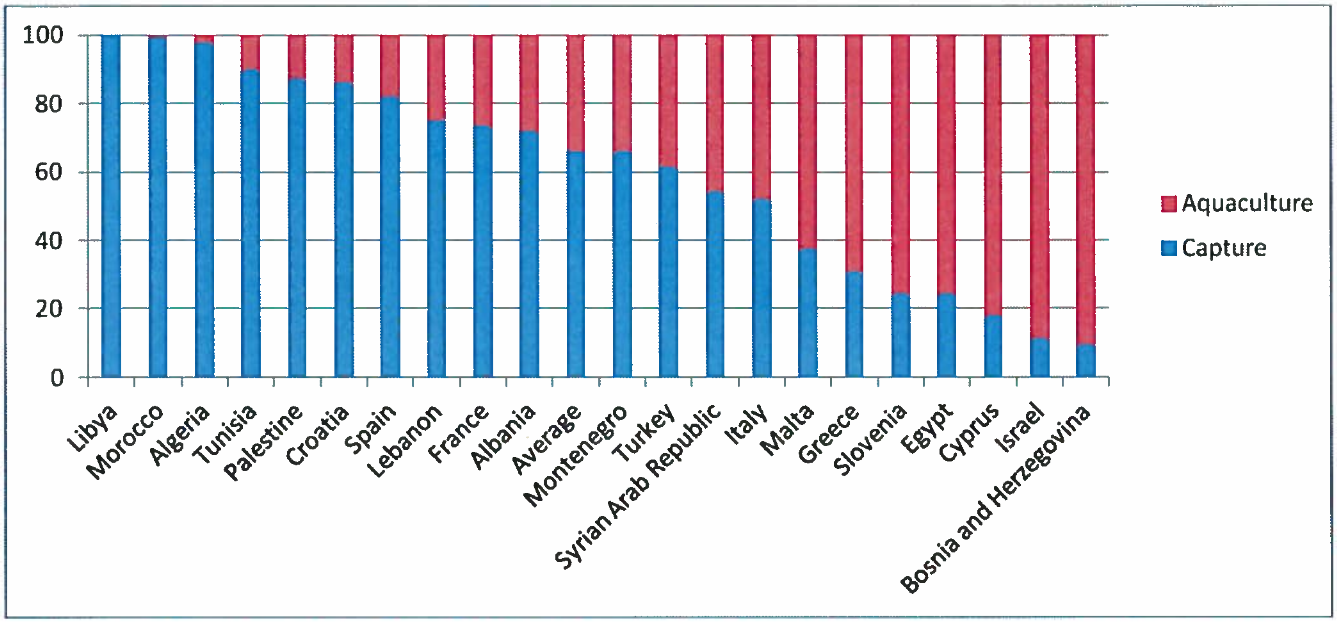
Country	Total seafood production	Capture fisheries production volume	Aquaculture production volume	Aquaculture production value
Albania	7461	5371	2090	7147
Algeria	102251	100058	2193	4329
Bosnia and Herzegovina	3229	305	2924	15955
Croatia	87728	75709	12019	71436
Cyprus	6526	1186	5340	38771
Egypt	1454402	356858	1097544	2088867
France	765353	563143	202210	891870
Gibraltar	0	0	0	0
Greece	208640	64045	144595	851975
Israel	25026	2885	22141	102471
Italy	340538	177918	162620	522856
Lebanon	5091	3811	1280	4060
Libya	36014	36004	10	20
Malta	6295	2356	3939	37202
Monaco	1	1	0	0
Montenegro	2392	1581	811	3954
Morocco	1260728	1258960	1768	8879
Palestine	2214	1930	284	2536
Slovenia	1626	400	1226	4777
Spain	1259104	1035395	223709	510446
Syrian Arab Republic	8800	4800	4000	13134
Tunisia	123077	110893	12184	84304
Turkey	607992	374128	233864	905901
Totals	6314485	4177735	2136750	6170890

Source: FAO, 2015.

Despite the predominance of capture fisheries as the main production source, aquaculture production in Mediterranean countries plays an increasing role in seafood supply and is very significant for some countries (see Figure 1).

Gibraltar and Monaco are not further included in the analysis due to their low total production and consumption due to their small population of almost 30 and 37 thousand respectively.

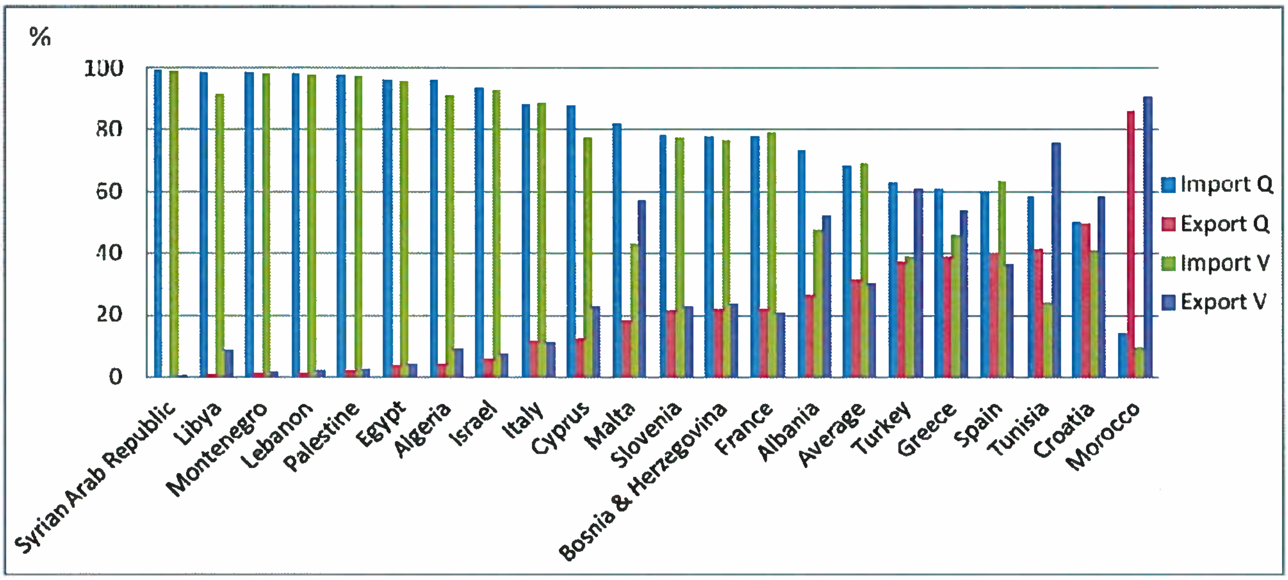
Figure 1. Capture and aquaculture production shares of the total seafood production by Mediterranean country (2013).



Source: authors' elaboration of FAO data (2015).

Mediterranean countries are net importers of seafood products, with imports being more than double the exports. Indeed, in 2011 Mediterranean countries imported almost 4.9 million tonnes of seafood valued at 23.2 billion U$D, compared to the 2.2 million tonnes exported valued at 10.2 billion U$D (FAO, 2015). Only Morocco exported more in quantity than it imported; while in monetary terms, exports from Morocco, Croatia, Tunisia, Greece, Turkey, Albania and Malta were more valuable than imports in 2011 (see Figure 2) (FAO, 2015). There has been a significant increase in external trade (import and exports) during recent years; countries like Egypt, Croatia, Lebanon or Syria have experienced an important increase (Franquesa, Oliver, & Basurco, 2008).

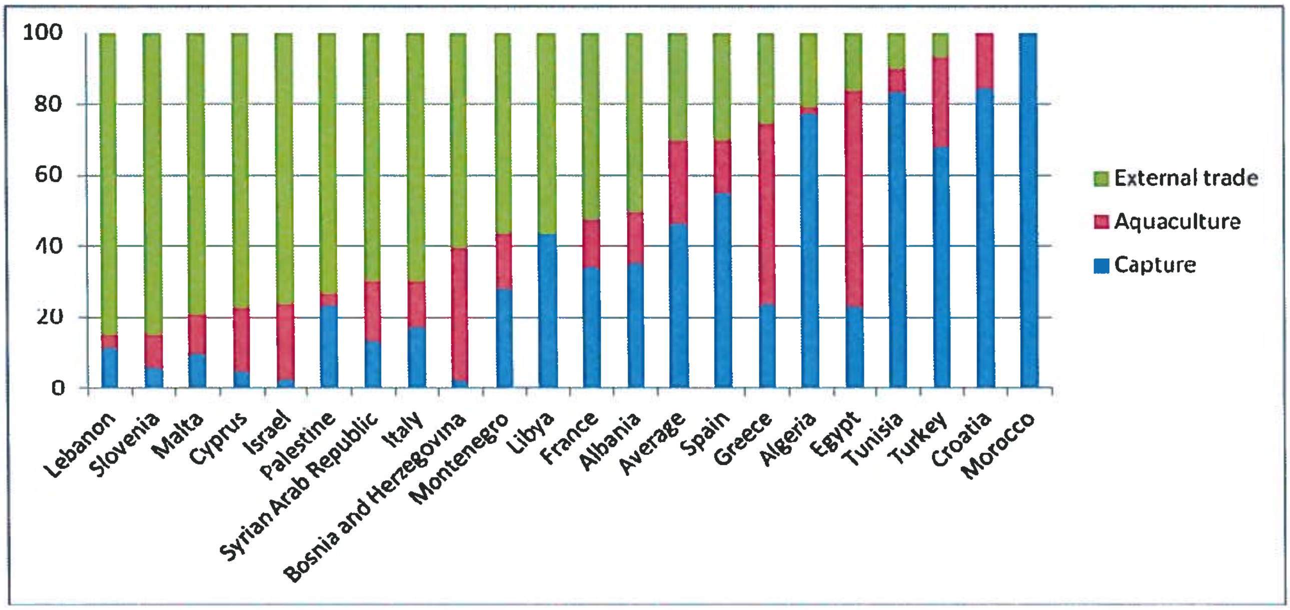
Figure 2. Import and export shares in quantity and value by Mediterranean country (2011).



Source: authors' elaboration of FAO data (2015).

In fact, external trade is the main seafood supply for most Mediterranean countries. External trade (imports – exports) represents 50 percent or more of the total seafood supply for Albania, Bosnia & Herzegovina, Cyprus, France, Israel, Italy, Lebanon, Libya Malta, Montenegro, Palestine, Slovenia and the Syrian Arab Republic in 2011 (see Figure 3).

Figure 3. Capture, aquaculture and external trade shares of the total seafood supply by Mediterranean country (2013).



Source: authors' elaboration of FAO data (2015).

Total seafood supply, or apparent consumption[7], in Mediterranean countries was almost 8.7 million tonnes in 2011 (see Table 5) (FAO, 2015). The countries with the largest seafood consumption are Spain, Egypt, France and Italy; while seafood consumed per capita (apparent consumption per capita[8]) is lead by Malta, followed by Spain, Greece, France, Cyprus, Morocco, and Egypt (see Table 5). Average seafood consumption per capita goes from the 47.6 kg per person from Malta to the 1.4 kg per person in Palestine. The total population of Mediterranean countries was 475 million people in 2011 (World Bank, 2015).

Table 5. Total seafood supply, apparent consumption per capita, price of aquaculture, imported and exported products (2011). See comment above

Country	Total seafood supply (tonnes)	Apparent consumption per capita (kg)	Price aquaculture products (USD/kg)	Price imported products (USD/kg)	Price exported products (USD/kg)
Albania	13761	4.7	2.7	3.2	9.6
Algeria	131912	3.5	1.9	2.0	4.6
Bosnia and Herzegovina	13316	3.5	4.2	4.3	4.8
Croatia	84042	19.6	5.5	3.2	4.7
Cyprus	25952	23.2	8.1	4.0	8.2
Egypt	1622715	20.4	2.0	2.0	2.2
France	1550397	23.7	4.5	5.8	5.4
Greece	270132	24.3	6.1	3.8	7.0
Israel	99062	12.8	4.5	4.8	5.9
Italy	1272667	21.4	3.4	6.1	5.8
Lebanon	34263	7.8	3.2	4.2	5.7
Libya	68814	11.3	2.0	2.1	16.5
Malta	19812	47.6	17.8	2.9	17.4
Montenegro	5442	8.8	4.6	4.8	6.2
Morocco	659527	20.6	3.7	2.5	4.0
Palestine	5645	1.4	6.1	3.4	3.6
Slovenia	15373	7.5	3.4	5.3	5.6
Spain	1834661	39.3	2.1	4.4	3.8
Syrian Arab Republic	44712	2.0	3.3	2.5	4.5
Tunisia	123439	11.6	6.7	1.7	7.5
Turkey	758253	10.4	4.0	2.1	5.6
Totals	8653898	18.2	3.0	4.8	4.6

Source: authors' elaboration of FAO data (2015).

[7] Apparent consumption is defined as the sum of capture fisheries production, aquaculture production and imports volume minus the exports volume.
[8] Apparent consumption divided by the population.

2.1. COUNTRY ANALYSIS

The countries analysed can be divided into three groups: (i) European Union Member countries; (ii) North African countries; and (iii) Other Mediterranean countries.

The countries included in each group are:

- European Union Member Countries: Croatia, Cyprus, France, Greece, Italy, Malta, Slovenia, and Spain.
- North African countries: Algeria, Egypt, Libya, Morocco and Tunisia.
- Other Mediterranean countries: Albania, Bosnia & Herzegovina, Israel, Lebanon, Palestine, Montenegro, Syria and Turkey.

2.1.1 U COUNTRIES

EU countries in the Mediterranean have traditionally had high levels of seafood consumption. Most of them have consumption levels of 20 kg per capita or higher (see Table 5). Only Slovenia has a significantly lower food consumption (7.5 kg per capita). This is in great part due to Slovenia's short coastline (46 km), a population of two million people and total area of more than 20 thousand km^2. Most of Slovenia's seafood supply comes from imports.

France, Greece, Italy and Spain are important fishing nations with high levels of seafood consumption. Italy complements its Mediterranean catches mainly with high levels of imports, France and Spain, together with high levels of imports, have their most important fishery grounds in the Atlantic Ocean, while Greece also has a significant part of its seafood supply coming from aquaculture. French, Italian and Spanish import prices are higher than those for export, while Greek export prices are higher, in great part because of exporting high-value aquaculture products (gilthead seabream and European seabass). Greece, together with Turkey, is the main producers of gilthead seabream and European seabass. Greek production of gilthead seabream and European seabass in 2013 is estimated to be 73 and 49 thousand tonnes, respectively. Other significant productions are Mediterranean mussel at more than 17 thousand tonnes and rainbow trout at almost 2 thousand tonnes.

Low average aquaculture prices in Spain can be explained because Spain produces a large volume of mussels (162 thousand tonnes in 2013) that are relatively cheap (0.65 U$D per kg). Other important aquaculture products in Spain are gilthead seabream and European seabass at 19 and 15 thousand tonnes, rainbow trout at 16 thousand tonnes and turbot at almost 7 thousand tonnes. It should be noted that almost three quarters of the gilthead seabream and European seabass production takes place in the Mediterranean area, while the majority of the mussel and turbot production takes place in Atlantic waters.

Similarly, most aquaculture production in France comes from the Atlantic waters. Main species farmed in France are Pacific cupped oyster with an estimated production in 2013 of 79 thousand tonnes, blue mussel at 61 thousand tonnes, rainbow trout at almost 30 thousand, and Mediterranean mussel at almost 14 thousand tonnes. In the Mediterranean Sea, the main species produced are Mediterranean mussel at 12 thousand tonnes and Pacific cupped oyster at 4 thousand tonnes. Gilthead seabream and European seabass production is relatively small compared to other countries in the Mediterranean, at about one thousand tonnes each.

Italian marine aquaculture takes place in the Mediterranean Sea. The main aquaculture species are Mediterranean mussel at 79 thousand tonnes, rainbow trout at more than 34 thousand tonnes, Japanese carpet shell at 30 thousand tonnes, European seabass at almost 7 thousand tonnes, and gilthead seabream at more than 5 thousand tonnes.

In Cyprus and Malta the main seafood supply are imports; while for Croatia imports play a tiny role and its main seafood supply comes from capture fisheries. Malta's aquaculture and export prices are the highest (see Table 5), which can be explained by the cultivation and its later export of Atlantic bluefin tuna (*Thunnus thynnus*). Farmed Atlantic bluefin tuna production in Malta was one thousand tonnes in 2013, while gilthead seabream production was 2.5 thousand tonnes. In Cyprus, gilthead seabream and European seabass productions were almost 4 thousand tonnes and more than one thousand tonnes, respectively. In Croatia, the main species produced in 2013 were gilthead seabream at almost 3 thousand tonnes, Mediterranean mussel and common carp at 2 thousand tonnes, Atlantic bluefin tuna at almost one thousand tonnes (capture catches of Atlantic bluefin tuna were also one thousand tonnes).

2.1.2 North African countries

Seafood consumption varies largely by country: Morocco and Egypt have a high consumption at more than 20 kg per capita; Libya and Tunisia have consumption above 10 kg per capita and

Algeria below 5 kg per capita. For Syria and Libya imports are the main source of supply; for Algeria and Morocco this role is played by the capture fisheries, while in Egypt, aquaculture is the main source of seafood.

The main seafood production in most North African countries (i.e., Algeria, Libya, Morocco and Tunisia) comes from capture fisheries. Indeed, these are the four countries with the largest share of capture fisheries in total seafood production. In 2013, Tunisia produced 8 thousand tonnes of gilthead seabream and almost 2 thousand tonnes of European seabass, Syria produced almost 2 thousand tonnes of common carp and one thousand tonnes of blue tilapia, Algeria produced more than one thousand tonnes of cyprinids, while the production of other species was below one thousand tonnes.

Egypt is an exception, and inland aquaculture plays a main role. Most of Egypt's aquaculture production is from the brackish water areas of its delta lakes and lagoons in the north of the country (Monfort, 2007). Egypt is the largest producer of tilapia in the Mediterranean. In fact, the main species produced is Nile tilapia (*Oreochromis niloticus*) at 636 thousand tonnes, followed by common carp (*Cyprinus carpio*) at 176 thousand tonnes, other cyprinids (118 thousand tonnes), mullets (116 thousand tonnes), gilthead seabream (15 thousand tonnes), torpedo-shaped catfishes (13 thousand tonnes) and European seabass (12 thousand tonnes). The Egyptian volume of exports represents only 4 percent of the imports. Tilapia, as well as most of the Egyptian production, has been traditionally mostly restricted to local markets due to its high production costs compared to other producer countries as well as food safety concerns from the EU and US (Feidi, 2004; Macfadyen, Nasr-Allah & Dickson, 2012; Goulding & Kamel, 2013). In addition, Norman-López and Bjørndal (2009) found that prices of frozen tilapia fillets in Egypt are not related to other tilapia prices in international markets.

On the other hand, Morocco's production comes mostly from capture fisheries (aquaculture represented a little more than the 0.1 percent of the total seafood production in 2013). Most of the landings of capture fisheries come from Atlantic waters (96%), while landings from the Mediterranean Sea account for less than 3 percent. Moreover, Morocco is the only net exporter (by volume) country in the whole region. The main products exported are European sardines and anchovies prepared or preserved, octopus, frozen cuttlefish, shrimps and prawns frozen, and fresh, chilled or boiled common crangon shrimps (FAO, 2015).

Libya's high export prices (see Table 5) are because most exports from Libya are of fresh and frozen wild-caught Atlantic bluefin tuna.

2.1.3 OTHER MEDITERRANEAN COUNTRIES

The other group of Mediterranean countries (i.e., Albania, Bosnia & Herzegovina, Israel, Lebanon, Montenegro, Palestine, Syria and Turkey) represent a very heterogeneous set of countries. This group of countries is characterised by low to medium seafood consumption per capita - from 1.4 kg per capita in Palestine and 2.0 kg per capita in Syria to 10.4 kg per capita in Turkey and 12.8 kg per capita in Israel.

In Lebanon, Israel, Palestine, Syria, Bosnia & Herzegovina, and Montenegro more than 50 percent of the seafood supply comes from imports. In Albania, both imports and capture fisheries play a key role in the seafood supply. While capture fisheries are the main source of seafood supply in Turkey, aquaculture production is also important, especially as a key source for exports.

The main species cultured in Turkey are rainbow trout at 128 thousand tonnes, European seabass at 68 thousand tonnes, and gilthead seabream at almost 36 thousand tonnes in 2013. The main species cultured in other Mediterranean countries are: in Israel, 8 thousand tonnes of tilapias, 5 thousand tonnes of common carp, more than 2 thousand tonnes of gilthead seabream, and 2 thousand tonnes of flathead grey mullet; in Bosnia & Herzegovina, more than 2 thousand tonnes of rainbow trout; in Syria, almost 2 thousand tonnes of common carp and more than 1 thousand tonnes of blue tilapia; and in Lebanon, 1 thousand tonnes of rainbow trout.

2.2. GILTHEAD SEABREAM AND EUROPEAN SEABASS

Gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*)[9] are the most produced species in the Mediterranean and Black Sea, at 293 thousand tonnes and $1.86 billion in

[9] The gilthead seabream (*Sparus aurata*) is a fish of the Sparidae family (bream) commonly found throughout the Mediterranean, as well as along the Northeastern Atlantic coasts from the United Kingdom to the Canary Islands. It can live in marine waters as well as in the brackish waters of coastal lagoons. It has an oval body, rather deep and compressed. It is silvery grey in colour with a golden frontal band between eyes edged by two dark areas. It commonly reaches about 35 centimetres in length, but may reach up to 70 centimetres and weigh up to about 17 kilograms. It is the only species of sea bream which is currently farmed on a large scale. Farmed seabream can reach the first commercial size of 350-400 grams in about one to one and a half years.

2013 (FAO, 2015)[10]. Gilthead seabream and European seabass represent 63 percent in quantity and 80 percent in value of all the aquaculture production in the Mediterranean basin.

Photos: Wild gilthead seabream and European seabass at the ex-vessel market

European seabass (*Dicentrarchus labrax*) is common all over the Mediterranean, the Black Sea and the North Eastern Atlantic from Norway to Senegal. It inhabits coastal waters as well as brackish waters to a depth of 100 m. It has a rather elongated body. It is a silvery grey colour that turns bluish on the back. It commonly reaches about 50 centimetres in length, but may reach up to 100 centimetres and weigh up to about 12 kilograms. Farmed seabass are generally harvested when they weigh 300 to 500 grams, which takes from a year and a half to two years, depending on water temperature.
Both, European seabass and gilthead seabream, are mostly cultivated in floating cages. They are almost always commercialised fresh/chilled as a whole-portion sized fish.

[10] Not considering inland productions,

Ninety-five percent of the world gilthead seabream and European seabass production comes from aquaculture, and 96 percent of the world gilthead seabream and European seabass production comes from Mediterranean countries, considering inland production too. The main producers are Turkey and Greece; while the main consumers are Spain, France, Italy, Greece and Turkey (see Tables 6 and 7).

Table 6. Production evolution of farmed gilthead seabream (*Sparus aurata*) by main producer countries in 2013.

Country / Year	1980	1985	1990	1995	2000	2005	2010	2011	2012	2013
Greece		7	1598	9387	38587	43829	57204	70900	72300	73300
Turkey			1031	4847	15460	28334	28157	32187	30743	35701
Spain		127	565	2706	8242	15433	20358	15118	16607	18897
Egypt				1062	8862	4398	15065	14155	14806	14537
Tunisia		5	85	160	409	576	2296	4184	5273	8475
Italy	250	360	850	3200	6000	6914	6260	5508	5400	5400
Cyprus			37	223	1384	1465	2807	3056	3126	3795
Croatia				90	800	1000	2400	1719	2173	2978
Malta				550	1512	540	1755	1082	2604	2550
Israel			84	230	2511	3366	1240	1440	2052	2520
Overall Total	257	564	4570	24481	87303	110755	142417	153752	159661	173062

Source: FAO (2015).

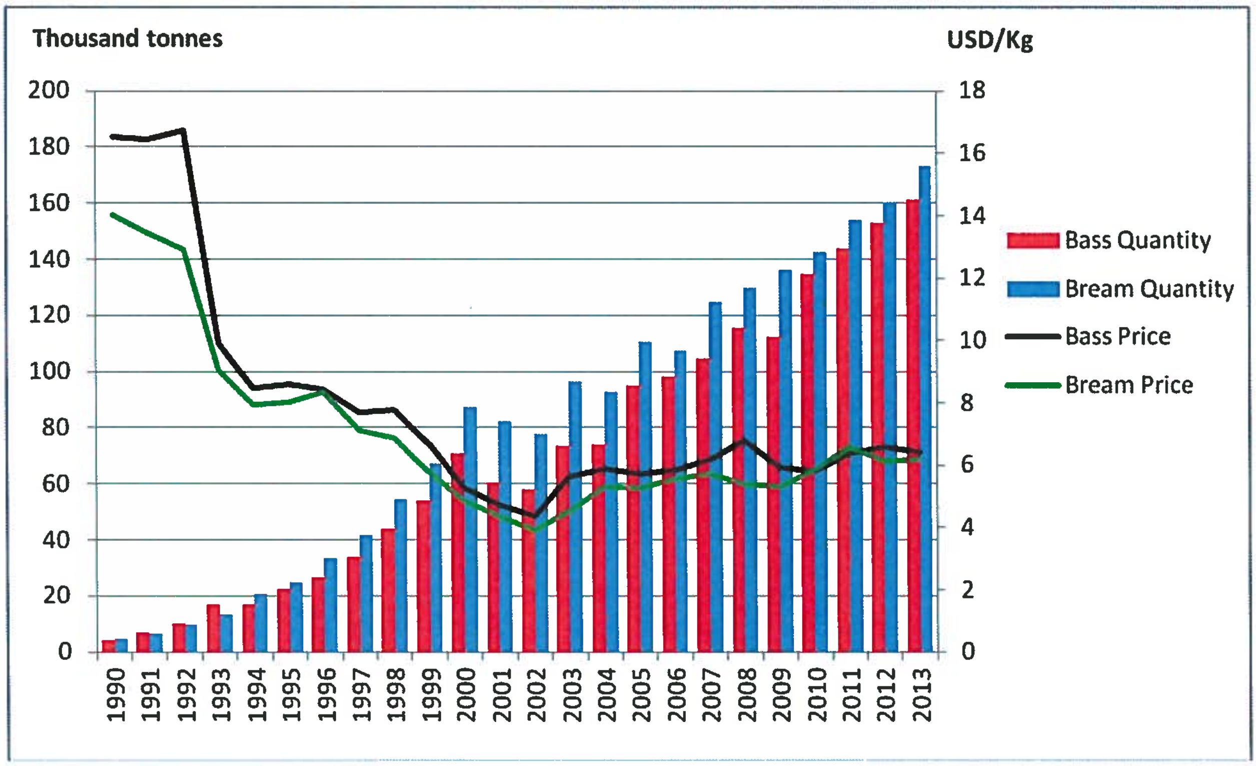
Table 7. Production evolution of farmed European seabass (*Dicentrarchus labrax*) by main producer countries in 2013.

Country	1980	1985	1990	1995	2000	2005	2010	2011	2012	2013
Turkey			102	2773	17877	37490	50796	47013	65512	67913
Greece	5	60	1952	9539	26653	30959	39884	44100	42500	48600
Spain		29	31	461	1837	5713	11491	17548	14455	14945
Egypt				755	10031	4192	16306	17714	13798	12328
Italy	120	340	1050	3600	8100	6262	6457	6672	6700	6700
Croatia				247	1300	2000	2800	2775	2453	2826
France		70	300	2656	3020	3913	2600	2241	2300	2300
Tunisia		15	283	230	202	633	1466	2832	1999	1968
Cyprus		1	15	99	299	583	1198	1495	1100	1422
United Kingdom							473	490	800	800
Overall Total	130	581	3921	22263	70694	95044	134541	144076	153002	161059

Source: FAO (2015).

The evolution of the gilthead seabream and European seabass aquaculture production presents many similarities (see Figure 4). Significant levels of European seabass and gilthead seabream production did not start until the second half of the 1980s and early 1990s even though the first efforts to breed European seabass and gilthead seabream took place in France and Italy in the late 1970s and early 1980s, initially in government research laboratories and increasingly in the private sector (University of Stirling, 2004). The principal reason for the slow initial development of the industry was the difficulty in producing large quantities of good quality fry, as well as the complexity in obtaining licences (University of Stirling, 2004). The production increase from the late 1980s onwards was the result of improvements at the hatcheries level that led to an increase in the supply of juveniles.

Figure 4. Total aquaculture production and price of gilthead seabream and European seabass (2013).



Source: authors' elaboration of FAO data (2015).

Prices of farmed gilthead seabream and European seabass achieved their minimum level in 2001 and 2002 (ex-farm prices for gilthead seabream and European seabass in 2002 reached 3.9 and 4.3 €/kg, respectively), due to major production increases from 2000. Prices often fell below the cost of production, resulting in a major crisis in the industry (University of Stirling, 2004; STEF, 2014). This brought a rationalisation of the industry and stabilisation of prices at around 6 €/kg.

3. METHODOLOGY

The development of prices over time provides important information on the relationship between products, as it has been widely recognised by economists such as Cournot (1838), Marshall (1947) and Stigler (1969). Market integration analysis using time series data for prices has been used for a number of seafood products. It is particularly useful when there is the need to analyse a large number of products, as demand analysis in such cases is not feasible (Asche, Gordon and Hannesson, 2004).

Market integration is analysed by looking at whether prices of products are related over time following Ravallion (1986), which allows price adjustment between markets to take time. So, we investigate if the price of a product (dependent variable P_1) can be explained by the price evolution of another product (explanatory variable P_2), as well as its own previous price evolution. We use the following model specification:

$$P_{1,t} = \alpha + \sum_{j=1}^{m} \beta_j P_{1,t-j} + \sum_{i=0}^{n} \delta_i P_{2,t-i} + e_t \qquad \text{(Eq. 1)}$$

Here α is a constant term and e is a white noise error term. Hence, if δ_i is equal to 0, there is no relation between the prices of both products, so there is no market integration. While, if δ_i is different to 0, there is a relation between the prices of both products, so there is market integration.

The relationships between variables have typically been studied with ordinary regression analysis. Such analysis can be used when variables (i.e., prices) are stationary[11] (Squires, Herrick Jr., and Hastie, 1989; Asche, Gordon and Hannesson, 2004). However, many economic variables show trends, and so these are non-stationary. When non-stationary time series (e.g. prices) are used in a regression model, relationships that appear to be significant may emerge from unrelated variables (spurious regression). Therefore, the use of cointegration methodology is required to estimate real long-run relationships between non-stationary variables. (Ardeni, 1989; Whalen, 1990; Goodwin &

[11] A stationary time series is a sequence of measurements of the same variable collected over time whose statistical properties such as mean, variance, autocorrelation, etc. are all constant over time.

Schroeder, 1991). Since most seafood prices have been found to be nonstationary, cointegration is the most commonly used empirical tool to test for market integration[12].

The idea of cointegration is that even if two or more variables are nonstationary in their levels, linear combinations (so-called cointegration vectors) which are stationary may exist (Engle & Granger, 1987). When cointegration is verified, the variables exhibit (one or more) long run relationships. Variables may drift apart due to random shocks, sticky prices, contracts, etc. in the short run, but in the long run, the economic processes force the variables back to their long run equilibrium path (Engle & Ganger, 1987).

The economic interpretation of cointegration is that "if two (or more) series are linked to form an equilibrium relationship spanning the long-run, then even though the series themselves may contain stochastic trends (that makes them to be non-stationary) they will nevertheless move closely together over time and the difference between them will be stable (so stationaryj)" (Harris, 1995, p22).

Therefore, prices for products in the same market are part of a long-run equilibrium system, although significant short-run deviations from equilibrium conditions may still be observed due to stochastic supply and demand shocks. So, if the products are substitutive, there will be market forces working to re-equilibrate the price ratio after a shock occurs in the market. Thus, when cointegration is verified, it implies the existence of a stable long-run relationship between the prices; from which it can be assumed that a price parity equilibrium condition exists; and consequently the variables form part of the same market (Asche & Steen, 1998). So, cointegration theory is consistent with Stigler & Sherwin's market's definition[13] and the stochastic behaviour of prices.

3.1. The Engle & Granger Cointegration Test

Earlier cointegration studies by Ardeni (1989) and Goodwin & Schroeder (1991) use the Engle and Granger bivariate approach, and test residuals (from ordinary least squares (OLS) estimations of the

[12] For recent examples see e.g. Nielsen *et al.*, 2007; Norman-López and Asche, 2008; Nielsen, Smit and Guillen, 2009.
[13] Stigler & Sherwin (1985) define substitute products as those which are "in the same market" and whose relative prices "maintain a stable ratio".

parameters of possible cointegration relations) for stationarity; which is restricted to pair-wise price comparisons (bivariate methodology).

If two I(d) time series, x_t and y_t, are considered, then any linear combination will also be I(d). If, however, a vector β exists such that the disturbance term of the regression is of a lower order of integration, i.e. I(d-b) where b>0, then these variables are said to be cointegrated of order I(d,b) (Engle & Granger, 1987).

Engle and Granger (1987) specify an autorregresive bivariate model such that:

$$Y_t = \phi_0 + \phi_1 \cdot X_t + \phi_1 \cdot X_{t-1} - \phi_1 \cdot X_{t-1} + \phi_2 \cdot x_{t-1} + \phi_3 \cdot Y_{t-1} + \varepsilon_t \qquad \text{(eq. 2)}$$

After optimum transformations, equation 2 can be rewritten in ECM form including both long- and short-run aspects such that:

$$\Delta Y_t = \phi_1 \cdot \Delta X_t - (1-\phi_3) \cdot (Y_{t-1} - \beta_0 - \hat{\beta}_1 \cdot X_{t-1}) + \eta_t \qquad \text{(eq. 3)}$$

where η_t~IID(0, σ^2).

Testing parameter restrictions is not permitted within this bivariate framework. This is of particular importance if one wants to test hypotheses on the parameters in the cointegration vector. One particular and interesting hypothesis that cannot be tested is if the law of one price (LOP) holds[14]. So, in the Engle and Granger bivariate framework, testing for LOP is not possible since normal inference is not valid. This originally led to a decline in interest in the LOP hypotheses, and instead the focus favours the less-restrictive notion that co-movements of prices (implied by a cointegration relationship) implies market integration.

3.2. THE JOHANSEN (& JUSELIUS) COINTEGRATION TEST

Newer studies have used the multivariate model approach of Johansen (1988 & 1991) and Johansen & Juselius (1990), solving the problems faced by bivariate methods by providing a matrix with all possible distinct cointegration vectors based on all the variables. Thus, the Johansen test enables testing for both cointegration and hypothesis testing on the parameters in the cointegration vector. Johansen (1988) illustrates a procedure to determine the number of cointegration vectors in a given

[14] The Law of One Price is used to identify market inter-dependence. After identifying a cointegrating factor, when the LOP is accepted, then the variables can be aggregated, while when the LOP is rejected, then the goods are substitutes.

set of variables. Later expansion (Johansen & Juselius, 1990 and Johansen, 1991) also incorporates analysis for the inclusion of other factors such as deterministic seasonality and time trends.

Under the Johansen approach the data is divided into two groupings, the variables in their levels and their first differences. Using the technique of canonical correlation, the linear combinations of the data (in their levels) that are highly correlated with the differences are found. If the correlation is sufficiently high, then it follows that these linear combinations are stationary, and thus are the cointegration vectors.

The multivariate approach developed by Johansen starts by defining a vector Z_t, containing *n* potentially endogenous variables, where it is possible to specify a data generating process and model Z_t as an unrestricted vector autoregression (VAR) with up to k-lags of Z_t:

$$Z_t = A_1 Z_{t-1} + \dots + A_k Z_{t-k} + \Phi D_t + \mu + \varepsilon_t \qquad \text{(Eq. 4)}$$

where Z_t is (n×1), each of the A_i is an (n×n) matrix of the coefficients, D_t are seasonal dummies orthogonal to the constant term μ and $\varepsilon_t \sim$ niid $(0,\Omega)$, so it is assumed to be an independent and identically distributed Gaussian process. Equation 4, can be reformulated in vector error-correction (VECM) form by subtracting Z_{t-1} from both sides:

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \dots + \Gamma_{k-1} \Delta Z_{t-k+1} + \Pi Z_{t-k} + \Phi D_t + \mu + \varepsilon_t \qquad \text{(Eq. 5)}$$

$$\text{where, } \Gamma_i = -(I - A_1 - \dots - A_i), \ (i = 1, \dots, k-1), \text{ and } \Pi = -(I - A_1 - \dots - A_k). \qquad \text{(Eq. 6)}$$

The system of equations 4 and 5, contains information on both the short- and the long-run adjustment to changes in Z_t. The rank of Π, denoted as r, determines how many linear combinations of Z_t are stationary.

If $r = N$, the variables in levels are stationary. While if $r = 0$ so that $P = 0$, none of the linear combinations are stationary. When $0 < r < N$, r cointegration vectors, or r stationary linear combinations of Z_t exist.

In this case, Π could be factorised. Then, $\Pi = \alpha\beta'$, where α represents the speed of adjustment to dis-equilibrium and β is a matrix of long-run coefficients and contains the cointegration vectors. Determining how many cointegration vectors exist in β, equals to testing for cointegration.

Johansen & Juselius (1990) show that after undertaking appropriate factorising and by solving an eigenvalue problem it is possible to determine the number of significant cointegration vectors.

One test to determine the number of cointegration vectors is the trace test, (η_r), which is a likelihood ratio test for at most *r* cointegration vectors using:

$$\eta_r = -T \Sigma^N_{i=r+1} \ln (1-\lambda_i) \qquad \text{(Eq. 7)}$$

where T is the number of observations and λ_i are the eigenvalues which solve the eigenvalue problem.

3.3. PROCEDURE

We investigate the existence of relationships between price series using the Johansen Cointegration test. Determining the lag order to take into account in the model is a key issue in cointegration. This happens because in order to apply cointegration, a series should be non-stationary; but the stationarity properties of a series can change with the number of lags considered as explanatory variables. The optimal number of lags for one series (e.g. found using a unit root test) may be different than the optimal number of lags for another series we want to compare. And these lag-lengths may be different from the optimal number of lags when applying cointegration methodology. Thus, estimating the optimal number of lags for one series using a unit root test may be of little help initially.

Moreover, different lag length selection criteria often lead to different conclusions regarding the optimal number of lags that should be used. Meanwhile, the choice of the lag length can considerably affect the results of the cointegration analysis (Emerson, 2007). Therefore, we determine the number of lags using 3 different criteria:

- Log Likelihood
- Akaike Information Criteria
- Schwarz Criteria

Four different outcomes can be obtained from the cointegration tests when estimating them for the number of lags obtained using the previous criteria:

- All tests show two Cointegration Equations. Then prices are not cointegrated, and consequently products are not in the same market.
- All tests show zero Cointegration Equations. Then prices are stationary and cointegration methodology cannot be applied.
- All tests show one Cointegration Equation. There is the need to investigate the stationarity properties of the series. There are two options. It could be that both series are non-stationary and they are cointegrated (i.e., are part of the same market), so there is only one cointegration equation. But it could be possible that one of the series is stationary and the other one is non-stationary, and consequently they are not cointegrated.
- Outcomes from the tests report different numbers of Cointegration Equations depending on the lag chosen. There is the need to investigate the stationarity properties of the series, and results should be considered with caution.

When cointegration methodology cannot be applied (no cointegration equations are found), regressions are used to investigate the relations between variables. Hence, there is an investigation of whether current or previous values of a series "x" can explain current values of series "y". The number of lags for running the regressions is determined using the outputs of the cointegration analysis and complemented with the Log Likelihood, Akaike Information Criteria, and Schwarz Criteria.

Similarly, Granger causality tests are run. The Granger approach to the question of whether series "x" causes series "y" is to see how much of the current series "y" can be explained by past values of series "y" and then to see whether adding lagged values of series "x" can improve the explanation.

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \ldots + \alpha_n y_{t-n} + \beta_1 x_{t-1} + \ldots + \beta_n x_{t-n} \quad \text{(Eq. 8)}$$

$$x_t = \alpha_0 + \alpha_1 x_{t-1} + \ldots + \alpha_n x_{t-n} + \beta_1 y_{t-1} + \ldots + \beta_n y_{t-n} \quad \text{(Eq. 9)}$$

Series "y" is said to be Granger-caused by series "x" if series "x" helps in the prediction of series "y", or equivalently if the coefficients on the lagged values of "x" are statistically significant (Granger, 1969).

The null hypothesis is that (series) "x does not Granger-cause (series) y" in the first regression and that (series) "y does not Granger-cause (series) x" in the second regression. The Granger causality test reports the Wald F-statistics for the joint hypothesis.

$$\beta_1 = \dots = \beta_n = 0 \qquad \text{(Eq. 10)}$$

It is important to note that the statement series “x Granger causes series y” does not imply that series “y” is the effect or the result of series “x”. Granger causality measures precedence and information content but does not by itself indicate causality in the strict sense of the term.

4. DATA

In this section the data used for the realisation of this study are described. Wild and farmed seabeam and seabass price data from Spain, France, Italy, Greece, Portugal and Turkey have been used for different levels in the market chain. Market stages analysed are wholesale, retail, together with the import/export level. Other species with available price data for wild and farmed varieties, such as turbot, blackspot seabeam, Atlantic cod, meagre, clams and mussels have been also analysed.

Weekly data have been used when possible; if weekly data were not available monthly data have been used. The most recent data available have been used, with price series starting no earlier than 2009 or 2010 and ending at the end of 2014 or in 2015. Longer price series are available for the Spain's Madrid and Barcelona wholesale markets, with series starting in 2003 and 2006, respectively. Unfortunately, all the required price series to complete the market integration analysis for all Mediterranean countries are not available or are not long enough.

The use of cointegration methodology is very data demanding, it requires a large number of observations (close to 100 observations depending on the characteristics of the series) in order to obtain robust results. In addition, in order to perform our study we require for each species analysed, price data disaggregated between farmed and wild origin. However, these data are rarely available, in part because: (i) few countries collect and report detailed price data, (ii) there are few markets where both wild and farmed supplies of a species are present and properly differentiated.

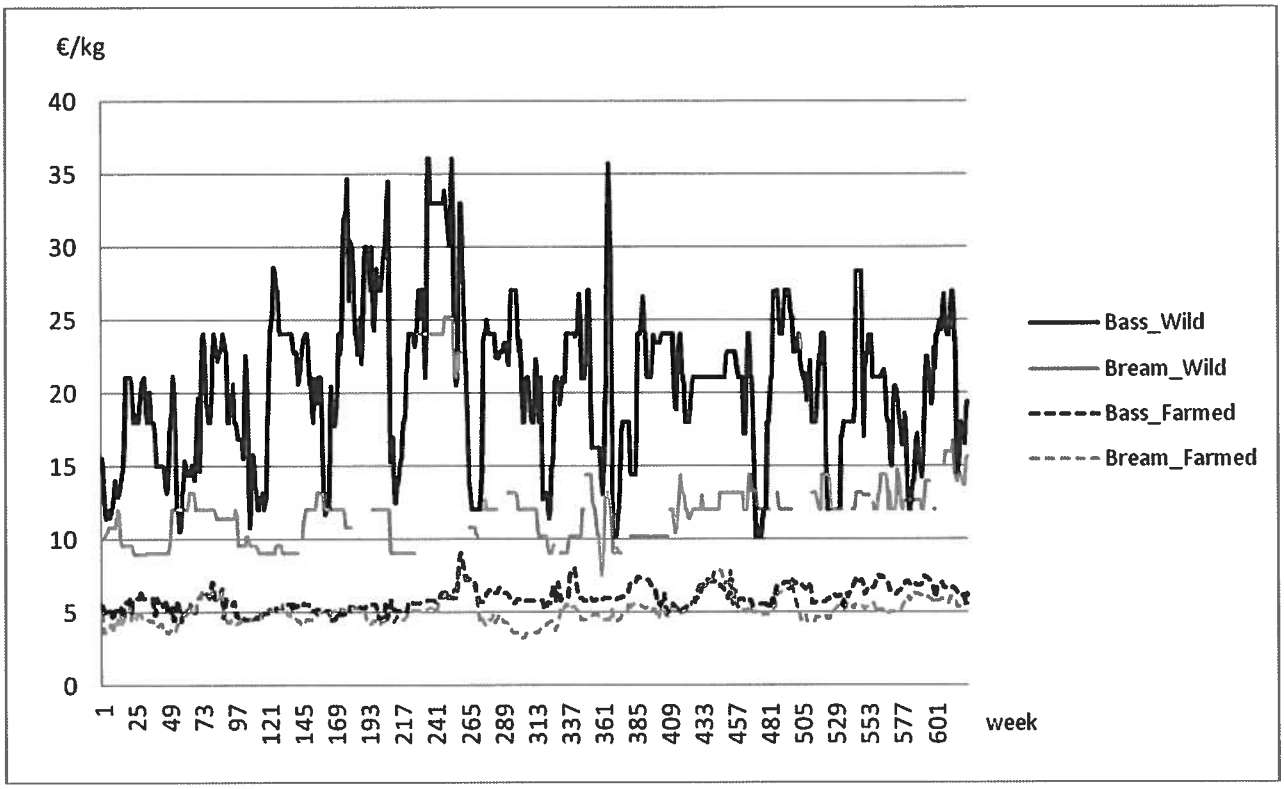
The price data used in this analysis is detailed by country:

4.1. SPAIN

Madrid's wholesale market (Mercamadrid), weekly data for the period 2003-14 (623 observations) for the species:

- Gilthead seabream (*Sparus aurata*), fresh whole, wild and farmed;
- European seabass (*Dicentrarchus labrax*), fresh whole, wild and farmed;
- Turbot (*Scophthalmus maximus*), fresh whole, wild and farmed.
- Sole (*Solea spp.*), fresh whole, wild and farmed, 2012-14 (141 observations).

Figure 5. Weekly prices of wild and farmed gilthead seabream and European seabass in Mercamadrid (2003-14).

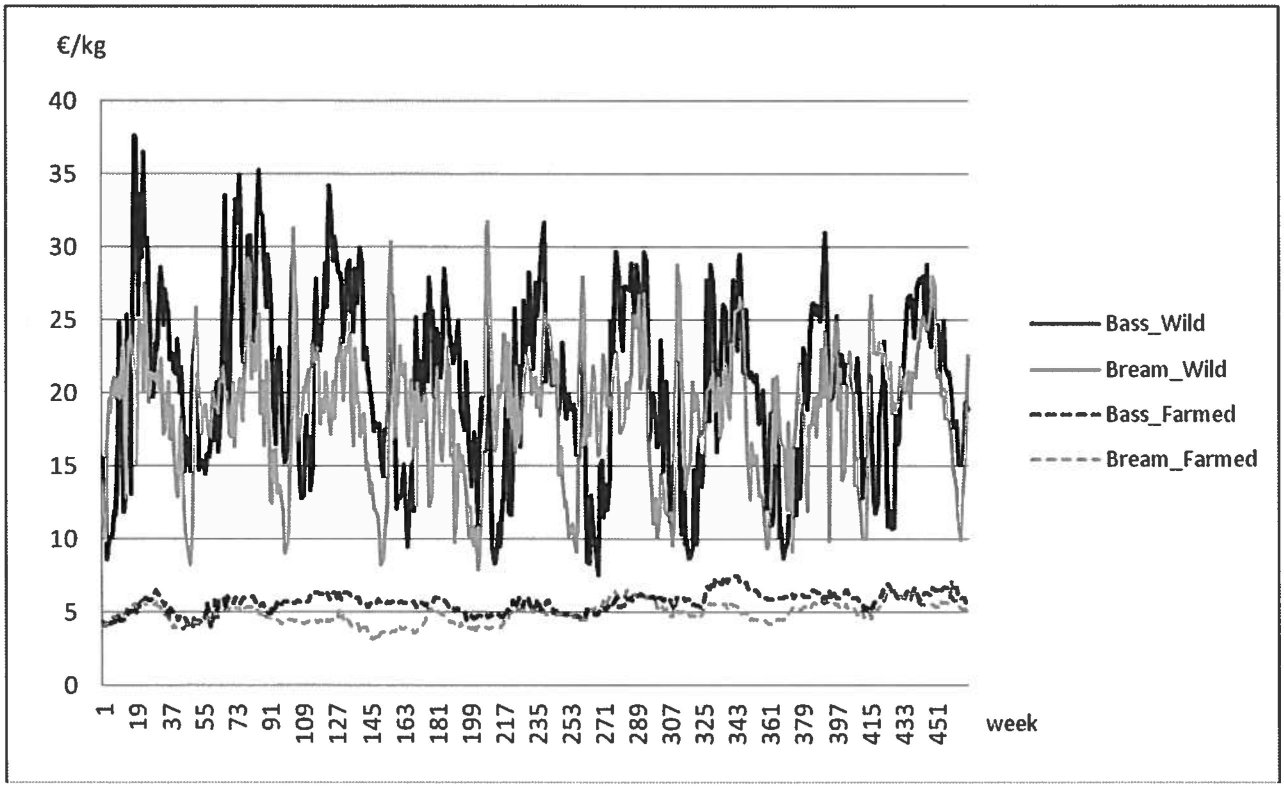


Source: Mercamadrid, 2015.

Barcelona's wholesale market (Mercabarna), weekly data for the period 2006-14 (468 observations) for the species:

- Gilthead seabream (*Sparus aurata*), fresh whole, wild and farmed;
- European seabass (*Dicentrarchus labrax*), fresh whole, wild and farmed;
- Turbot (*Scophthalmus maximus*), fresh whole, wild and farmed.
- Blackspot (red) seabream (*Pagellus bogaraveo*), fresh whole, wild and farmed;
- Atlantic Cod (*Gadus morhua*), fresh whole, wild and farmed;
- Clams (*Venerupis spp.*), fresh whole, wild and farmed;
- Meagre (*Argyrosomus regius*), fresh whole, wild and farmed.

Figure 5. Weekly prices of wild and farmed gilthead seabream and European seabass in Mercabarna (2006-14).



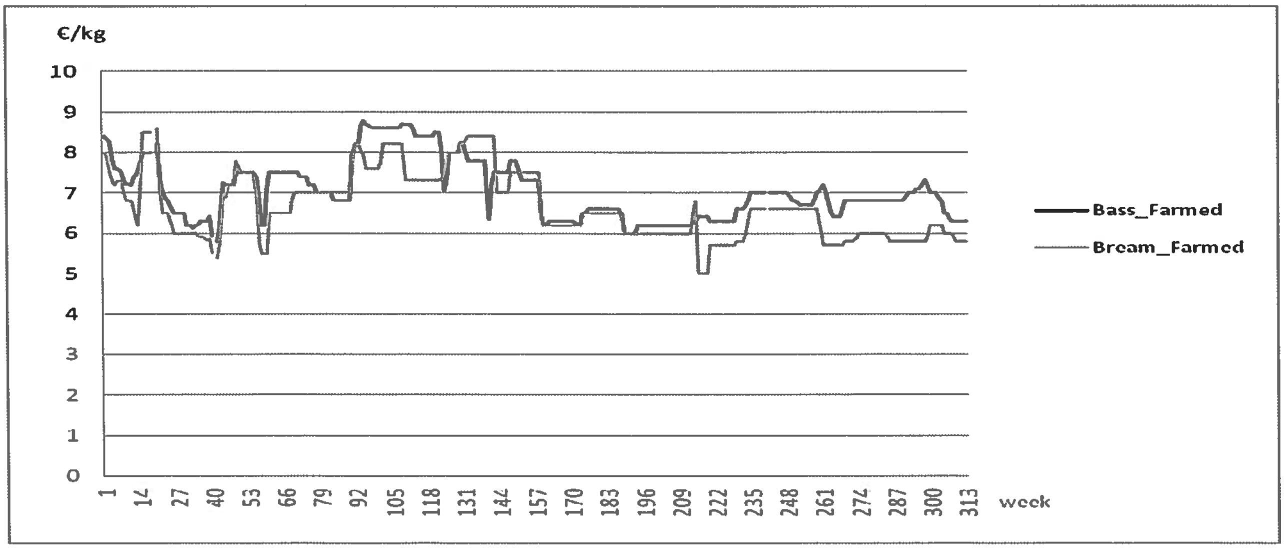
Source: Mercabarna, 2015.

4.2. FRANCE

Paris wholesale market (Rungis), weekly data for the period 2009-14 (313 observations):

- Gilthead seabream (*Sparus aurata*), fresh whole 400-600 g, farmed;
- European seabass (*Dicentrarchus labrax*), fresh whole 400-600 g, farmed.

Figure 6. Weekly prices of farmed gilthead seabream and European seabass in Rungis (2009-14).

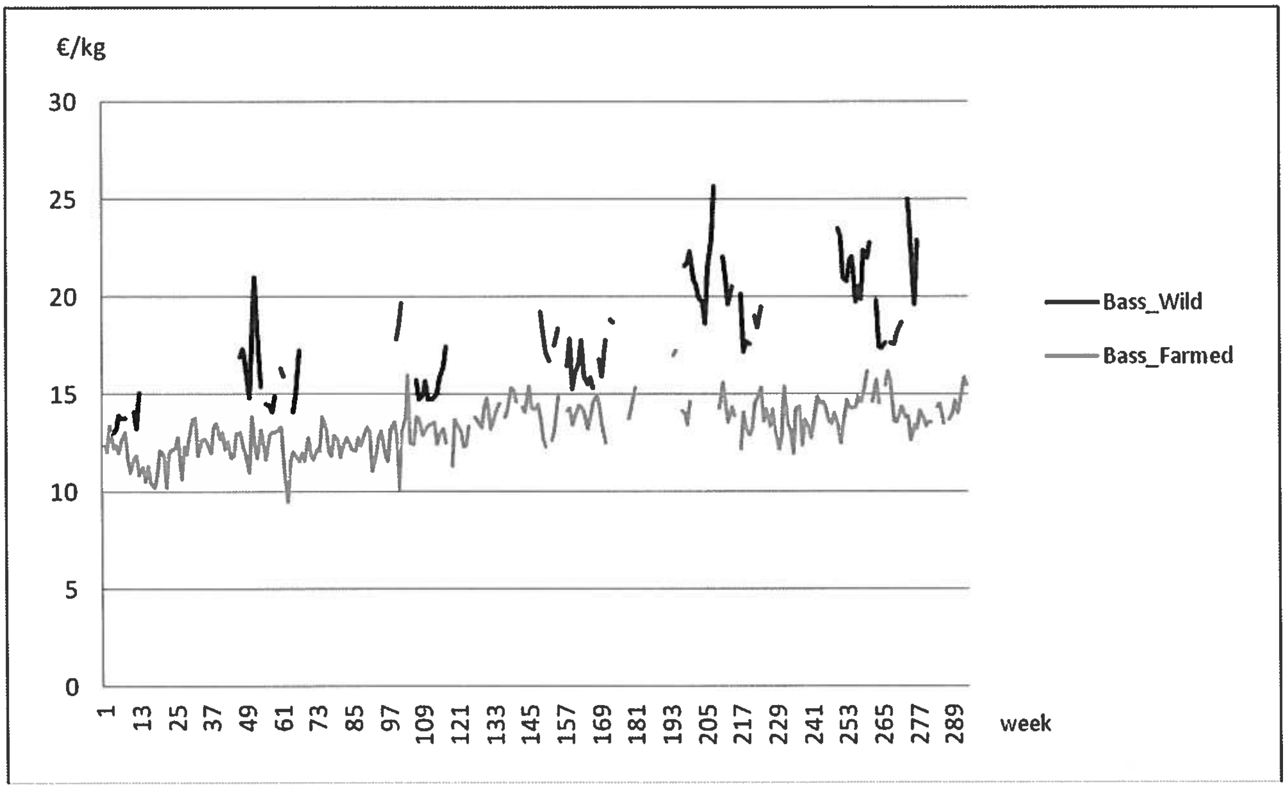


Source: EUMOFA, 2015.

Retail, weekly data for the period 2010-mid 2015:

- European seabass (*Dicentrarchus labrax*), fresh whole, wild and farmed (114 and 257 observations, respectively).

Figure 7. Weekly prices of wild and farmed European seabass at the French retail level (2010-mid 2015).



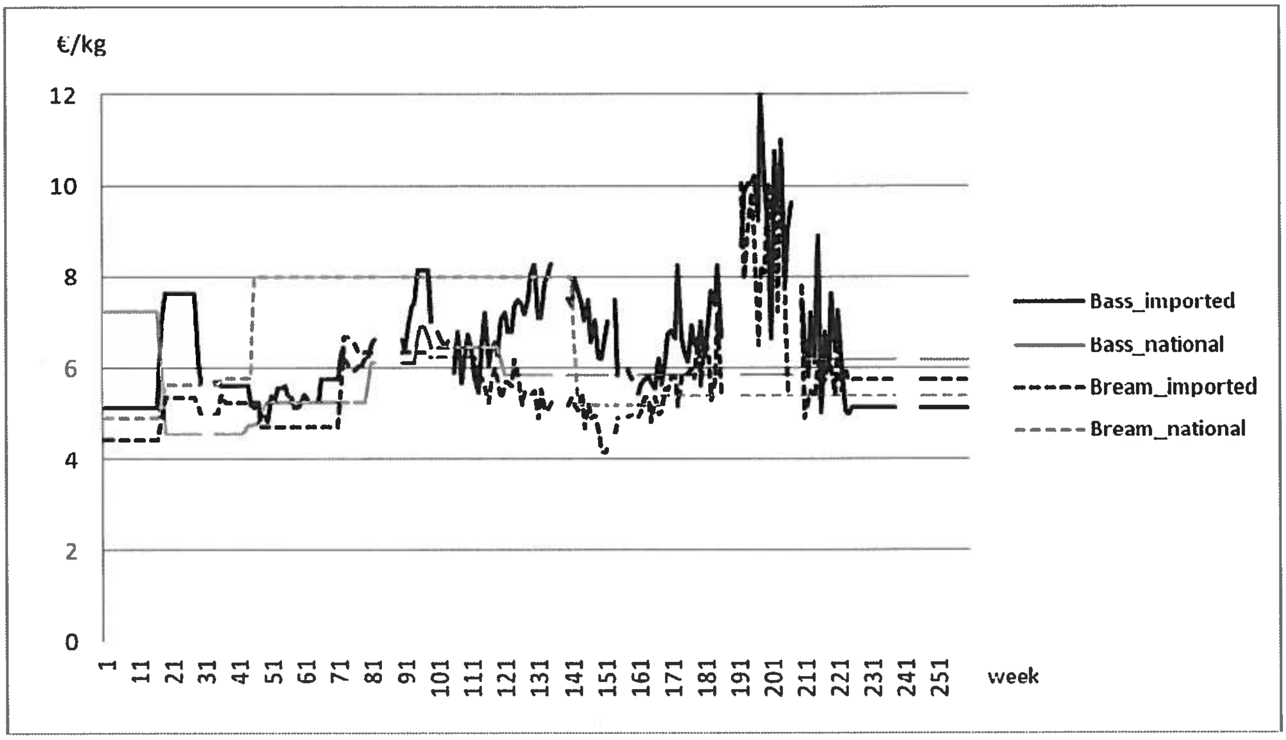
Source: EUMOFA, 2015.

4.3. Italy

Milano's wholesale market, weekly data for the period 2010-14 (225 observations) for the species:

- Gilthead seabream (*Sparus aurata*), fresh whole, national and imported;
- European seabass (*Dicentrarchus labrax*), fresh whole, national and imported.

Figure 8. Weekly prices of national and imported gilthead seabream and European seabass in Milano wholesale market (2010-14).



Source: EUMOFA, 2015.

Roma's wholesale market, weekly data for the period 2010-14 for the species:

- Gilthead seabream (*Sparus aurata*), fresh whole, national and imported (247 and 185 observations, respectively);
- European seabass (*Dicentrarchus labrax*), fresh whole, national and imported (151 and 182 observations, respectively).

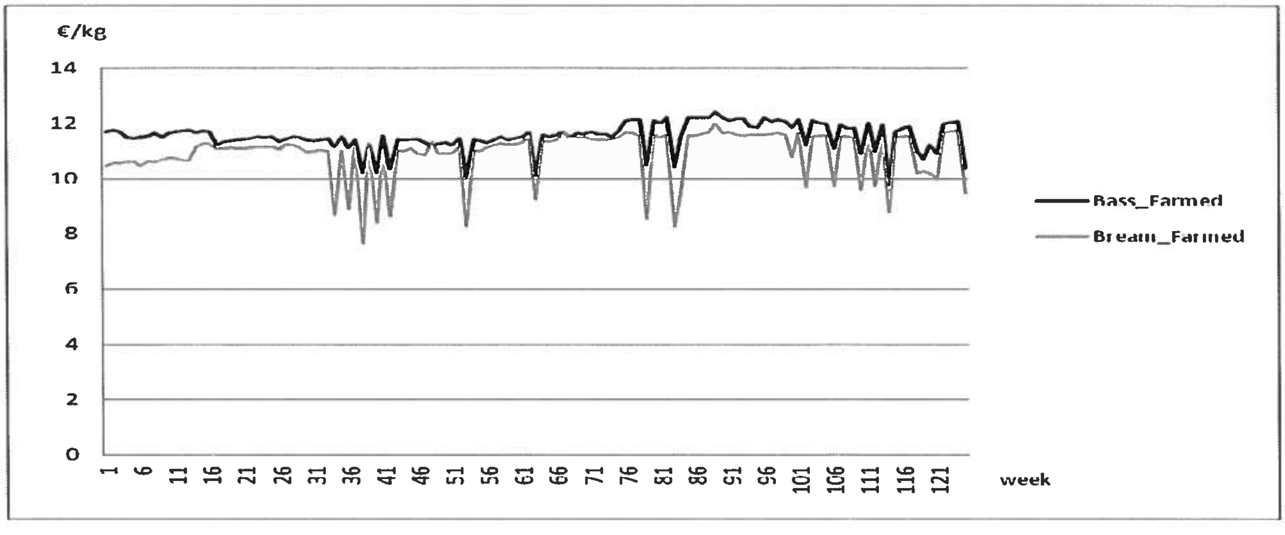
Figure 9. Weekly prices of national and imported gilthead seabream and European seabass in Roma wholesale market (2010-14).

Source: EUMOFA, 2015.

Retail, weekly data for the period from January 2013 to mid 2015 (125 observations):

- European seabass (*Dicentrarchus labrax*), fresh whole, farmed;
- Gilthead seabream (*Sparus aurata*), fresh whole, farmed.

Figure 10. Weekly prices of farmed European seabass and gilthead seabream at the Italian retail level (2013-mid 2015).



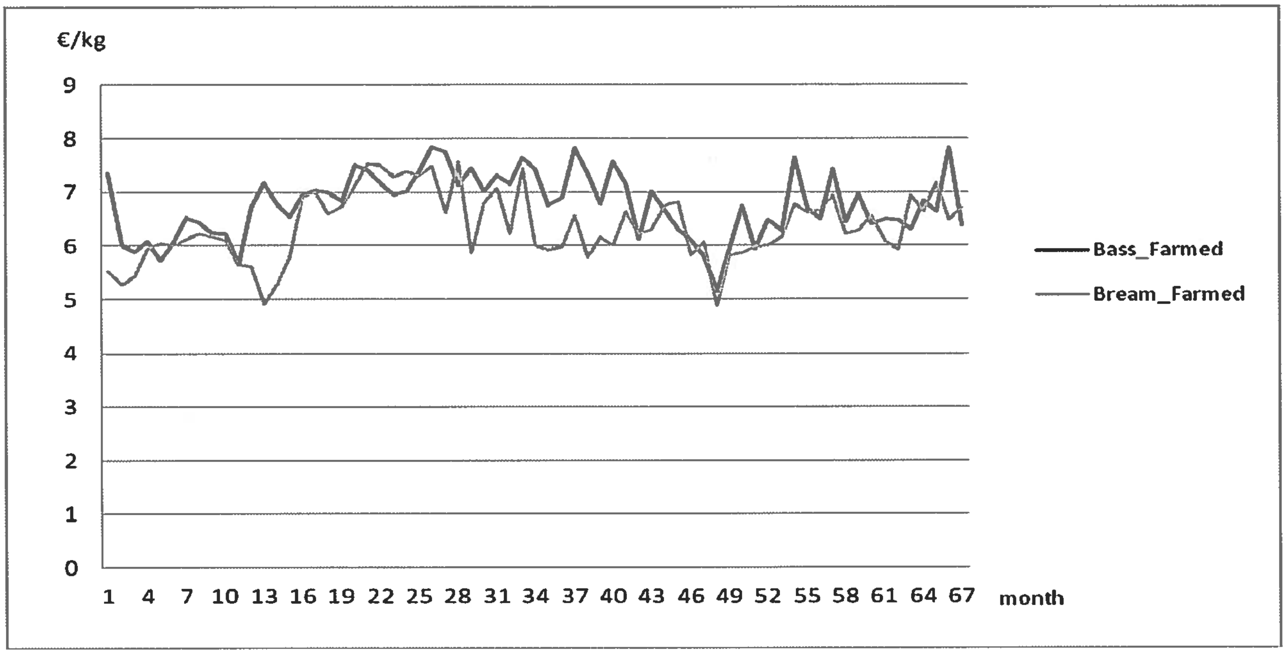
Source: EUMOFA, 2015.

4.4. PORTUGAL

Retail, monthly data for the period from January 2010 to July 2015 (67 observations):

- European seabass (*Dicentrarchus labrax*), fresh whole, farmed;
- Gilthead seabream (*Sparus aurata*), fresh whole, farmed.

Figure 11. Monthly prices of farmed European seabass and gilthead seabream at the Portuguese retail level (2010-July 2015).



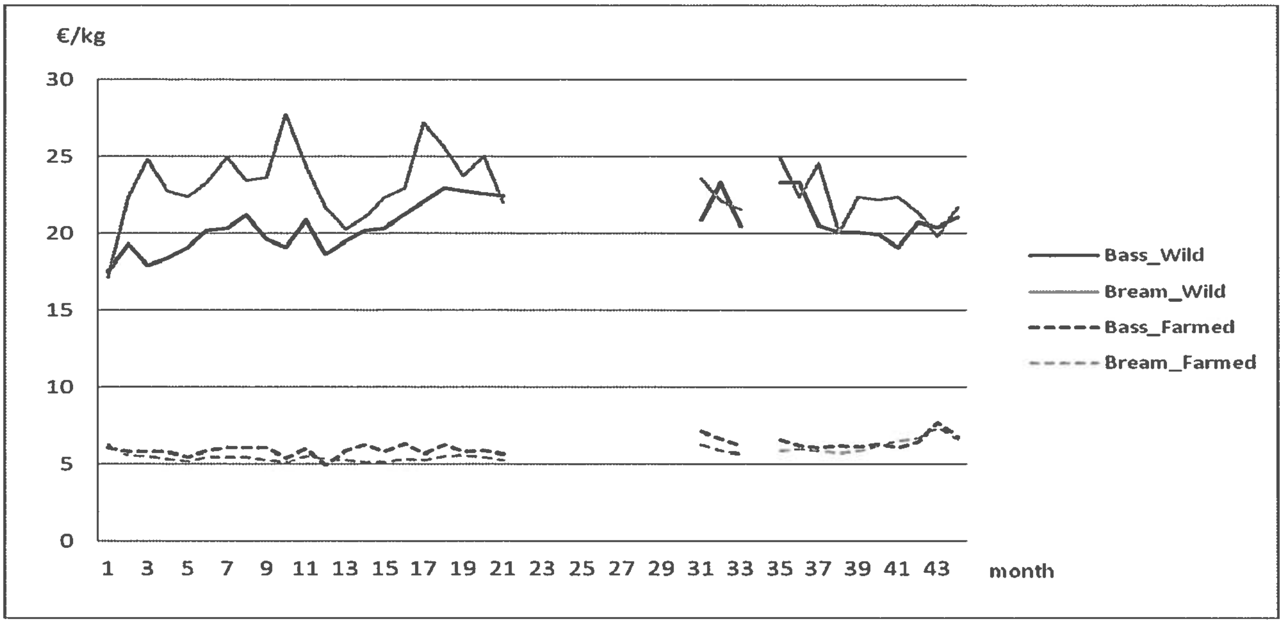
Source: EUMOFA, 2015.

4.5. GREECE

Retail, monthly data for the period from November 2011 to July 2015 (34 observations):

- European seabass (*Dicentrarchus labrax*), fresh whole, wild and farmed;
- Gilthead seabream (*Sparus aurata*), fresh whole, wild and farmed.

Figure 12. Monthly prices of wild and farmed European seabass and gilthead seabream at the Greek retail level (November 2011-July 2015).



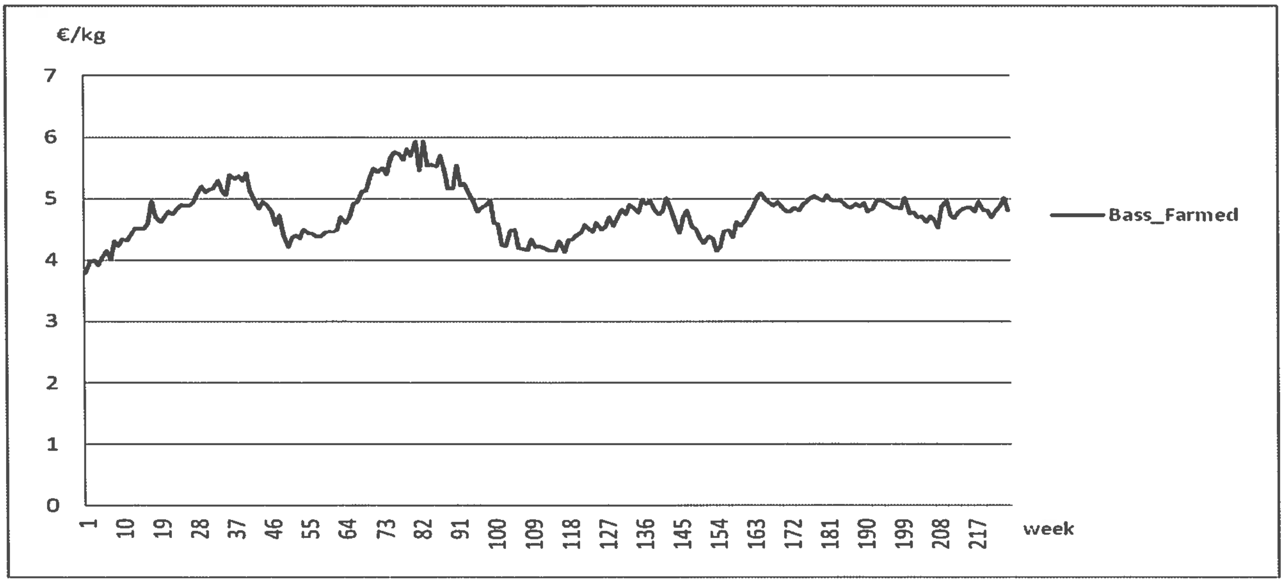
Source: EUMOFA, 2015.

4.6. TURKEY

Weekly import prices from Turkey to the EU for the period 2011 to April 2015 (225 observations):

- European seabass (*Dicentrarchus labrax*), fresh whole, farmed.

Figure 13. Weekly prices of farmed European seabass imports from Turkey to the EU (2011-April 2015).



Source: EUMOFA, 2015.

5. RESULTS

In this section, we report the market integration results obtained in this study. Full results are fully reported in the Appendix.

5.1. WILD AND FARMED INTEGRATION: GILTHEAD SEABREAM AND EUROPEAN SEABASS

We summarise the market integration between wild and farmed conspecifics of gilthead seabream and European seabass in this section. By analysing the market integration between wild and farmed gilthead seabream and European seabass it is possible to investgate whether prices are related, and consequently if wild and farmed products are considered the same product or substitutes.

Table: Market integration results between wild and farmed conspecifics

Species	Market	Market level	Period	Market integration
European Seabass	Madrid (Spain)	Wholesale	2003-14	No
European Seabass	Barcelona (Spain)	Wholesale	2006-14	No
European Seabass	France	Retail	2009-14	No
Gilthead Seabream	Madrid (Spain)	Wholesale	2003-14	No
Gilthead Seabream	Barcelona (Spain)	wholesale	2006-14	No

Results show that there is no market integration between wild and farmed conspecifics of gilthead seabream and European seabass for all cases analysed. So, wild and farm varieties of gilthead seabream and European seabass are not price related.

52. WILD AND FARMED INTEGRATION: OTHER SPECIES

In this section, we analyse the market integration between wild and farmed conspecifics of species other than European seabass and gilthead seabream. Thus, this section analyses the market integration between wild and farmed conspecifics of species other than gilthead seabream and European seabass.

Table: Market integration results between wild and farmed conspecifics other than seabass and seabream

Species	Market	Market level	Period	Market integration
Turbot (*Scophthalmus maximus*)	Madrid (Spain)	wholesale	2003-14	No
Sole (Solea spp.)	Madrid (Spain)	wholesale	2012-14	No
Turbot (*Scophthalmus maximus*)	Barcelona (Spain)	wholesale	2006-14	No
Blackspot (red) seabream (*Pagellus bogaraveo*)	Barcelona (Spain)	wholesale	2006-14	No
Atlantic Cod (*Gadus morhua*)	Barcelona (Spain)	wholesale	2006-14	No
Clams (*Venerupis spp.*)	Barcelona (Spain)	wholesale	2006-14	No
Meagre (*Argyrosomus regius*)	Barcelona (Spain)	wholesale	2006-14	No

Results show that there is no market integration between wild and farmed conspecifics for all species analysed. So, again, prices of wild and farmed conspecifics are not related, and so they cannot be considered the same product or substitutes.

5.3. SPECIES INTEGRATION: SEABREAM AND SEABASS

In this section, we explore whether gilthead seabream and European seabass are integrated into the market and this includes whether seabream and seabass can be considered substitutes.

Table: Species integration results

Species		Market	Market level	Period	Market integration
European Seabass - Gilthead Seabream	Wild	Madrid (Spain)	wholesale	2003-14	No
European Seabass - Gilthead Seabream	Wild	Barcelona (Spain)	wholesale	2006-14	No
European Seabass - Gilthead Seabream	Farmed	Madrid (Spain)	wholesale	2003-14	No
European Seabass - Gilthead Seabream	Farmed	Barcelona (Spain)	wholesale	2006-14	No
European Seabass - Gilthead Seabream	Farmed	Paris (France)	wholesale	2009-14	Yes
European Seabass - Gilthead Seabream	Farmed	Italy	retail	2013-15	Yes/Partly
European Seabass - Gilthead Seabream	Farmed	Portugal	retail	2010-15	Uncertain

Results show that there is no market integration between gilthead seabream and European seabass in the Spanish market. But market integration (i.e., prices moving together overtime) between farmed gilthead seabream and European seabass has been found at the Paris wholesale market, and at the retail level in Italy where seabream prices seem to benchmark seabass prices. Results for the Portuguese retail level are not conclusive because market integration is denied or accepted depending on the number of lags chosen.

5.4. GEOGRAPHICAL INTEGRATION

In this section, we analyse the geographical component of the market integration of different wild and farmed species. Thus, the investigation focuses on whether the price of seabream and seabass in different geographical markets move together or are independent.

Table: Geographical market integration results for different wild and farmed species

Species		Market	Market level	Period	Market integration
European Seabass	Wild	Madrid - Barcelona (Spain)	wholesale	2006-14	No
European Seabass	Farmed	Madrid - Barcelona (Spain)	wholesale	2006-14	No
European Seabass	Farmed	Madrid (Spain) – Paris (France)	wholesale	2009-14	No
European Seabass	Farmed	Barcelona (Spain) – Paris (France)	wholesale	2009-14	Uncertain
European Seabass	Farmed	Turkey - Madrid (Spain)	Imports - wholesale	2011-14	No
European Seabass	Farmed	Turkey - Barcelona (Spain)	Imports - wholesale	2011-14	Yes/Partly
European Seabass	Farmed	Turkey – Paris (France)	Imports - wholesale	2011-14	Partly/Uncertain
Gilthead Seabream	Wild	Madrid - Barcelona (Spain)	wholesale	2006-14	No
Gilthead Seabream	Farmed	Madrid - Barcelona (Spain)	wholesale	2006-14	No
Gilthead Seabream	Farmed	Madrid (Spain) – Paris (France)	wholesale	2009-14	Uncertain
Gilthead Seabream	Farmed	Barcelona (Spain) – Paris (France)	wholesale	2009-14	No
Turbot (*Scophthalmus maximus*)	Wild	Madrid - Barcelona (Spain)	wholesale	2006-14	No
Turbot (*Scophthalmus maximus*)	Farmed	Madrid - Barcelona (Spain)	wholesale	2006-14	Yes

Results show that there is no market integration between wild species from different markets in all the cases analysed. Instead, a certain degree of integration between markets has been found for farmed species.

Prices of farmed turbot (*Scophthalmus maximus*) in Barcelona and Madrid wholesale markets are integrated.

Prices of farmed European seabass in Barcelona and Paris wholesale markets are related to the prices of farmed European seabass imported from Turkey into the EU.

Results for market integration between the prices for farmed gilthead seabream in Paris and Madrid wholesale markets are not conclusive because market integration is denied or accepted depending on the number of lags chosen.

6. DISCUSSION

Bjørndal and Guillen (2016) analyse the literature on market interactions between wild and farmed fish. The literature on market competition between aquaculture and wild fish is based on a small number of species and markets. Studies concentrate on the US and EU markets, which are the most traded species and the main consumer markets. Market integration studies initially focused on salmon, followed by an analysis of shrimp and tilapia, and recently of seabass and seabream (Bjørndal and Guillen, 2016). In particular, when it comes to the Mediterranean area, existing knowledge on competition interactions between wild and farmed species in the Mediterranean is limited, and based solely on studies investigating gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*).

Most of the world gilthead seabream and European seabass production comes from aquaculture - about 95 percent. Gilthead seabream and European seabass are the most farmed species in the Mediterranean and Black Sea. Gilthead seabream and European seabass represent 63 percent in quantity and 80 percent in value of all the marine aquaculture production in the Mediterranean and Black Sea. Ninety-six percent of the world gilthead seabream and European seabass production comes from Mediterranean countries. The main producers are Turkey and Greece; while the main consumers are Spain, France, Italy, Greece and Turkey. The 5 to 10 €/kg retail price for seabass and seabream is far too high for a large proportion of the population living in the southern Mediterranean countries (Monfort, 2007).

The literature on market competition between farmed and wild gilthead seabream and European seabass has focused on the Spanish, French and Italian markets. These studies on competition interactions between wild and farmed species in Mediterranean countries are based on a very limited number of cases with no general trends detected. For the Spanish market, Alfranca *et al.* (2004) found that farmed gilthead seabream prices determine the evolution of wild gilthead seabream prices more directly than the wild gilthead seabream prices in the Barcelona wholesale market. However, Rodríguez *et al.* (2013) show that wild and farmed gilthead seabream are not integrated, and consequently they are two heterogeneous products that are not substitutes in the Madrid wholesale market. In French households, Regnier and Bayramoglu (2014) found that fresh whole wild seabream and farmed gilthead seabream are partially integrated and that their price relationship is led by farmed seabream; while, those for whole wild seabass and farmed European seabass are not integrated. On the other hand, Brigante and Lem (2001) concluded that wild and farmed conspecifics are not substitutes for gilthead seabream and European seabass in Italy.

Results from this study confirm that there is no market integration between wild and farmed conspecifics of gilthead seabream and European seabass for all cases analysed (Barcelona and Madrid wholesale markets, and French retail market).

In addition, there is no market integration between wild and farmed turbot (*Scophthalmus maximus*) in the Barcelona and Madrid wholesale markets. There is also no market integration between wild and farmed conspecifics of sole (Solea spp.) in the Madrid wholesale market, Blackspot (red) seabream (*Pagellus bogaraveo*), Atlantic Cod (*Gadus morhua*), Clams (*Venerupis spp.*), and Meagre (*Argyrosomus regius*) in the Barcelona wholesale market.

This differentiation between farmed and aquaculture products can be explained, at least in part, by the negative perception aquaculture products have in comparison to wild fish in Spain, and Southern Europe in general (Fernández-Polanco & Luna, 2010; Claret *et al.*, 2012). Wild fish is always preferred among Southern European consumers when compared to farmed fish (Claret et al., 2012). Southern European consumers perceive farmed fish as being of lower quality and affected by more health and safety issues than wild fish (Kole, 2003; Verbeke et al., 2007; Fernández-Polanco and Luna, 2010). Farmed fish is also perceived as more processed or manipulated than those from the wild (Claret et al., 2012). This is translated into lower prices for farmed fish than for wild (capture) fish and some fine restaurants only serve wild fish products, specifying this on the menu. Consequently, a share of the wild production will not enter into the more traditional market chains. This differentiation in favour of wild products happens even if the aquaculture sector has the competitive advantage that the sector has a higher degree of control over the production process and can deliver at the right time, in the right amount and at the right quality (Asche, Guttormsen and Nielsen, 2013).

The fact that most seabass and seabream are commercialised as fresh whole and head-on, can help the market to differentiate between products. Consumers in Southern European/Mediterranean countries prefer whole fish. In contrast, Northen European consumers prefer filleted fish products. Despite this potential demand, industrial production of fillets is minor. High production costs for large individual fish does not allow for competitive prices for seabass and seabream fillets and other value added presentations (Monfort, 2007). Hence, the expansion of seabass and seabream in non-Mediterranean markets has been limited.

Results show that there is no market integration between gilthead seabream and European seabass in the Spanish market. But market integration has been found between farmed gilthead seabream and European seabass in the Paris wholesale market, and at the retail level in Italy where seabream prices seem to benchmark seabass prices.

These results for the Spanish market are in line with Alfranca *et al.* (2004) who found that the influence on farmed and wild gilthead seabream (*Sparus aurata*) prices of wild sole, farmed Atlantic salmon (*Salmo salar*), farmed European seabass (*Dicentrarchus labrax*), and wild European seabass (*Dicentrarchus labrax*) prices is rather weak with a low level of significance in the Barcelona wholesale market.

The differences in the outcomes obtained could be based, at least in part, due to the different data sources employed, markets and the time periods analysed. Fish markets are dynamic and are continuously changing, so results can be sensitive to the period investigated (Setälä et al., 2003). This made us work with the latest data available and with relatively similar time periods for all cases.

The evolution of the gilthead seabream and European seabass aquaculture production presents many similarities. In fact, both species main production areas and techniques are the same, with many companies producing both species. So, it is not surprising that price evolutions for both products are similar (see previous Figure 4). Indeed, market integration (i.e., prices moving together overtime) between farmed gilthead seabream and European seabass has been found at the Paris wholesale market, and at the retail level in Italy where seabream prices seem to lead (benchmark) seabass prices. However, outcomes from this study also show that there is no market integration between gilthead seabream and European seabass in the Spanish wholesale markets. Results for the Portuguese retail level are not conclusive because market integration is denied or accepted depending on the number of lags chosen.

Actually, Emerson (2007) demonstrated that the choice of lag length can drastically affect the results of the cointegration analysis. Moreover, different lag length selection criteria often lead to a different conclusion regarding the optimal lag order that should be used. Therefore, in this study, we determine the number of lags using 3 different criteria: Log Likelihood, Akaike Information Criteria, and Schwarz Criteria. This has lead several times to contradictory results depending on the number of lags chosen (i.e., depending on the criteria used). We have marked these cases as not conclusive or uncertain.

Finally, we have analysed the spatial or geographical market integration. Results show that there is no market integration between wild species in all markets analysed. However, some market integration has been found for farmed species. Prices of farmed turbot (*Scophthalmus maximus*) in Barcelona and Madrid wholesale markets are integrated. Unfortunately, turbot price data is not available from other Mediterranean markets.

While prices of farmed European seabass in Barcelona and Paris wholesale markets are related to the prices of farmed European seabass imported from Turkey into the EU. A direct relationship between Barcelona and Paris wholesale market prices for farmed European seabass is not conclusive. Similarly, the existence of market integration between farmed gilthead seabream prices in Paris and Madrid wholesale markets is not conclusive.

These later results are a bit surprising because we were expecting to find a higher level of market integration between markets for farmed seabream and seabass, due to the high volumes of imports coming from Greece and Turkey arriving at the Spanish, French and Italian markets. These imports would lead the long-term price evolution of these products in the more local markets. However, we have only found partial evidence for European seabass.

This outcome is difficult to explain and would require larger and better data sets before we could draw more irrefutable statements. For example, data is currently not available, or at least into the extent necessary to do this kind of analysis, for Southern Mediterranean countries. In addition, some data for Northern Mediterranean countries suffer from data quality and missing observations.

We expect that in the near future more data will be available in the Mediterranen region, part of these data also disaggregated by size of the product[15], as well as considering the presence of ecolabels or the case of biological production.

[15] Mercamadrid has already started to differentiate the farmed gilthead seabream commercialized into seabream from 300 to 400 grams, from 400 to 600 grams and larger than 600 grams.

7. CONCLUSIONS

Previously available studies on competition interactions between wild and farmed species in the Mediterranean are based on a rather limited number of cases with no general trends detected. The differences in the outcomes obtained could be based, at least in part, in the different data sources employed and time periods analyzed. In fact, market integration results can be sensitive to the period investigated. This is because fish markets are dynamic and are continuously changing.

Therefore, in this study we investigate in more detail the existence of market interactions between wild and farmed species in different Mediterranean countries. Our results show that there is no market integration between wild and farmed products in Mediterranean countries for gilthead seabream, European seabass, as well as other species (turbot, blackspot red seabream, Atlantic cod, meagre and clams). This lack of integration between farmed and wild products has been explained in the literature by the traditional consumption (knowledge) of fish, a preference for local products, the use of different market chains, and a persisting negative perception for farmed products in the area.

Results also show that there is market integration (i.e., prices moving together overtime) between farmed gilthead seabream and European seabass in the Paris wholesale market, and at the retail level in Italy where seabream prices seem to benchmark seabass prices. But there is no market integration between gilthead seabream and European seabass in the Spanish wholesale markets.

Moreover, results show that there is no market integration between wild species from different markets in all cases analysed. Instead, a certain degree of integration between markets has been found for farmed species. Prices of farmed turbot in Barcelona and Madrid wholesale markets are integrated. While prices of farmed European seabass in Barcelona and Paris wholesale markets are related to the prices of farmed European seabass imported from Turkey into the EU.

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