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The Development of a New Farmed Species – ProductionTechnology and Markets for Turbot

by

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Abstract

Turbot (*Scophthalmus maximus*) is a high value fish that is much favoured in many market segments such as white tablecloth restaurants. Aquaculture of turbot started first in Scotland in the 1970s, but from the early 1980s the expansion in production volume and number of farms took place in Galicia, Spain. Still the main production takes place in Galicia with modest culture in France, Portugal, Denmark, Germany, Iceland, Ireland, Italy, Norway and Wales. This picture may change due to plans for substantial expansion of production in Portugal. As a consequence, aquaculture's share of the market will dominate compared to the contribution from the wild fishery. The purpose of this report is to analyse current developments and make a forecast of future trends in turbot production and markets. There are important developments in farming technology that may impact on future supply and cost of production. On this background, we will analyse the future sustainability of turbot farming from a technological as well as economic point of view.

Acknowledgement

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0. INTRODUCTION

Turbot (*Scophthalmus maximus*) is a high value fish that is much favoured in many market segments such as white tablecloth restaurants. It natural range of distribution is in the Northeast Atlantic along European coasts to the Arctic Circle, throughout the Mediterranean and in the western part of the Baltic Sea. It lives in shallow water to 100 m depths, inhabiting sandy, muddy bottoms and is both fished and farmed commercially. Turbot is marketed fresh and frozen.

Aquaculture of turbot started first in Scotland in the 1970s, but from the early 1980s the expansion in production volume and number of farms took place in Galicia, Spain. Techno-biological improvements in the early 1990s triggered a steady albeit slow growth in production across numerous European countries. Still the main production takes place in Galicia with modest culture in France, Portugal, Denmark, Germany, Iceland, Ireland, Italy, Norway and Wales. This picture will likely change from 2010 when Portugal is expected to become the leading producer due to the planned production of 7,000 tonnes at Pescanova's aquaculture cluster in the northern part of the country. European production, at about 11,000 tonnes in 2010, may expand to around 16,500 tonnes in 2012 As a consequence, aquaculture's share of the market will dominate compared to the contribution from the wild fishery (6,700 tonnes in 2008).

The purpose of this report is to analyse current developments and make a forecast of future trends in turbot production and markets. Production of this species is likely to increase considerably in coming years. In addition, there are important developments in farming technology that may impact on future supply and cost of production. Turbot is a high valued species, much favoured in fine restaurants. Increased production is likely to have an impact on price, as larger quantities will necessitate entry into new market segments. On this background, we will analyse the future sustainability of turbot farming from a technological as well as economic point of view.

The paper is organised as follows: Wild catches of turbot are reviewed in Section 1, while an overview over farmed production is presented in Section 2. Markets are reviewed in Section 3. This is followed by an analysis of pros and cons of

existing and new farming technologies, including a brief analysis of cost of production (Section 4). The final section presents a future outlook for the farming of turbot. The Appendix contains additional data.

1. WILD CATCHES OF TURBOT

Figure 1 gives catches of turbot by all countries of the world and by the EU nations for 1970-2008. There is a cyclical pattern for both global and EU catches. The global catch of turbot in 1970 was 10,800 tonnes, whereas the EU catch was 6,600 tonnes (Appendix, Table A4). Global catches peaked at 15,000 tonnes in 1979. Subsequently, they went into a trough, reaching a minimum of 5,500 tonnes in 1985. After a period of increase, catches have shown a general downward trend since the mid-1990s, however, with sporadic/temporary increases in some years. The catch at the global level was 6,665 tonnes in 2008, with 5,740 tonnes for the EU, the lowest levels recorded. Thus, the EU countries accounted for 86% of global catch in 1986.

Outside the EU, Turkey is by far the most important country harvesting turbot with 528 tonnes recorded in 2008, however, this is considerably lower than catch levels in the 1980s and 1990s. Other countries that harvest turbot include Ukraine, Norway, Morocco and the Russian Federation (Appendix, Table A4).

Within Europe, the principle catches are by the fleets of the Netherlands, United Kingdom, Denmark, France, Belgium, Germany, Ireland, Spain, Portugal and Greece (Figure 2). Since 1970 these countries have accounted for between 88 - 97% of the EU 25 catch, with their dominance decreasing over time. Most harvesting nations have seen their catches fall since the mid-1990s.

The Netherlands catches the largest tonnage, peaking at 4,098 tonnes in 1979 and 3,780 tonnes in 1991. In 2008 catch was down to 1,751 tonnes.

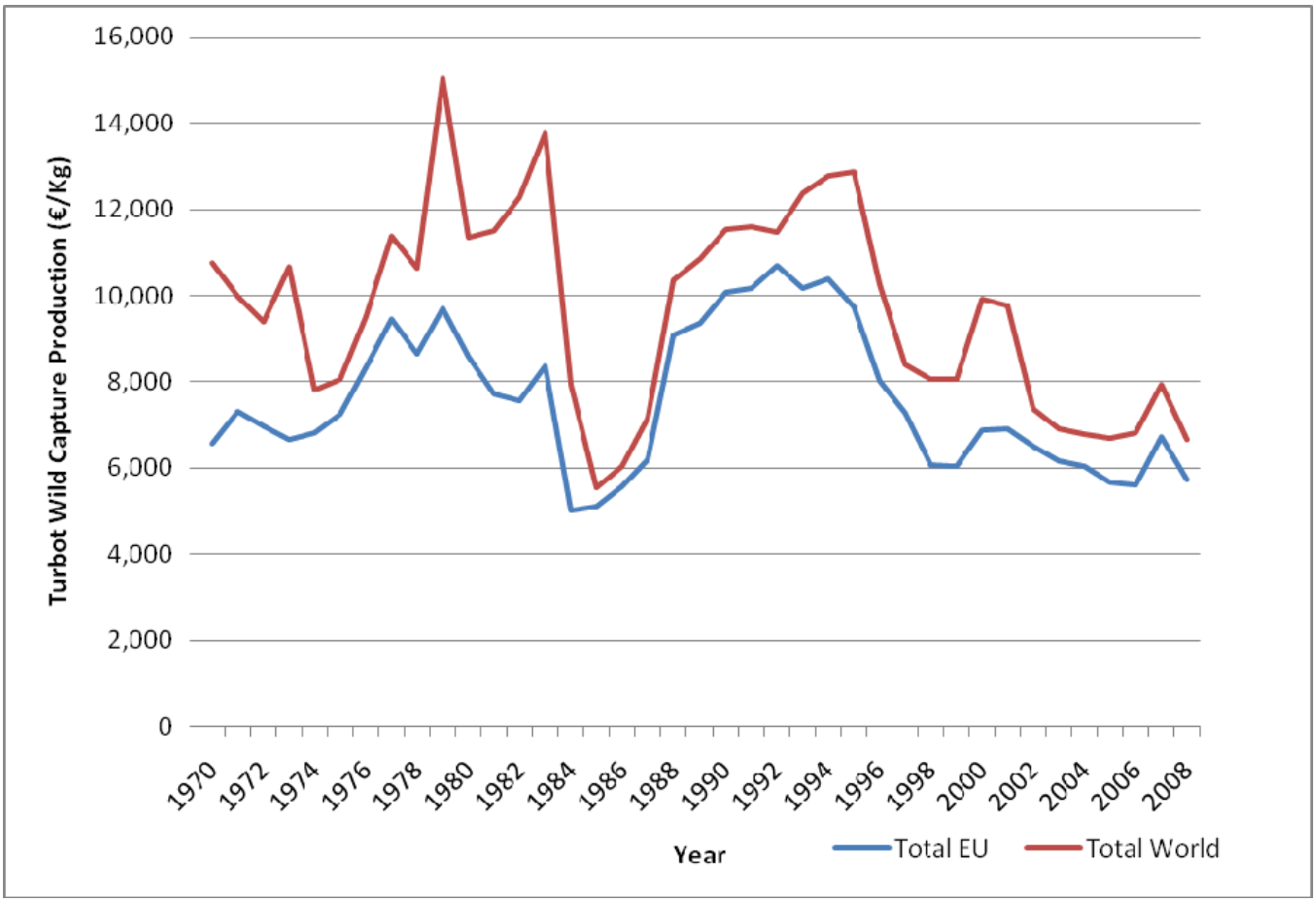

Figure 1: European Union (EU25) and Global Catch of Turbot 1970- 2008. Tonnes.

It is believed that the prospects for increased landings are limited; if anything, they may decline even further. Thus, any expansion in quantity must come from farming.

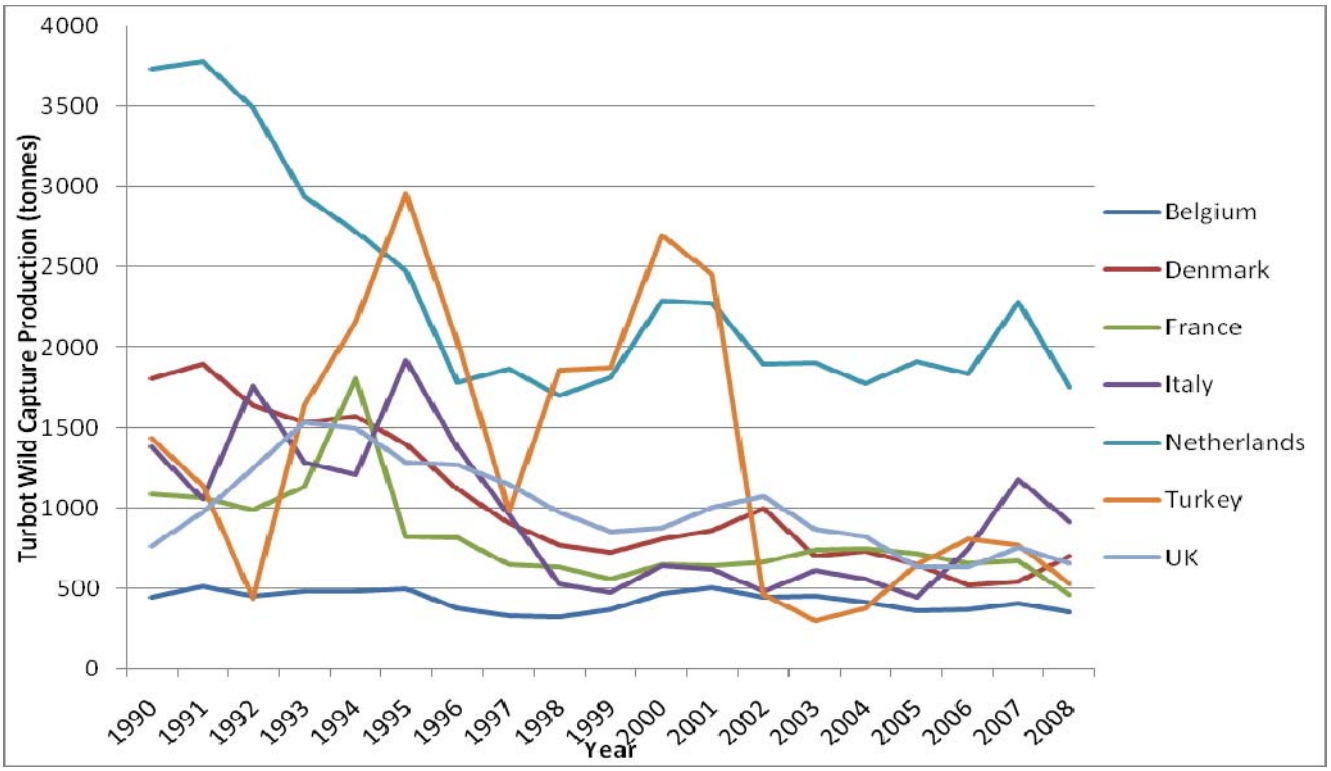

Figure. 2. Turbot Harvest by Selected Countries 1990-2008. Tonnes.

2. EU FARMED TURBOT PRODUCTION

In terms of global farmed production of turbot, production is almost exclusively EU based (Figure 3).

Overall EU farmed production of turbot has increased from 53 tonnes in 1985 to 8,205 tonnes in 2007 with the greatest annual growth rates being seen in the late 1980s and early 1990s. The last few years have seen growth rates of between 10% and 15% per annum. The growth in farmed output of turbot within the EU has reached such proportions that as of 2007 it constituted about 50% of total global production of turbot from both farmed and wild sources.

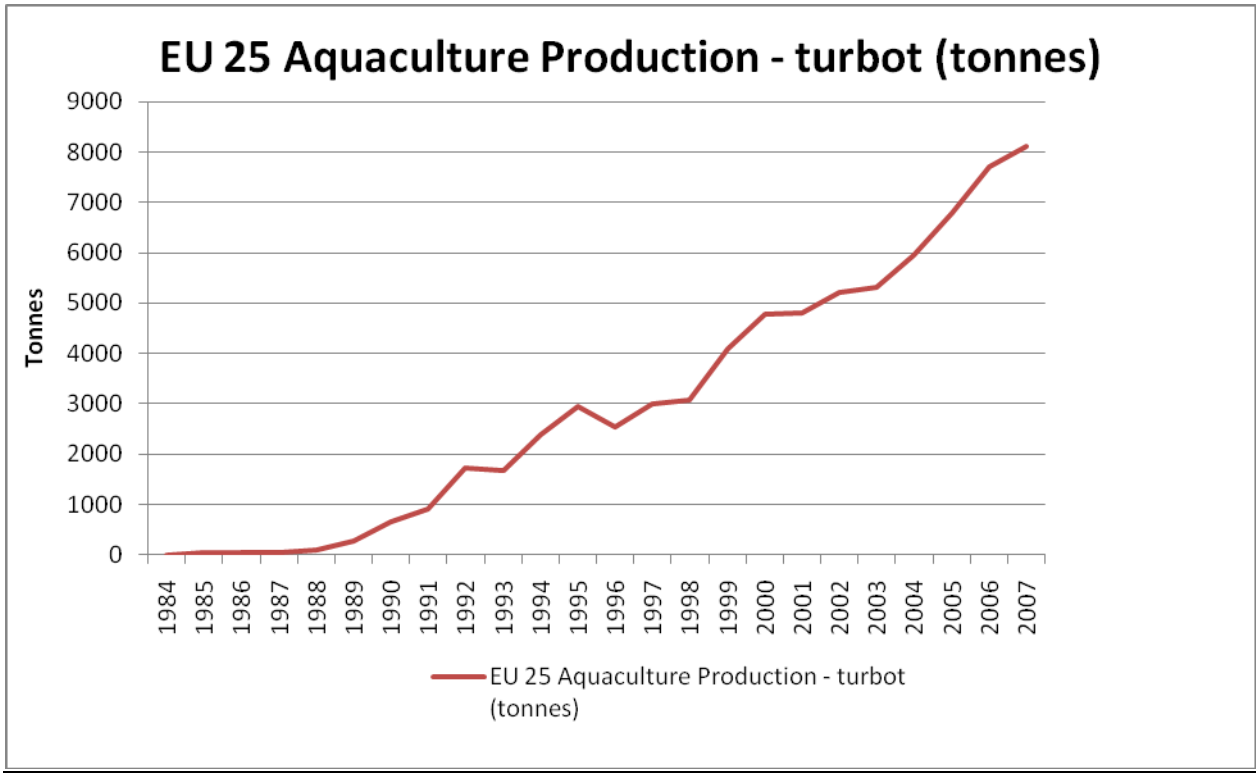

Figure 3: EU 25 Aquaculture Production of Turbot 1984-2007. Tonnes.

Outside of the EU, small quantities are farmed in Iceland (peaking at 115 tonnes in 2005, down to 100 tonnes in 2006-07). South Africa has also appeared in the production statistics for some years[1].

Within Europe, as shown in Figure 4, farmed production comes from five main countries, with the bulk coming from Spain (84% in 2007). Spanish production[2] has grown consistently from 38 tonnes in 1985 to 6,838 tonnes in 2007, with a slight downward move in 1997 and 1998.

French production has also risen, going from 15 tonnes in 1985 to 980 tonnes in 1997 (with a very poor year in 1996), before levelling out. In 2007, French turbot

[1] China is not considered in this report, although this country is belived to produce over 50,000 tonnes of turbot. See http://books.google.es/books?id=hj-ypUJKkgYC&pg=PT205&dq=china+turbot+2010&hl=es&ei=_XKgTIuaHdm5jAeH4JnCDQ&sa=X&oi=book_result&ct=result&resnum=2&ved=0CDUQ6AEwAQ#v=onepage&q=china%20turbot%202010&f=false

[2] Worldwide, Spain is the largest producer of turbot with Stolt Sea Farm S.A. the world's leading producer of farmed turbot. The company produces 1 million juveniles out of two hatcheries, which in turn supplies grow out facilities in the region.

production was 850 tonnes (12% of EU production)[3]. Portuguese turbot farming is relatively more recent in origin. Records start in 1994 at 35 tonnes, since when they have risen to a peak of 386 tonnes in 2002 before dropping to 167 tonnes in 2007[4]. As a consequence of new investments, Portuguese production is expected to increase considerably in coming years (see below).

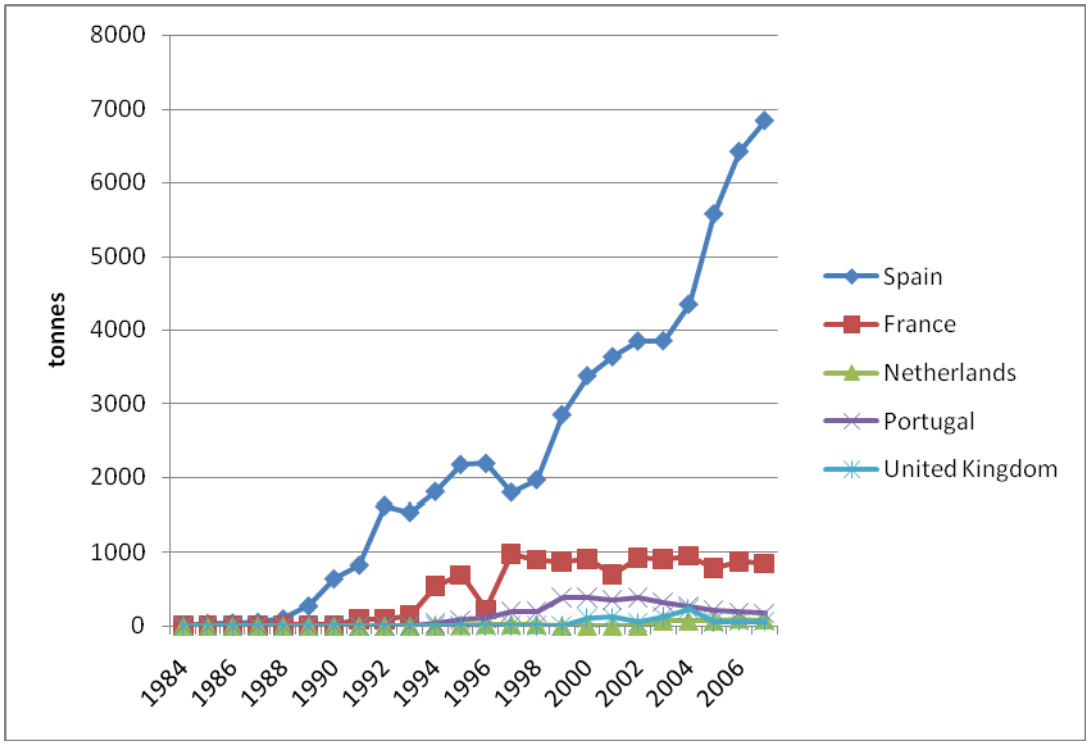

Figure 4: EU Production of Farmed Turbot. Key Nations 1985-2007. Tonnes.

Despite turbot farming being started in Scotland in 1970, commercial turbot farming records for the United Kingdom are also only recent, recording 107 tonnes in 2000 and peaking at 233 tonnes in 2004 before dropping to only 62 tonnes in 2007[5]; a similar magnitude of production from the Netherlands[6] in the same year.

[3] Although France produces turbot, it imports additional turbot, mostly from Spain. It is also the world's leading producer of juvenile turbot most of which is exported to China. A proportion of French production is exported live.
[4] All turbot production takes place via land-based systems, with the majority operated by Stolt Sea Farm S.A.
[5] Production comes from one operation.
[6] Seafarm BV is the only company culturing turbot, raising them from fry to market size using a land-based system. Live fish are supplied to markets in China and Japan.

Together the farmed production from these five countries comprises over 98.5% of EU production of turbot. The remainder comes from small-scale operations in Denmark[7], Germany[8] and Ireland[9].

EU Value of Aquaculture Production

Corresponding with the growth in turbot production, the value of farmed turbot within the EU has increased from €38,000 in 1984 to €64.3 Million in 2007 (figure 5).

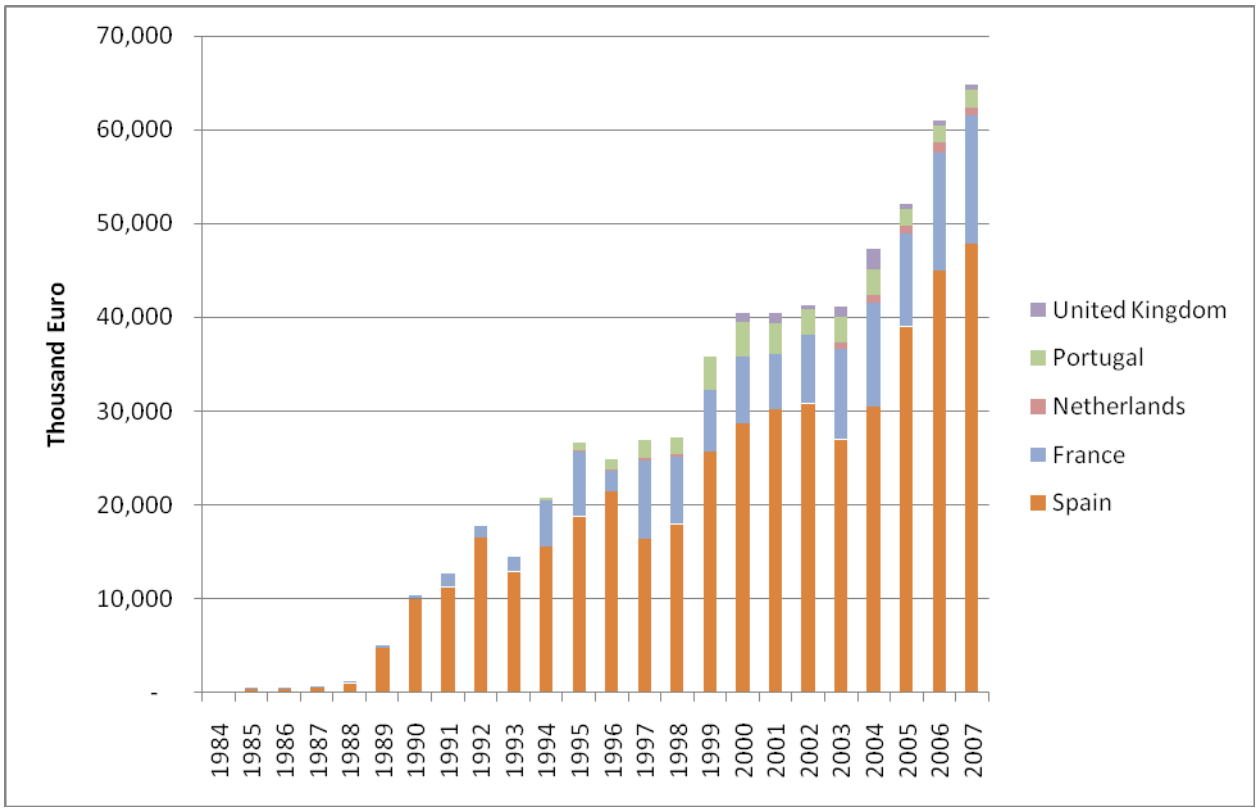

Figure 5: Value of EU Turbot Aquaculture Production, Key Nations 1984-2007. '000 tonnes.

Galicia, Spain

The Spanish production of tubot is concentrated in the region of Galicia. Alternative production data have been collected for Spain (Galicia) and word total for 2007-10. These are presented in Table 1. Farmed turbot production in Galicia has

[7] Technology for turbot production in Denmark is well developed, particularly the production of fry, much of which is exported.
[8] In Germany there is one hatchery and cage farm operation producing turbot.
[9] Ireland had one commercial turbot operation in County Galway. Unfortunately the farm suffered a major system failure and went into liquidation in early 2005.

increased substantially over time, from 2,243 tonnes in 1999, reaching about 8,400 tonnes in 2010. In 2010, Galicia represented 76% of a world production estimated at 9,450 tonnes.

Acuinova has built a turbot farm with a 7,000 tonne capacity in Mira, Portugal, with capital subsidies from the EU. In 2010, an output of 1,500 tonnes is expected, while full capacity is expected to be reached in 2012 (Fish Farming Expert, 2010). It this materialises, world production may increase to 16,500 tonnes in 2012. It will also lessen Galicia's dominance of turbot production.

Table 1. Production of Farmed Turbot in Spain (95% Galicia) and World Production, Tonnes. 1999-2010.

	Production (Tonnes)	World Production (Tonnes)
1999	2,243	-
2000	3,347	-
2001	3,759	-
2002	3,998	-
2003	3,440	-
2004	4,256	-
2005	4,275	-
2006	5,975	-
2007	6,080	7,800
2008	7,870	9,450
2009	8,320	-
2010	9,400	11,000

Sources:
Farmed production:
-1999-2009: Spanish Marine Fish Farmers Association (APROMAR), several years. Available at: http://www.apromar.es/Informes/
-2010 (estimate): industry sources.
World production: industry sources.

EU trade balance

In terms of trade, imports by the EU25 nations completely ceased after 1991. Exports in contrast continued, although at low levels. In 2006 the EU25 nations exported 464 tonnes of turbot, down from 879 tonnes in 1979. Correspondingly, the balance of trade in recent years has been synonymous with exports, however, as

quantities are limited, more than 95% of all turbot – farmed and wild is consumed in Europe.

3. MARKETS FOR TURBOT

Availability of market data for turbot is limited, both when it comes to consumption and trade. In the following, quantity data are presented for a few countries, and an overview over develepment in prices is presented.

3.1 National turbot markets

Let us now look at some of the main markets for turbot. *Spain* is not only the largest producer of turbot, but also one of the largest markets. Landings of wild turbot, on the other hand, are negligible (Appendix, Table A4). Thus, the market is served almost entirely by farmed product.

Retail sales by sales channel for the period 2004-09 are given in Table 2. These figures, which represent estimates of turbot consumption, are based on consumer surveys. Although there are variations from year to year, there is an upward trend in sales, which increased from 2,787 tonnes in 2004 to 3,894 tonnes in 2009 with a very noticeable increase from 2007 to 2008. The 2009 quantity represents almost half of annual production, which was 8,320 tonnes in 2009 (Table 1).

Table 2. Sales (Tonnes) in the Main Retail Channels in Spain. 2004-2009

	Hyper-market	Super-Market	Food Market	Fish-monger	Frozen shop	General food	Others	Total
2004	527	830	374	527	361	25	143	2.787
2005	440	593	337	567	97	60	102	2,196
2006	537	839	407	730	139	51	188	2,891
2007	473	711	342	807	150	26	97	2,606
2008	556	1,290	482	803	166	13	201	3,511
2009	932	1,536	396	764	68	33	165	3,894

Source: Panel of Food Consumption. Spanish Ministry of Rural and Marine Environment. Formerly Agriculture, Fisheries and Food. Available at: http://www.mapa.es/es/alimentacion/pags/consumo/BD/consulta.asp

In 2009, supermarkets represented the most important retail channel, with 39% of total sales, followed by hypermarkets (24%) and fish mongers (19%). The relative shares of supermarkets and hypermarkets appear to have increased over time, while that of fishmongers has declined.

Although turbot is a traditional species Spain, mainly in the northern area, it is cunsumed less than other farmed species like seabream or seabass[10]. In the period 2005-07, about 18% of the Spaniards consumed turbot with maximum frequency of once per month.[11] Consumers scored turbot as a good quality and safe fish to eat, but somehow expensive.

Being a more expensive product than other species commonly consumed in Spain, high education level and high income are characteristics of turbot consumers, as well as middle age segments. Turbot is not easy to prepare, which implies that a large amount is consumed in the hospitality sector. Consumption in restaurants helps increasing the final price of this product, however, it also resulted in a brake on expanding consumption in the period studied.

Like several other species that are supplied by both capture fisheries and aquaculture, farmed origin is not well recognised by turbot consumers. However, the percentage of turbot consumers who are aware of the availability of farmed turbot has increased from 19% to a 32% between 2005 and 2007. This trend may continue as the supply from aquaculture increases.

Consumers who are eating farmed turbot scored farmed turbot as cheaper than wild, but of lower quality and safety. These scores are common for all farmed species that were studied (bass, bream, turbot and trout), but in the case of turbot they were homogeneous across consumers' segments and places of purchase.

Export data for Spain are not available. A production of more 8,000 tonnes in 2009 and a domestic consumption of slightly less than 4,000 tonnes indicates that Spanish exports for that year may have been more than 4,000 tonnes. Spain is, without doubt, the largest exporter of turbot in Europe. Export markets include Italy, France, Germany and the United Kingdom.

Net supply of turbot in *Italy* for the period 2000-2007 is given in Table 3. In addition to domestic landings, turbot is imported, while exports are neglibile. In the period 2000-03, annual net supply was around 1,400 tonnes. Since then, there appears to be an upward trend in net supply which reached 1,675 tonnes in 2006.

[10] The following paragraphs are based on a survery of farmed fish consumption in Spain for 2005-07, see UC - MARM (2009).
[11] MARM. Panel de Consumo Alimentario, 2008. Available at: http://www.mapa.es/es/alimentacion/pags/consumo/BD/consulta.asp

Table 3. Net Supply of Turbot in Italy

Year	Imports	Exports	Turbot Catch (Tonnes)	Net Supply (Tonnes)
2000	793	5	643	1,431
2001	786	14	622	1,394
2002	789	4	482	1,267
2003	829	11	610	1,428
2004	904	13	561	1,452
2005	1,037	20	445	1,462
2006	942	16	749	1,675

Sources:
-For imports and exports: www.ismea.it
http://.ismea.it++%22rombo+chiodata%22&ei=LzGiS_CkH5KTjAeR_sWQCg&usg=AFQjCNEsV2gsLWaIrnVBlP79OpnegAiwzg&sig2=VMwXKb1DDnH-E2ce1PDaAQ
-For turbot catch: Table A1.

In *France*, annual catches have varied between 457 – 744 tonnes since 2000. Farmed production in 2007 was 850 tonnes.

Since 2000, annual *UK* harvest has varied between 633 – 1,065 tonnes. Farmed production is very small. It is know that the UK imports turbot, in particular from Spain. As turbot is combined with other species in trade statistics, it is not known how much is imported – or exported, for that matter.

3.2 Turbot prices

Spain

As mentioned above, Galicia is the main producer of turbot in Europe. Price observations for this region are presented in Table 4. The ex-farm price was relatively stable around € 8.90/kg for the period 2003-06. In then increased to € 9.62/kg in 2007. Subsequently there has been a fairly substantial price reduction; in 2009, in July, the price was € 6.77/kg. One reason for this is believed to be the recession. Also, a number of companies have experienced cashflow problems, which have forced them to sell fish of lower than optimal size. This puts pressure on the price.

Table 4. Ex-Farm Price of Farmed Turbot in Galicia €/kg. 2003-2009.

	Price (size 1 - 2 Kg)
2003	8.89
2004	8.80
2005	8.78
2006	8.90
2007	9.62
2008	8.31
2009	6.77
2010	n/a

Source. Spanish Marine Fish Farmers Association (APROMAR), several years. Available at: http://www.apromar.es/Informes/

Prices continued falling in 2010, with a price of € 6/kg recorded in February (Fish Farming Expert, 2010). According to industry sources, prices have recovered later in the middle of the year but then fell again towards the end of 2010.

Most turbot is harvested at a weight of 1.5 – 2.0 kg per fish. It must be noted that the price varies with fish size, with larger fish fetching a higher price per kg.

Monthly prices for farmed turbot for the period January 2000 – March 2010 are presented in Figure 6. For the first five years, the prices generally varied between € 8-10/kg. In then showed an increasing trend, from € 8/kg in early 2006, reaching a peak of € 13.50/kg in September 2007, the highest price recorded in this time period. Subsequently, the price trend has been negative, reaching a low of € 6/kg at the end of 2009, although increasing to € 7.50/kg in March 2010.

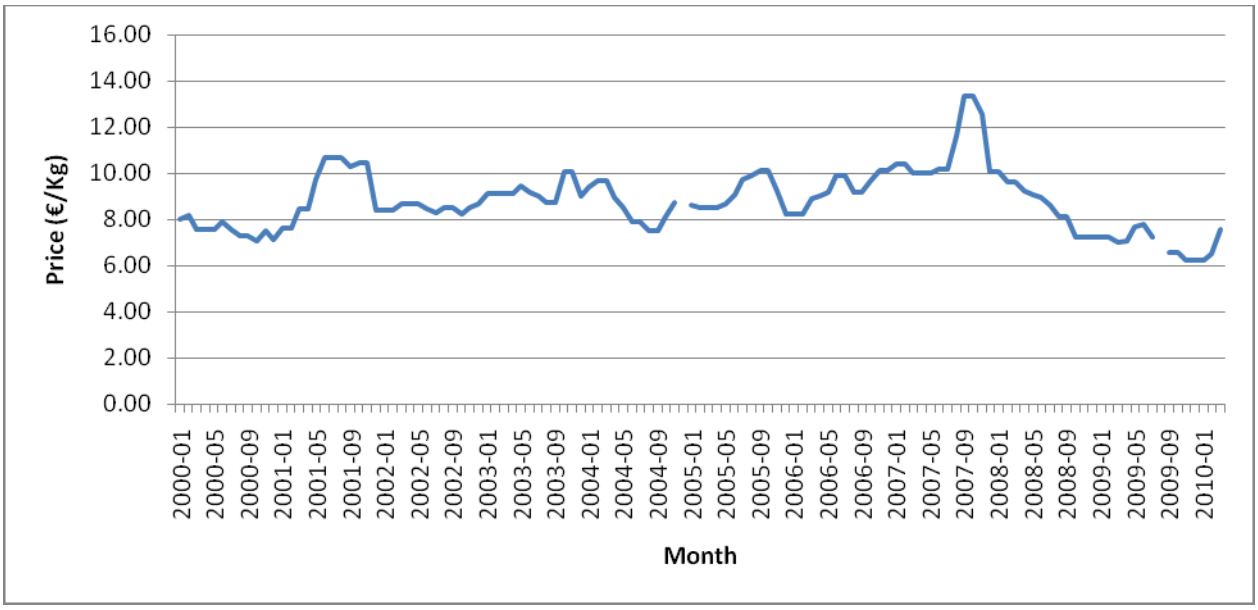

Figure 6. Monthly Turbot Prices, in Spain, Origin Spain, Fresh, Whole, Cultured, 1 – 2 kg/pc, January 2000 – March 2010.

Prices for the main retail channels are also available (Table 5). It is interesting to note that the development in prices is different for the different channels. In 2009, fishmonger fetches the highest price; moreover, its prices has increased in recent years in contrast to other channels.

Table 5. Prices (€/kg) in the Main Retail Channels in Spain. 2004-2009

	Hypermarket	Supermarket	Food market	Fishmonger	Frozen shop
2004	9.78	8.45	8.49	8.75	6.79
2005	9.84	9.49	8.77	8.62	6.69
2006	10.06	10.12	8.94	9.22	6.35
2007	10.62	9.61	8.26	9.11	7.15
2008	9.46	9.44	9.20	8.89	7.42
2009	9.39	9.01	9.39	9.50	8.11

Source: Panel of Food Consumption. Spanish Ministry of Rural and Marine Environment. Formerly Agriculture, Fisheries and Food. Available at: http://www.mapa.es/es/alimentacion/pags/consumo/BD/consulta.asp

Prices of Wild Turbot

We have been able to find time series data for the price of wild turbot for only two countries, the Netherlands (1994-2006) and Belgium (1992-2006). As mentioned, the Netherlands has the largest catches in the EU. For Belgium, annual catch for the

period under consideration has varied between 203 - 355 tonnes. Average annual ex-vessel prices for the two countries are given in Figure 7.

As can be seen, the price pattern is similar for the the countries. There was an upward price trend until 1997; followed by a temporary decline. Then, the price in Belgium increased from €9.58/kg in 1997 to €12.36/kg in 2006, while in Netherlands the price increased from €9.34/kg to €10.43 in the same period. Nevertheless, there appears to be a widening price gap after 2000, with turbot fetching the highest price in Belgium, presumably due to a lower quantity.

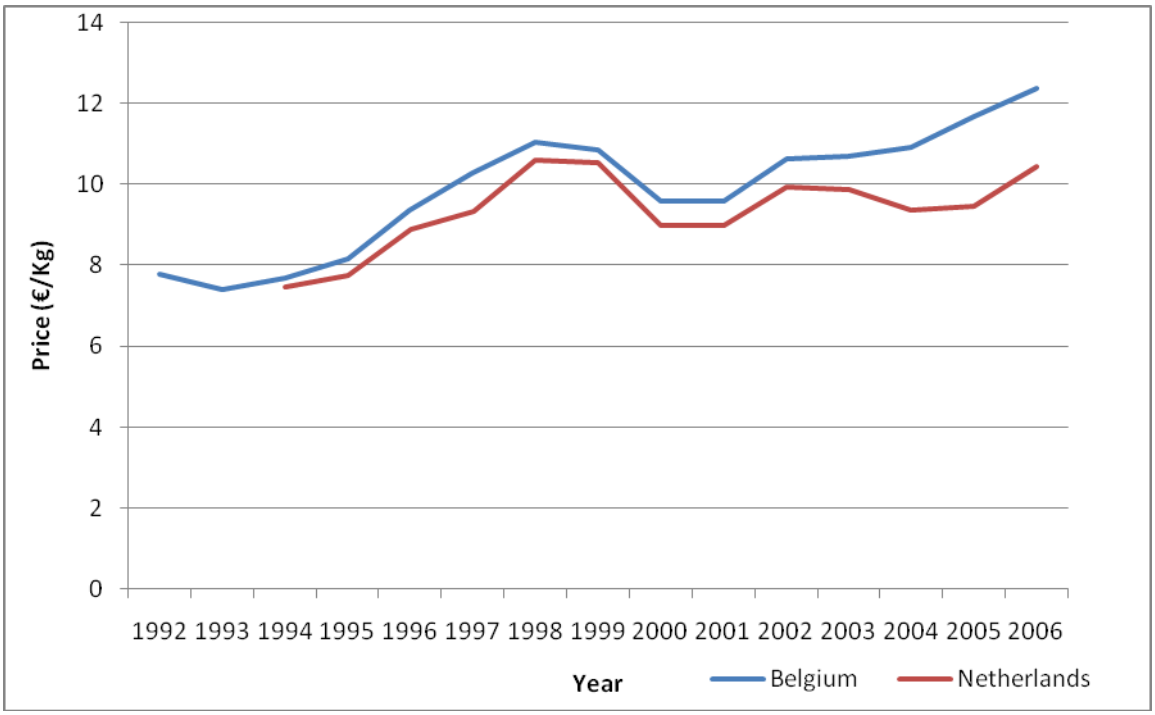

Figure 7. Annual Nominal Price of Wild Turbot, Belgium (1992-2006) and the Netherlands (1994-2006), €/kg.

Figure 8 shows average annual farmed price for turbot in the EU for 1992-2006. The price is seen to decline from € 9.67/kg in 1996 to € 7.84 in 2006. It also shows wild prices for Belgium and the Netherlands, as replicated from Figure 7.

When comparing prices of farmed and wild product, it is interesting to note that for the first five years of the data series, the price of farmed was higher than the price of wild. Presumably this was due to very low quantities of farmed turbot. Over time one can observe a growing divergence between farmed and wild prices. In other

words, there are indications that the price premium for wild product may be increasing.

Unlike the largely horizontal price trend for European farmed turbot, the price yielded for EU wild caught turbot shows an upward trend, having increased by 60% between 1992 and 2005, reaching €13.526 per kg (Figure 6). Farmed turbot in that year was only yielding approximately 42% of the price yielded by wild caught turbot.

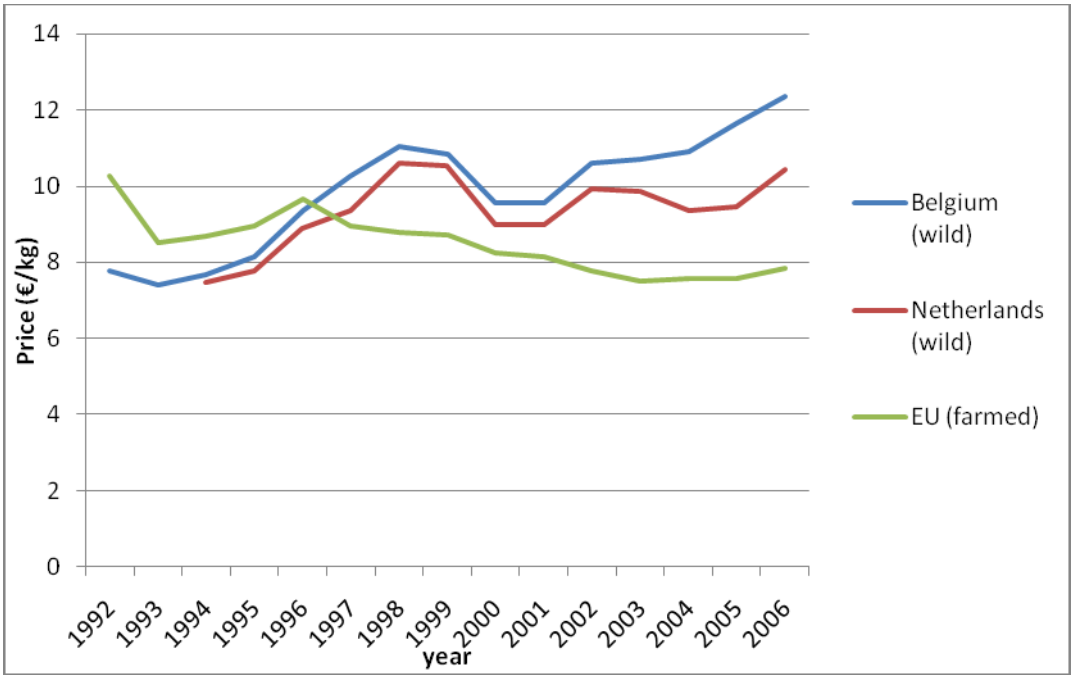

Figure. 8 Average Annual Wild Turbot Prices for Belgium (1992-2006) and the Netherlands (1994-2006); Average Annual Farmed Turbot Price for the EU (1992-2006); €/kg.

Figure 9 shows EU farmed production and real price[12] of turbot per kg for the period 1989-2007. As the EU represents the lion's share of turbot farming, the figure is representative of the world market and world price for turbot.

In this period, production increased from 287 tonnes in 1989 to 8,105 tonnes in 2007. The real price initially fell sharply, from € 33.68/Kg in 1989 to € 13.24/kg in 1993. Subsequently, it has shown only a gradual decline. The 2007 price was € 7.93/kg, down from € 8.08 in 2005 and € 10.29 in 2000.

The price-quantity development of a newly farmed species has been analysed by Asche and Bjørndal (2011). Salmon, sea bass and sea bream are species that were

[12] Nominal prices have been converted into real prices by use of the Consumer Price Index for Spain. This is because Spain is the largest producer of farmed turbot in Europe.

highly valued before aquaculture increased the supply, but lost that position as prices decreased. Turbot, however, is a species that has maintained its exclusive image. Some of the explanation is of course that production has increased only moderately, as shown in Figure 9 from about 300 tonnes in 1989 to 8,200 tonnes in 2007. As expected, this has lead to a decline in price. The price in 2007 was €7.45 kg, slightly less than half of the 1992 price, but about 60% of the 1993 price.

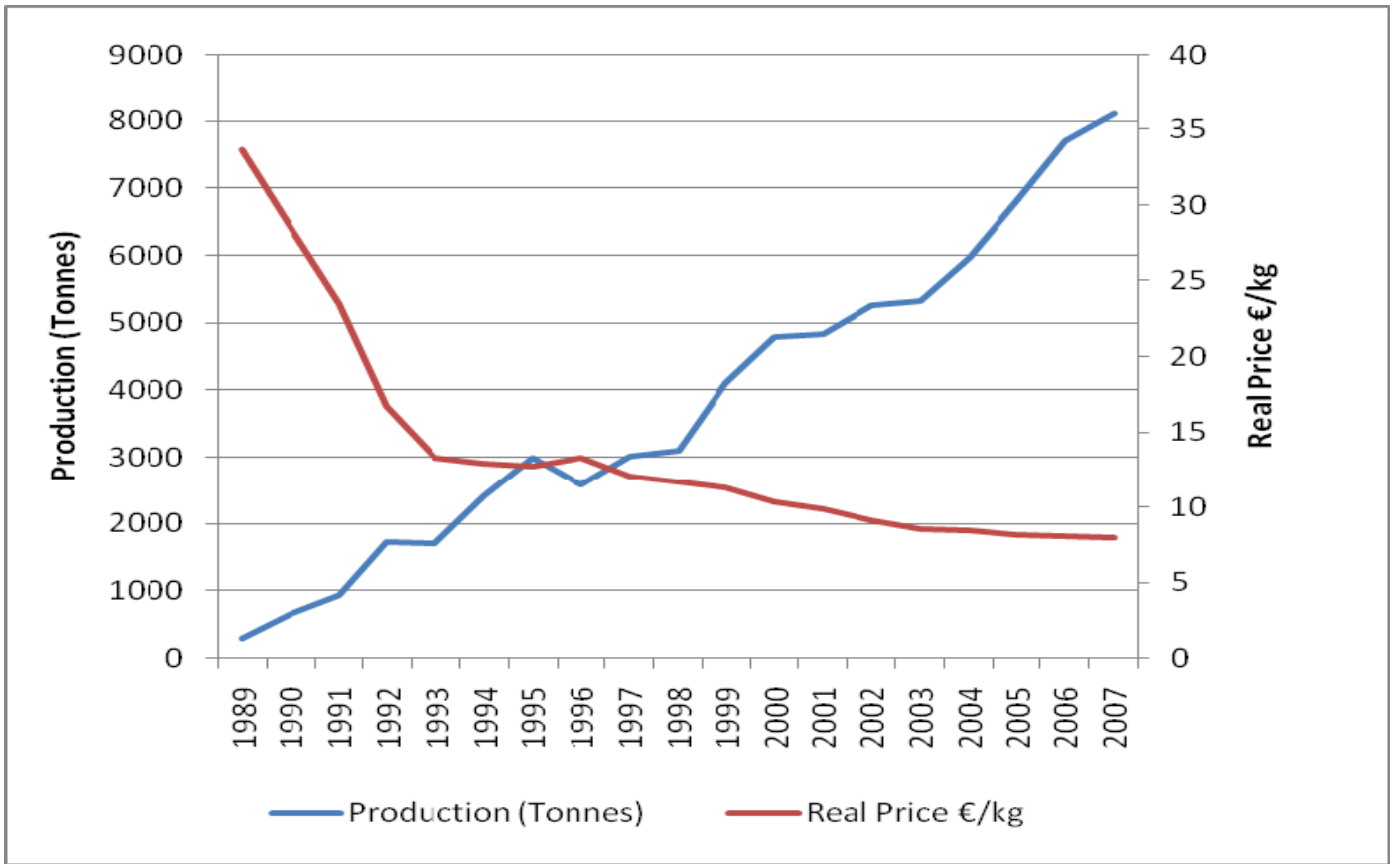

Figure 9. EU Farmed Turbot Production (Tonnes) and Real Price €/Kg (2005 = 100). 1989-2007.

The interesting question about turbot is why production has not increased more. Many top chefs regard it as the most attractive fish species. Moreover, it has a great reputation in a much wider area than sea bass and sea bream as it is also caught (in small quantities) in Northern Europe, and hence it has a larger market to tap. The reason for the limited growth in farmed quantity has to do with production technology (Section 4). Turbot cannot be produced in sea pens, but must be produced in land-based tanks or raceways. This requires more investment, and makes it more

difficult to increase production when market signals are positive. Moreover, the larger investment also increases capital costs, and thereby production costs, relative to species where sea pens are used. Hence, production costs cannot decline as much as for salmon as long as this production technology is used.

The final lesson, when comparing turbot to salmon, is that it is not likely to remain a luxury product if production increases so much that it must compete primarily on price. On the other hand, it is virtually impossible to prevent a substantial increase in production if technological innovations reduce production costs and enhance profitability. Increased profits would be a strong incentive to expand production. Hence, for a high valued farmed species to remain exclusive, production costs cannot be reduced too much as this would inevitably expand output and reduce price so that the luxury image would be lost.

4. FARMING TECHNOLOGIES

In this section, we will give a description of farming technologies currently in use, from hatchery practices to grow-out. The prospects of new hyperintensive technologies will be considered. Finally, results from a cost of production analysis will be presented.

Hatchery practices

Broodstocks are mainly built up from farmed individuals as part of more than decade-long selection programmes among producers. Individually tagged breeders are maintained in concrete tanks at low density (about 5 kg/m^2) and are fed specially designed brood-stock pellets. An optimised light regime and temperature for broodstock keeping through the year is of great importance to obtain high egg quality and to obtain egg production all year round.

Turbot do not spawn spontaneously in captivity, so gametes are routinely hand-stripped. Turbot females may produce 1 - 10 million eggs through the season, depending on fish size. Newly hatched larvae, 6-7 days after fertilisation, are about 3 mm long. Larval rearing is typically intensive with densities of about 20 larvae per l in tanks with rather low water renewal although with increasing exchange rate as they grow bigger. At the beginning of the exogenous feeding stage (about three days after

hatching), larvae are fed the rotifer *Brachionus plicatilis* for about 10 days followed by *Artemia* nauplii. Green water-technology is often applied based on on-site-produced phytoplankton or commercially available alga pasta. Metamorphosis ends after 40-50 days when larvae are about 25 mm long. For the next two months, the juveniles are nursed in small tanks and are fed dry granulates of increasing size until they reach a weight of 5-10 g.

Larval survival is generally 10-25% to metamorphosis and the percentage of juveniles without deformities – and thus selected for on-growing - is now typically above 90%. All juveniles are vaccinated against important fish diseases, but occasionally "new" diseases or parasites are introduced among juveniles causing severe problems - if undetected – for on-growing companies as seen in Galicia in 2006-2007.

Grow-out

The 5-10 g turbot juveniles are subsequently stocked into a nursery section and when they reach a size of 200-400 g, they are transferred to permanent on-growing tanks that typically will have a surface of 60-120 m^2 and with a water depth of 0.5 – 1 m. Initial density of 20 kg/m^2 will increase to 50-70 kg/m^2 for market-sized turbot. The tanks are self-cleaning due to tank design and circulation pattern of water. The oxygen level in the outlet water will be kept above 60% saturation while intake water will normally have oxygen injected by venturi in the intake pipe to achieve a level of 120-150% saturation in the incoming water and thus reduce pumping of water to less than the half.

Repeated feedings take place to saturation with pellets by feeding machines of different types although small farms still use hand-feeding. Size grading is undertaken 2-4 times during the next 1-1½ years to keep together equal-sized fish and thus obtain a more homogeneous growth rhythm. Since males have a slower growth rate, they will be graded out and sent to market at below 1 kg while females will be in the size range of 1-2 kg with a modest quantity of fish larger than 2 kg. A population or cohort of 5-10 g fish will thus be harvested within two years.

At the large-sized turbot farms, rearing takes place in out-door tanks with open-circuit flow-through system for seawater, and with use of a tank cover to

prevent fish from being sun-burned. Still only a small part of the European turbot production is undertaken in re-circulation aquaculture system (RAS). Most farms are located in places with a seawater temperature in the range of 10-20º C throughout the year and with close-to-optimal temperature (~15ºC) most of the year.

Industrial Aquaculture Parks

Currently, most land-based seafood production requires significant land areas. One alternative to reduce this area is to use production technologies that require less area, such as shallow raceway systems where production takes place in a rack with raceways in three-six levels. The smaller footprint and high compactness of this hyperintensive aquafarming technology is well-suited for use in industrial aquaculture parks, which typically yield 5-10 times higher production per surface area than conventional farming technology.

Industrial parks are generally developed to make industrial activities more efficient and physically separate them from other activities. These parks are often characterized by a cluster structure that provides advantages from being co-located with other activities. Industrial aquaculture parks are a promising alternative for further expansion of the fast-growing, land-based production of seafood in many coastal and inland regions.

Aquaculture industry development from small units to industrial parks is possible and advantageous, because it could make even high cost countries into competitive producers of valuable seafood through the use of compact land-based facilities. Resource-saving approaches can support low-cost production based on advanced technology in combination with production methods that comply with product traceability, animal welfare rules, environmental regulations and other criteria for sustainability. It is significantly easier to meet these demands within the frame of a cluster structure in an industrial park, with coordination of main operations and services, than at single, dispersed production units.

For example, a land-based operation for the production of 10,000 tonnes of a niche species would demand more than 300,000 m^2 of industrial buildings when conventional technology is used. This represents a huge economic challenge. With

hyperintensive technology, the goal is to reduce the industrial building size by 80%, or to produce the same volume within a 60,000 m^2 building. This implies a production increase from 30 to more than 150 kg/m^2 of building surface.

The hyperintensive concept is also expected to reduce the use of other input elements, such as feed, water, oxygen, energy, and manpower. Another important aspect is labour productivity. With conventional technology, output per employee has been 20-50 tonnes/year for a species like turbot. With shallow raceway systems, the goal is to increase production to 50-200 tonnes/year/employee, depending on the overall size of the farm. This higher productivity is needed to obtain stable and high profit margins for investors. As the raceway systems are designed to facilitate automation, it is easier to achieve ambitious improvements in productivity with this technology than other alternatives.

Possible synergistic effects include hyperintensive fish production coupled with the use of industrial cooling waters, which would open for employment in regions where this resource is available. With water chemistry adjustments now available[13], it may also be possible to install industrial parks close to important markets, opening up the farming of marine species in almost freshwater conditions.

Planned Parks

In Galicia in northwestern Spain, the regional government has launched a plan for 25 separate industrial aquaculture parks covering 300 ha, with a planned annual fish production of 22,500 tonnes. This could represent a paradigm for European aquaculture and have a cascading effect in the industry.

The parks are planned with conventional aquatechnology, but could undertake a transition to hyperintensive technology for those still at the planning stage. The forecasted impact of the technology transition could be very significant, increasing the production volume to about 200,000 tonnes with application of hyperintensive technology.

Advantages of shallow raceway systems include:

- Minimal land requirement. Depending on the number of production layers, shallow raceways may require only about 20% of the area for the same

[13] http://www.marical.biz

biomass production as with conventional systems. They can be built on inexpensive land at some distance from the coast or on low-value agriculture land at the sea-front.

- Water conservation. Shallow raceway systems are easy to connect to water sources and support water reuse or recirculation. In a flow-through system with reuse, shallow raceways require only about 30% of the water used with conventional technology for equivalent biomass.
- High-density production. The use of floating pellets and movable screens in raceway systems supports high fish density and 30% higher standing biomass for the same tank surface.
- Species flexibility. Shallow raceways can be used for both pelagic and benthic-pelagic fish species.
- Feed efficiency. The use of floating pellets in raceways can reduce feed-conversion ratios up to 10%.
- Operational efficiency. Raceway systems can be installed as modules called "towers" to keep pace with increases in biomass and reduce start-up costs.
- Reduced labour requirement. Shallow raceways are expected to require only 50-75% of the staff needed to run conventional systems for the same production capacity.

Cost of Production

Bjørndal and Palmieri (2008) undertook an analysis of cost of production for turbot, based on data from a number of farms in Spain and Portugal. In the base case with an annual output of 133 tonnes, average cost per kg turbot has been estimated at € 7.54. An expansion in production capacity to an annual output level of 400 tonnes per year was also considered. This would reduce the average cost per kg of turbot produced to € 5.07, a reduction of about 33% per kg compared to the smaller farm. This indicates quite substantial economies of scale.

Investments in a turbot farm with production capacity of about 133 tonnes per year represent about € 4.3 million. To threble the production capacity to 400 tonnes, additional investments of about € 1.80 million are required. As additional investment costs are considerably less, relatively speaking, than the increase in output, this

indicates a source of economies of scale. In addition, with larger output the labour force and management are utilised more efficiently, which will also bring down cost of production.

A number of sensitivity analyses were also undertaken for the farm with a 400 tonne production capacity. A doubling of the natural mortality compared to the base case causes cost of production to increase from € 5.07 to € 5.41, a 7% increase. An increase in the growth rate so that the average weight per fish is 1.5 kg as opposed to 1.2 kg in the baseline, leads to a reduction in production cost to € 4.32 per kg, or 15% less than in the base case. A deterioration in the feed conversion ratio from 0.95 to 1.10 causes cost of production per kg to increase by 4% to € 5.27, while a reduction in the fry cost from € 1.38 to € 1.20 per unit leads to a 3.5 % decrease in cost of production to € 4.89.

Overall, these results represent moderate sensitivity of cost of production to changes in these important biological parameters.

5. FUTURE OUTLOOK

The actual seafood market in Europe reflects the traditional pattern of availability of seafood from wild stocks. However, this is increasingly changing as aquaculture enables production to be better geared to market demand. It should therefore be expected that as aquaculture production continues to grow, the balance of seafood products will also change. Consumer preference will be an increasingly important driver for aquaculture development (Sturrock *et al.*, 2008).

A number of factors will influence the development of the market for turbot. These includes consumer purchasing behaviour and responses of the multiple retailers to the increase in production. Turbot is a popular, but nevertheless premium fish species. Prospects for steady growth within limits are to a great extend determined by price.

Innovation processes and institutional support will be important factors in the potential development of turbot aquaculture (Sturrock *et al.*, 2008). The further development of commercial aquaculture systems suitable for the production of turbot is key in the expansion of the market for this species. Site availability and cost, taking into consideration physical availability and government regulations, affect supply.

Support for innovation, taking into account government and business investment in R&D, education and training, and the support of government and financial institutions for commercial (technology-based) risk takers will also influence the future of the industry.

Introduction of new technology gives ability to expand production considerably, as discussed in Section 4.

As noted above, Galicia is the largest producing area for *turbot* in the world, with an expected output of 8,400 tonnes for 2010. World production of turbot was 9,500 tonnes in 2008 and is expected to reach almost 11,000 tonnes in 2010 and 16,500 tonnes in 2010. Among other things, this is as a consequence of Acuinova's establishment of a turbot farm with a 7,000 tonne production capacity in Portugal.

Cost of production for large farms is € 5.00 – 5.50 per kg in Galicia. Packaging and transport is another € 1.00 on top of this. Smaller farms will, however, have higher costs of production. Portugal may possibly have lower cost of production than Galicia. First of all, large production volumes may give rise to economies of scale. EU subsidies may reduce capital costs, and labour costs are lower than in Spain. Finally, transportation routes may be better than in Galicia, giving lower distribution costs.

Turbot prices have been high over the past few years, but have shown a reduction since 2007 (although there are signs of a recovery in the second part of 2010). One reason for this is likely to be the current the recession which, among other things, has reduced restaurant consumption. In addition, some companies have experienced financial problems. As a consequence, some had to sell product at lower than optimal weight in order to maintain cashflows. These developments have put pressure on the price.

According to the forecast mentioned above, world turbot production may increase by more than 70% from 2008 to 2012. Turbot is a very popular product, and many markets remain to be exploited, in Europe and elsewhere. Nevertheless, such a large production increase in a four year period is likely to put a negative pressure on the price. The impetus is therefore on the producers to develop new markets.

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APPENDIX: STATISTICAL DATA

This report uses data from the following sources:

Eurostat New Cronos, © European Communities, 26th April 2007, Source Eurostat delivered by ESDS International, (MIMAS) University of Manchester
FAO Fisheries and Aquaculture Information and Statistics Service 2007. Fisheries commodities production and trade 1976-2006. FISHSTAT Plus - Universal software for fishery statistical time series [online or CD-ROM]. Food and Agriculture Organization of the United Nations. Available at: http://www.fao.org/fi/statist/FISOFT/FISHPLUS.asp

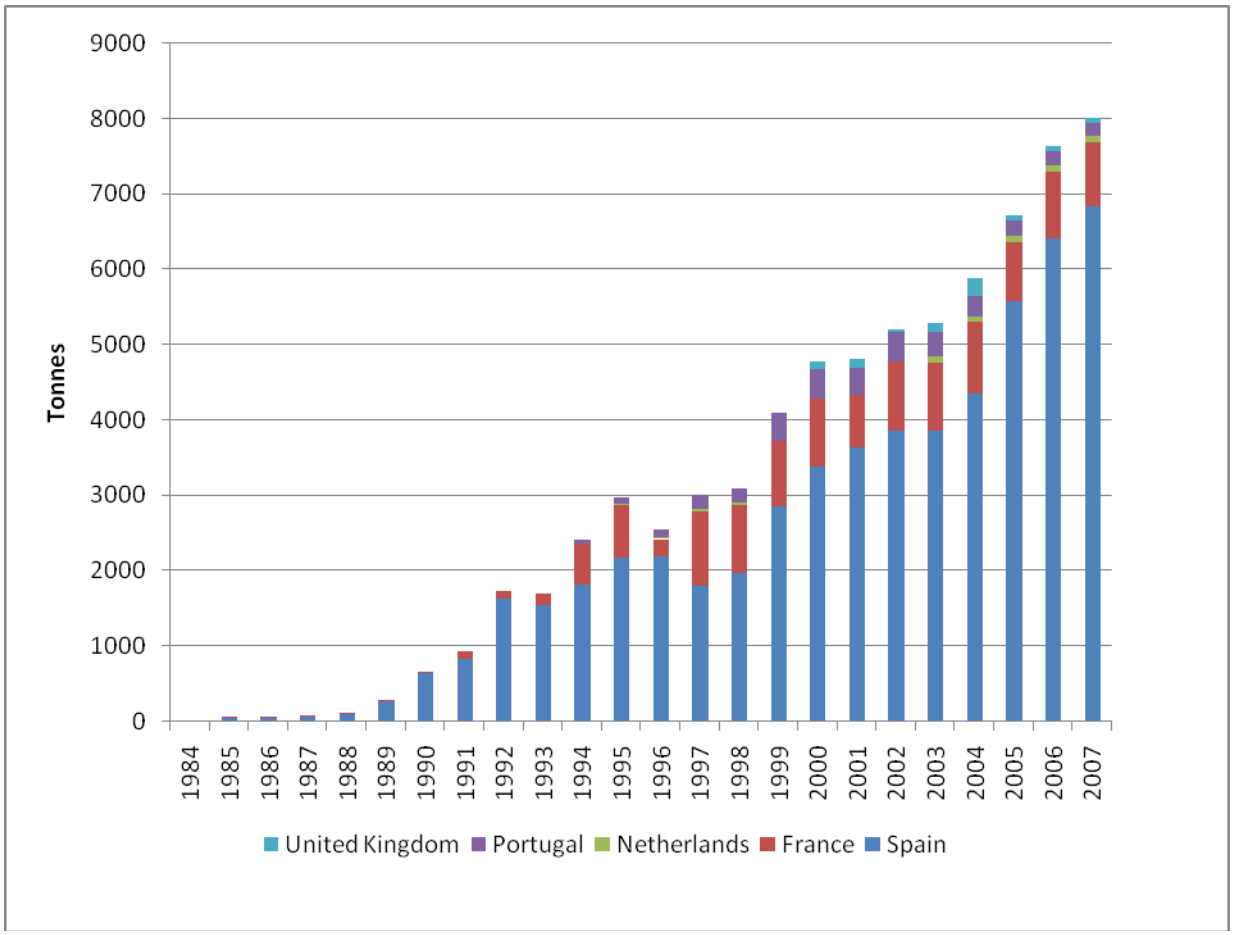

Figure A1. Volume of Farmed Turbot Production – Key Nations, 1984 – 2007.

Table A1. Prices of Wild Turbot Belgium. 1992-2006.

Year	Value (€)	Catch (Tonnes)	Price (€/Kg)	CPI	Real Price (€/Kg)
1992	2,626,291	338	7.770	77.70007	10.000
1993	2,628,288	355	7.404	79.84026	9.274
1994	2,602,810	339	7.678	81.7385	9.393
1995	2,571,049	315	8.162	82.93839	9.841
1996	2,595,722	277	9.371	84.65823	11.069
1997	2,454,307	239	10.269	86.0365	11.936
1998	2,241,494	203	11.042	86.85211	12.714
1999	2,494,190	230	10.844	87.82582	12.347
2000	2,776,734	290	9.575	90.06105	10.632
2001	2,643,437	276	9.578	92.28655	10.379
2002	3,034,442	286	10.610	93.80265	11.311
2003	3,852,874	360	10.702	95.29443	11.230
2004	3,726,106	342	10.895	97.27751	11.200
2005	3,531,328	303	11.655	100	11.655
2006	3,819,159	309	12.360	101.7909	12.143

Table A2. Prices of Wild Turbot The Netherlands. 1994-2006.

Year	Value (€)	Catch (Tonnes)	Price (€/Kg)	CPI	Real Price (€/Kg)
1994	23,603,115	3,159	7.472	78.08547	9.569
1995	22,303,109	2,873	7.763	79.58723	9.754
1996	19,042,241	2,142	8.890	81.16243	10.953
1997	20,358,660	2,180	9.339	82.92866	11.261
1998	21,522,018	2,032	10.592	84.57518	12.524
1999	22,593,589	2,145	10.533	86.42993	12.187
2000	24,824,472	2,763	8.985	88.43223	10.160
2001	25,705,920	2,863	8.979	92.11308	9.748
2002	24,305,268	2,447	9.933	95.14054	10.440
2003	20,787,218	2,110	9.852	97.15042	10.141
2004	21,790,900	2,330	9.352	98.35349	9.509
2005	23,052,012	2,437	9.459	100	9.459
2006	22,320,476	2,140	10.430	101.1677	10.310

Source: Eurostat New Cronos (http://esds.mcc.ac.uk/wds_eurostat)
CPI sourse: OECD Stat Extracts
http://stats.oecd.org/index.aspx?querytype=view&queryname=221

Table A3. EU Production of Farmed Salmon, Value, Nominal and Real Prices 1989-2007.

Year	Production (Tonnes)	Value ('000 €)	Nominal Price €/kg	Consumer Price Index – Spain	Real Price €/kg
1989	287	4,960.80	17.285	51.31	33.68
1990	656	10,247.60	15.621	54.79	28.51
1991	925	12,623.70	13.647	58.08	23.50
1992	1,725	17,718.90	10.272	61.47	16.71
1993	1,693	14,410.30	8.5117	64.28	13.24
1994	2,399	20,849.50	8.691	67.29	12.91
1995	2,978	26,680.30	8.959	70.49	12.71
1996	2,571	24,847.70	9.665	73.03	13.23
1997	3,001	26,924.80	8.972	74.44	12.05
1998	3,087	27,186.50	8.807	75.75	11.63
1999	4,103	35,854.80	8.739	77.54	11.27
2000	4,785	39,454.60	8.245	80.17	10.29
2001	4,829	39,360.40	8.151	83.08	9.81
2002	5,258	40,933.60	7.785	85.62	9.09
2003	5,331	40,060.20	7.515	88.25	8.51
2004	5,962	45,281.40	7.595	90.88	8.36
2005	6,792	51,575.50	7.594	93.98	8.08
2006	7,703	60,373.60	7.838	97.27	8.06
2007	8,105	64,250.80	7.927	100	7.93

Consumer Price Index: http://stats.oecd.org

Table A4. Global Catch of Turbot 1950 – 2008. Tonnes.

Country	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
Belgium	1,000	1,000	1,000	1,100	900	900	1,000	1,000	800	600
Bulgaria	.	.	.	.	.	.	.	.	.	.
Denmark	1,000	1,000	900	800	1,000	1,000	1,000	800	1,100	900
Finland	.	.	.	.	.	.	.	.	.	.
France	1,200	1,100	1,300	1,500	1,400	1,500	1,500	1,400	1,600	1,400
Germany	500	300	500	500	500	600	700	600	600	500
Greece	.	.	.	.	.	.	.	.	.	.
Ireland	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	100	100	100
Italy	.	.	.	.	.	.	.	.	.	.
Latvia	.	.	.	.	.	.	.	.	.	.
Lithuania	.	.	.	.	.	.	.	.	.	.
Netherlands	700	700	800	700	700	800	900	800	1,000	800
Poland	.	.	.	.	.	.	.	.	.	.
Portugal	<0.5	<0.5	<0.5	<0.5	100	<0.5	<0.5	<0.5	<0.5	<0.5
Romania	.	.	.	.	.	.	.	100	100	100
Slovenia	.	.	.	.	.	.	.	.	.	.
Spain	100	100	100	200	100	200	200	200	100	100
Sweden	100	100	100	100	100	100	100	100	100	100
UK	3,300	3,200	2,800	2,900	3,100	2,800	3,100	3,100	2,800	2,700
Total EU	**7,900**	**7,500**	**7,500**	**7,800**	**7,900**	**7,900**	**8,500**	**8,200**	**8,300**	**7,300**
Albania	.	.	.	.	.	.	.	.	.	.
Channel Islands	.	.	.	.	.	.	.	.	.	.
Faroe Isl	.	.	.	.	.	.	.	.	.	.
Iceland	.	.	.	.	.	.	.	.	.	.
Isle of Man	.	.	.	.	.	.	.	.	.	.
Morocco	-	-	-	-	-	-	-	-	-	-
Norway	.	.	.	.	.	.	.	.	.	.
Russian Federation	.	.	.	.	.	.	.	.	.	.
Togo	.	.	.	.	.	.	.	.	.	.
Tunisia	.	.	.	.	.	.	.	.	.	.
Turkey	.	.	.	.	.	.	.	1,700	2,900	2,900
Ukraine	.	.	.	.	.	.	.	.	.	.
Total non-EU	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1700**	**2900**	**2900**
TOTAL	**7,900**	**7,500**	**7,500**	**7,800**	**7,900**	**7,900**	**8,500**	**9,900**	**11,200**	**10,200**

Country	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Belgium	600	600	600	700	400	400	400	400	300	300
Bulgaria	.	.	.	.	500	400	400	300	300	200
Denmark	900	900	900	1,300	900	600	800	600	900	900
Finland	.	.	.	.	.	.	.	.	.	.
France	1,200	1,300	1,200	1,100	1,000	1,000	1,000	1,000	800	800
Germany	500	600	500	700	600	400	600	600	500	400
Greece	.	.	.	.	.	.	.	.	.	.
Ireland	100	100	100	100	100	100	100	100	100	100
Italy	.	.	.	.	.	.	.	600	900	800
Latvia	.	.	.	.	.	.	.	.	.	.
Lithuania	.	.	.	.	.	.	.	.	.	.
Netherlands	1,100	1,300	1,400	1,200	1,300	1,200	1,500	1,700	2,100	2,300
Poland	.	.	.	.	.	.	.	.	.	.
Portugal	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Romania	100	200	200	300	400	200	100	100	100	100
Slovenia	.	.	.	.	.	.	.	.	.	.
Spain	100	100	200	200	200	100	300	100	100	100
Sweden	100	100	100	100	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
UK	2,500	2,500	2,100	2,200	2,100	1,900	1,700	1,400	1,100	1,200
Total EU	**7,200**	**7,700**	**7,300**	**7,900**	**7,500**	**6,300**	**6,900**	**6,900**	**7,200**	**7,200**
Albania	.	.	.	.	.	.	.	.	.	.
Channel Islands	.	.	.	.	.	.	.	.	.	.
Faroe Isl	.	.	.	.	.	.	.	.	.	.
Iceland	.	.	.	.	.	.	.	.	.	.
Isle of Man	.	.	.	.	.	.	.	.	.	.
Morocco	-	-	-	-	-	-	-	-	-	-
Norway	.	.	.	.	.	.	.	.	.	.
Russian Federation	.	.	.	.	.	.	.	.	.	.
Togo	.	.	.	.	.	.	.	.	.	.
Tunisia	.	.	.	.	.	.	.	.	.	.
Turkey	1,300	1,400	1,200	1,600	1,600	1,700	2,500	1,800	2,100	2,700
Ukraine	.	.	.	.	.	.	.	.	.	.
Total non-EU	**1300**	**1400**	**1200**	**1600**	**1600**	**1700**	**2500**	**1800**	**2100**	**2700**
TOTAL	**8,500**	**9,100**	**8,500**	**9,500**	**9,100**	**8,000**	**9,400**	**8,700**	**9,300**	**9,900**

Country	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Belgium	200	200	200	200	185	218	318	213	232	252
Bulgaria	268	222	175	249	312	204	217	63	121	70
Denmark	600	700	700	600	420	632	822	882	1,153	1,539
Finland	.	.	.	.	.	.	.	.	.	.
France	685	761	700	700	602	658	713	1,824	848	739
Germany	300	300	300	200	172	232	228	242	216	200
Greece	.	.	.	.	.	.	.	.	.	.
Ireland	100	100	100	100	104	108	180	158	141	149
Italy	1,135	1,374	1,037	798	1,107	1,012	1,380	1,640	1,416	1,331
Latvia	.	.	.	.	.	.	.	.	.	.
Lithuania	.	.	.	.	.	.	.	.	.	.
Netherlands	1,900	2,500	2,500	2,600	2,890	3,364	3,458	3,392	3,410	4,098
Poland	-	-	-	-	-	-	-	-	-	-
Portugal	<0.5	100	100	100	65	79	109	92	74	94
Romania	89	43	70	118	29	16	36	11	-	7
Slovenia	.	.	.	.	.	.	.	.	.	.
Spain	-	-	-	-	-	-	-	-	-	135
Sweden	<0.5	<0.5	<0.5	<0.5	13	15	15	13	16	17
UK	1,300	1,000	1,100	1,000	916	724	869	923	1,034	1,086
Total EU	**6,577**	**7,300**	**6,982**	**6,665**	**6,815**	**7,262**	**8,345**	**9,453**	**8,661**	**9,717**
Albania	.	.	.	.	.	.	.	.	.	.
Channel Islands	-	-	-	-	-	-	-	-	.	.
Faroe Isl	-	-	-	-	-	-	-	-	-	-
Iceland	-	-	-	-	-	-	-	-	-	-
Isle of Man	.	.	.	.	.	.	.	.	.	1
Morocco	-	-	-	-	-	-	-	-	-	-
Norway	-	-	-	-	-	-	-	-	-	-
Russian Federation	.	.	.	.	.	.	.	.	.	.
Togo	-	-	-	-	-	-	-	-	-	-
Tunisia	<0.5	1	3	-	<0.5	-	-	-	-	-
Turkey	4,181	2,689	2,394	3,982	986	808	1,173	1,913	1,958	5,314
Ukraine	.	.	.	.	.	.	.	.	.	.
Total non-EU	**4181**	**2690**	**2397**	**3982**	**986**	**808**	**1173**	**1913**	**1958**	**5315**
TOTAL	**10,758**	**9,990**	**9,379**	**10,647**	**7,801**	**8,070**	**9,518**	**11,366**	**10,619**	**15,032**

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Belgium	237	228	243	303	356	345	292	266	254	318
Bulgaria	89	9	9	7	21	51	12	3	4	1
Denmark	1,626	1,323	1,130	1,141	1,234	1,345	1,393	1,414	1,297	1,102
Finland	.	.	.	.	.	.	.	.	.	.
France	748	843	727	970	880	861	823	889	1,051	1,243
Germany	186	142	78	68	72	78	97	98	111	134
Greece	.	.	20	12	18	17	80	320	160	150
Ireland	171	199	274	232	223	198	201	283	346	263
Italy	1,154	938	1,213	1,608	1,402	1,308	1,716	1,831	1,988	1,485
Latvia	.	.	.	.	.	.	.	.	-	-
Lithuania	.	.	.	.	.	.	.	.	-	-
Netherlands	3,260	3,089	3,046	3,199	.	.	.	.	2,670	3,666
Poland	-	-	-	-	-	-	-	-	-	-
Portugal	111	106	93	93	84	93	96	105	113	82
Romania	9	2	2	3	4	11	7	1	2	-
Slovenia	.	.	.	.	.	.	.	.	.	.
Spain	203	189	132	143	111	151	232	210	246	196
Sweden	21	15	18	20	22	28	30	40	54	44
UK	771	630	570	560	588	616	607	743	788	670
Total EU	**8,586**	**7,713**	**7,555**	**8,359**	**5,015**	**5,102**	**5,586**	**6,203**	**9,084**	**9,354**
Albania	.	.	.	.	.	.	.	.	.	.
Channel Islands	.	.	.	.	.	6	8	6	4	2
Faroe Isl	-	-	-	-	-	-	-	-	-	-
Iceland	-	-	-	-	-	-	-	-	-	-
Isle of Man	<0.5	1	1	<0.5	9	1	<0.5	1	<0.5	<0.5
Morocco	-	-	-	-	-	-	-	-	-	-
Norway	.	.	.	.	.	.	.	.	.	.
Russian Federation	.	.	.	.	.	.	.	.	-	-
Togo	-	-	-	-	-	-	-	-	-	-
Tunisia	-	-	-	-	-	-	-	-	-	1
Turkey	2,771	3,785	4,723	5,398	2,920	435	449	939	1,259	1,481
Ukraine	.	.	.	.	.	.	.	.	-	-
Total non-EU	**2771**	**3786**	**4724**	**5398**	**2929**	**442**	**457**	**946**	**1263**	**1484**
TOTAL	**11,357**	**11,499**	**12,279**	**13,757**	**7,944**	**5,544**	**6,043**	**7,149**	**10,347**	**10,838**

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Belgium	442	512	456	480	480	499	382	337	327	368
Bulgaria	.	.	.	.	.	60	62	60	64	54
Denmark	1,801	1,895	1,642	1,531	1,572	1,396	1,117	908	770	727
Finland	.	.	.	.	.	.	.	.	.	.
France	1,088	1,065	989	1,132	1,805	822	810	646	629	553
Germany	222	278	300	385	384	399	256	330	267	309
Greece	74	93	152	182	115	102	60	60	47	65
Ireland	251	203	247	223	194	233	261	257	234	261
Italy	1,388	1,058	1,766	1,288	1,213	1,923	1,377	964	528	478
Latvia	-	-	-	-	-	49	42	46	36	54
Lithuania	-	-	-	-	-	-	-	-	62	58
Netherlands	3,731	3,780	3,495	2,938	2,724	2,476	1,780	1,866	1,700	1,812
Poland	-	-	-	-	-	-	-	-	-	-
Portugal	63	49	66	65	54	57	40	28	27	34
Romania	-	2	-	6	6	4	6	1	-	2
Slovenia	.	.	-	-	-	-	-	-	-	-
Spain	206	209	241	289	243	257	282	339	231	252
Sweden	63	71	104	114	113	195	296	294	188	159
UK	760	972	1,243	1,531	1,490	1,281	1,270	1,148	974	851
Total EU	**10,089**	**10,187**	**10,701**	**10,164**	**10,393**	**9,753**	**8,041**	**7,284**	**6,084**	**6,037**
Albania	.	.	.	.	.	.	.	.	.	1
Channel Islands	2	2	2	2	6	6	5	5	3	4
Faroe Isl	-	-	-	320	-	-	2	-	-	-
Iceland	-	<0.5	<0.5	<0.5	<0.5	1	<0.5	<0.5	<0.5	<0.5
Isle of Man	1	1	1	1	<0.5	<0.5	1	1	<0.5	<0.5
Morocco	-	-	-	-	-	-	-	-	-	-
Norway	.	38	73	66	62	53	54	57	45	48
Russian Federation	-	-	-	-	-	-	-	-	-	-
Togo	-	-	-	1	<0.5	<0.5	<0.5	2	<0.5	-
Tunisia	<0.5	<0.5	<0.5	1	2	<0.5	<0.5	<0.5	-	-
Turkey	1,434	1,137	437	1,636	2,159	2,955	2,035	980	1,860	1,870
Ukraine	-	220	254	167	139	96	120	82	63	110
Total non-EU	**1437**	**1398**	**767**	**2194**	**2368**	**3111**	**2217**	**1127**	**1971**	**2033**
TOTAL	**11,526**	**11,585**	**11,468**	**12,358**	**12,761**	**12,864**	**10,258**	**8,411**	**8,055**	**8,070**

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008
Belgium	464	506	445	451	415	367	373	406	357
Bulgaria	55	57	136	41	16	13	15	67	55
Denmark	809	864	994	700	737	647	522	543	700
Finland	6	4	3	3	3	1	3	1	1
France	650	639	660	734	744	718	654	668	457
Germany	454	363	343	353	343	334	288	282	261
Greece	63	77	75	75	54	71	48	81	106
Ireland	236	185	183	231	321	215	198	194	171
Italy	643	622	482	610	561	445	749	1,179	916
Latvia	16	6	9	9	8	7	6	2	2
Lithuania	23	18	18	13	8	18	10	12	10
Netherlands	2,287	2,277	1,899	1,908	1,778	1,915	1,839	2,279	1,751
Poland	-	-	-	-	43	76	99	91	111
Portugal	63	83	69	62	67	73	53	31	29
Romania	2	13	17	24	42	37	32	57	47
Slovenia	-	-	-	1	-	-	<0.5	1	1
Spain	124	122	43	42	37	50	50	45	55
Sweden	106	64	55	41	33	41	40	40	55
UK	877	1,001	1,067	868	822	633	635	754	653
Total EU	**6,878**	**6,901**	**6,498**	**6,166**	**6,032**	**5,661**	**5,614**	**6,733**	**5,738**
Albania	1	.	.	3	2	3	3	10	7
Channel Islands	6	9	6	8	14	18	7	3	3
Faroe Isl	-	<0.5	1	7	1	1	1	<0.5	-
Iceland	<0.5	<0.5	<0.5	<0.5	-	-	-	-	-
Isle of Man	-	<0.5	-	4	-	-	-	-	-
Morocco	96	49	86	118	96	73	76	61	63
Norway	69	94	99	84	86	78	55	58	44
Russian Federation	53	69	50	28	15	28	-	30	21
Togo	1	2	2	<0.5	1	<0.5	-	-	-
Tunisia	-	-	-	-	-	-	-	-	-
Turkey	2,700	2,455	459	300	376	649	807	769	528
Ukraine	118	171	157	199	168	188	245	279	261
Total non-EU	**3044**	**2849**	**860**	**751**	**759**	**1038**	**1194**	**1210**	**927**
TOTAL	**9,922**	**9,750**	**7,358**	**6,917**	**6,791**	**6,699**	**6,808**	**7,943**	**6,665**

Source: Fishstat Plus.

Table A5. Aquaculture production of Turbot 1985-2007. Tonnes.

Country	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Denmark	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
France	15	10	15	15	15	15	100	100	150	550	694	225	980	900	868
Germany	.	.	.	.	1	1	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	<0.5	-
Ireland	.	.	.	.	.	.	.	3	4	3	15	30	.	5	8
Italy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Malta	-	-	-	-	-	-	-	-	-	1	1	<0.5	-	-	-
Netherlands	-	-	-	-	-	-	-	-	-	-	12	25	25	25	.
Portugal	.	.	.	.	.	.	.	.	.	35	82	102	196	188	378
Spain	38	40	50	97	271	640	825	1,622	1,539	1,810	2,174	2,189	1,800	1,969	2,849
United Kingdom	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total EU	**53**	**50**	**65**	**112**	**287**	**656**	**925**	**1,725**	**1,693**	**2,399**	**2,978**	**2,571**	**3,001**	**3,087**	**4,103**
Iceland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South Africa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total non-EU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**53**	**50**	**65**	**112**	**287**	**656**	**925**	**1,725**	**1,693**	**2,399**	**2,978**	**2,571**	**3,001**	**3,087**	**4,103**

Country	2000	2001	2002	2003	2004	2005	2006	2007
Denmark			1	4	6	8	7	38
France	908	702	924	909	949	791	870	850
Germany			2		58	68	60	60
Ireland	12	28	50	40	25	6		
Italy			3					
Malta								
Netherlands				75	75	75	100	90
Portugal	380	343	386	323	269	214	185	167
Spain	3,378	3,636	3,847	3,852	4,347	5,572	6,419	6,838
United Kingdom	107	120	45	128	233	58	62	62
Total EU	**4,785**	**4,829**	**5,258**	**5,331**	**5,962**	**6,792**	**7,703**	**8,105**
Iceland		27	9	32	46	115	100	100
South Africa	1		2	14	2	1		
Total non-EU	1	27	11	46	48	116	100	100
Total	**4,786**	**4,856**	**5,269**	**5,377**	**6,010**	**6,908**	**7,803**	**8,205**

Source: Fishstat Plus.

Table A6. Value of EU Farmed Turbot Production, Key Nations 1985-2007 ('000 Euros).

Country	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
France	87.5	75.2	129.9	161.5	240	270	1,400	1,200	1,500	4,963.2	6,957.9	2,199.7	8,406	7,200
Netherlands											108	245	245	245
Portugal										350	820	999.6	1,901.2	1,823.6
Spain	380	400	500	970	4,720.8	9,977.6	11,226.7	16,518.9	12,910.3	15,536.3	18,794.4	21,403.4	16,372.6	17,917.9
United Kingdom														
Total	**467.5**	**475.2**	**629.9**	**1,131.5**	**4,960.8**	**10,247.6**	**12,623.7**	**17,718.9**	**14,410.3**	**20,849.5**	**26,680.3**	**24,847.7**	**26,924.8**	**27,186.5**

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007
France	6,622.8	7,131.6	5,923.1	7,429.9	9,717.1	11,173.6	9,952.5	12,693.9	13,619.3
Netherlands					675.3	746	747.5	1,004.5	925.2
Portugal	3,591	3,610	3,258.5	2,727.7	2,703.8	2,832.8	1,871.5	1,742.2	1,840.3
Spain	25,641	28,713	30,178.8	30,776	26,964	30,429	39,004	44,933	47,866
United Kingdom		963	1,080	405	1,152	2,097	522	558	558
Total		**39,454.6**	**39,360.4**	**40,933.6**	**40,060.2**	**4,5281.4**	**51,575.5**	**60,373.6**	**64,250.8**

Source: Fishstat Plus.

Table A7. Monthly Turbot Prices, in Spain, origin Spain, fresh, whole, cultured, 1-2 kg/pc, in €/kg

Monthly turbot prices, in Spain, origin Spain
fresh, whole, cultured, 1-2 kg/pc, in €/kg

	J	F	M	A	M	J	J	A	S	O	N	D
2000	8.04	8.19	7.59	7.59	7.59	7.89	7.59	7.29	7.29	7.06	7.51	7.14
2001	7.66	7.66	8.49	8.49	9.77	10.67	10.67	10.67	10.29	10.44	10.44	8.41
2002	8.41	8.41	8.70	8.70	8.70	8.48	8.33	8.55	8.55	8.23	8.53	8.68
2003	9.15	9.15	9.15	9.15	9.45	9.20	9.00	8.75	8.75	10.10	10.10	9.05
2004	9.40	9.70	9.70	8.95	8.55	7.90	7.90	7.55	7.50	8.15	8.75	Na
2005	8.65	8.55	8.55	8.55	8.70	9.10	9.75	9.90	10.15	10.15	9.25	8.25
2006	8.25	8.25	8.90	9.00	9.20	9.90	9.90	9.20	9.20	9.70	10.15	10.15
2007	10.40	10.40	10.00	10.00	10.00	10.20	10.20	11.65	13.35	13.35	12.55	10.05
2008	10.05	9.65	9.65	9.25	9.10	8.95	8.65	8.15	8.15	7.25	7.25	7.25
2009	7.25	7.25	7.05	7.10	7.70	7.80	7.25	na	6.60	6.60	6.25	6.25
2010	6.25	6.50	7.60									

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Source: EPR - 20100315.