

An appraisal of historical glass eel fisheries and markets: landings, trade routes and future prospect for management

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ABSTRACT

Using commercial and fishery data, we recount the main features and key points of the historical trade of the European eel. Glass eel fisheries have been active since the end of the 19th century with landings estimated around 200 t. Fisheries and trade developed mainly in the south of France and markets expanded progressively along the Atlantic coast during the first 30 years of the 20th century. Export of eel towards Spain is accurately reported by the railway statistics and was 531 t at its peak in 1925. The Spanish civil war closed the trade, and during the Franco regime, the trade route towards Spain, despite representing 80 % of the total volume, remained totally opaque. Demand from Japan for European glass eel began in 1969 in Europe and increased the profitability of the fishery, which by that time had already introduced push nets all along the coast. Landings in Europe peaked around 1976 at 2,700 t. From 1982 to 1995, decline in recruitment and collapse of exports to Japan made the fishery less attractive. In 1995, a surge in demand from the Chinese market on a then dwindling stock brought a large increase in prices, levelled only by the Asian financial crisis in 1997 and the malachite green residues issue in 2006. Combined analyses from various source of data shows that landings are now below 100 t. The increasing profitability despite the severe decline in recruitment raises the possibility of an ‘economic’ Allee effect. This effect and the changes brought by CITES and European regulation are discussed along with the requirements needed for achieving a sustainable state in the glass eel fisheries.

INTRODUCTION

After a transatlantic migration from the Sargasso Sea to the European and North African continental shelves, European eel *Anguilla anguilla* larvae begin their metamorphosis into glass eel. These juveniles make the final migration from the continental shelf (TESCH, 1977) to estuaries using behaviour patterns adapted to using tidal stream transport (GASCUEL, 1986; WIPPELHAUSER and MCCLEAVE, 1987). The glass eels are initially transparent, develop pigment and resume feeding on entry to estuaries (ELIE *et al.*, 1982), becoming the small yellow eel which colonise inland and coastal waters (MORIARTY, 1986a).

The seasonal inshore migration of glass eel (BERTIN, 1951; TESCH, 1977) occurs in winter (ELIE and ROCHARD, 1994). The distribution area spreads from North Africa (Morocco) to Northern Europe (Norway) including the Mediterranean basin (Schmidt, 1922). Within this distribution, the main fisheries are concentrated in the western Mediterranean, Portugal, the Bay of Biscay, Ireland and the western coast of England (DEKKER, 2003). In these areas, the concentration of glass eel in estuaries is large enough to enable glass eel fisheries to be a profitable activity.

The glass eel fishery in France employed 1,050 marine fishermen and 240 fluvial fishermen in 2006. Access to an estuary is restricted by the requirement to purchase a licence. Turnover of a typical boat is around € 100,000 with glass eel fishing activity representing from 62 to 100 % of this annual turnover (ICES, 2007).

Glass eel migrations of lesser importance are known to occur in the Channel (STRUBBERG, 1908; TESCH, 1977), Skagerak-Kattegatt (HAGSTRÖM and WICKSTRÖM 1990), central and eastern Mediterranean (SCHMIDT, 1922; DEKKER, 2002). In these areas, glass eel migration has historically supported various trap and transport operations for restocking purposes.

Eel aquaculture is based on wild stock since European eel reproduction is not currently feasible. Japanese researchers have succeeded in reproduction and breeding of larvae to the glass eel stage but no commercial hatchery exists as yet because of the financial costs of artificial reproduction (Tanaka et al., 2001). The decline in glass eel recruitment for the three main species (GUÉRAULT *et al.*, 1986; MORIARTY, 1986a; MORIARTY and DEKKER, 1997; DEKKER *et al.*, 2003), has brought large changes in the international glass eel trade. The Japanese people have a long tradition of eating eel, especially as *kabayaki*, roasted eel using a secret soy sauce. In the late 1960's, the decline in catch of Japanese glass eel meant that local supplies were no longer sufficient for the Japanese market. In response to this problem, live European glass eel were imported to stock the eel farms. The strong Japanese demand has switched to European rather than American glass eel because of the greater rearing potential and volume of European landings (Bonhommeau, Patrick, pers. com.). It has in turn modified the profitability of European glass eel fisheries, in a European context where most eel fisheries are now dwindling to a fraction of their past catches.

The decline in glass eel recruitment has led to the inclusion of European eel in Annex II B of the Convention on International Trade on Endangered Species of wild fauna and flora (CITES). From 2009 onward, exporting countries will have to prove the sustainable exploitation of each lot traded outside Europe. It has also brought the European Commission to adopt a new regulation (1100/2007), which will bring large changes in glass eel trade. Glass eel fisheries will have to reserve a part of their catch, from 35 % in 2009 to 60% in 2013, for restocking within Europe. In addition, national management plans will have to demonstrate the sustainability of human impacts.

In this context, we provide an appraisal of the European glass eel market, which has not been reported recently (but see for instance ELIE AND FONTENELLE, 1982; CASTELNAUD et al., 1994). Starting from 1900, we provide an overview of the changes brought in the glass eel fishery, try to rebuild a series of landings and trade data from the best available information, and finally try to provide the best description of the current state of glass eel fisheries and trade.

From this overview we analyse the risk of economic extinction of the species and give a hint of the possible consequence of the new regulation on trade, and analyse the bases of a sustainable management strategy.

MATERIAL AND METHODS

Analysis of trade data.

A database on glass eel trade is built from various sources of trade data :

- The French Customs (OFIMER) with 580 annual data from 1962 to 2006 reporting trade towards 32 countries,
- The European database EUROSTAT; 12567 monthly trade data from 1995 to 2007 towards 23 countries, (Some marginal export destination representing small quantities were not taken into account)
- Daily shipping records from an independent French glass eel trader which were converted into 256 annual mean export prices and total quantity towards 16 countries from 1961 to 2005 (Bonhommeau Gilbert and Patrick, Somme et Loire, Saint Nazaire, France, personal communication),
- 24 annual glass eel prices from the Asturian market from 1983 to 2006 (Estibalitz Diaz, AZTI, personal communication).

Prices are corrected for French and Spanish local inflation to an equivalent to 2006 values for French and Spanish currencies). All prices thereafter correspond also to the equivalent price in 2006.

Except for the French trade, trade data do not discriminate between eel stages, i.e., glass, yellow or silver eel. They only indicate the process applied while preparing the eels : frozen, smoked, alive, or fresh. Based on prices, destination, total weight and process, some monthly or annual records are identified as being constituted of either glass eel or yellow/silver eel. For instance, regular trade of small weight and high value between France and Germany, Mexico or Asia can in most of cases be identified as glass eel shipping. In contrast, sales of low value and large weight can be ascribed to grown eel. All trade towards Italy was identified as being grown eel. While glass eel have been known to be exported to the Naples area for food consumption prior to the 1980s, this market has not continued because of the ban on glass eel fishing in Italy. However, since the greater part of the trade has always been of small eels caught in the French Mediterranean lagoons, and sent to Italy for aquaculture purposes, and since those eels have always had a greater value than those sold for food consumption in the European market, a unique category was chosen for Italy.

The trend in glass eel prices is extracted from the previously selected values and compared between the various sources of data. A general linear model is fitted to both import and export data using a weighting according to the trade volume. It is then used to compute the annual mean price per destination. For data where an annual price per destination could not be calculated, the mean or weighted mean price of the four series has been used.

A general trend for the mean price of yellow/silver eel is also calculated. Missing years are interpolated and the whole series is smoothed. As in the case of glass eel, import and export prices are mixed in the analysis.

The share between glass eel and grown eel among values previously identified as a blend of glass eel and grown eel data is calculated according to the mean annual price of both stages. Commercial data are then used to reconstruct a time series of glass eel export towards various countries.

Analysis of catch data.

The annual landings per marine area have been computed both in quantity and value from 1895 to 1983 from the French statistics of the marine administration (BOUDE, 1987). The records start in 1902 in the Atlantic region. They are compared to historical trade series available (GANDOLFI HORNYOLD, 1933; GANDOLFI HORNYOLD, 1936) and contemporary expert estimates of the volumes landed by the fishery. (ARNE, 1908; POPELIN, 1971; CASTELNAUD *et al.*, 1994; CASTELNAUD, 2000; 2002; LÉAUTÉ and CAILL-MILLY, 2002).

More recent statistics collected by the administration for small boats from 2000 to 2006 have been analysed. These have been discarded as incomplete or irrelevant. When compared with local records from other sources, the estimation of the real landings is underestimated by a factor between 2 and 10.

Time series of landings

An attempt has been made to rebuild the possible series of landings of glass eel from trade and catch data, by using expert estimates of the volume of export in 1975 and by correcting the volume of trade towards Spain to account for the underreporting of the trade of frozen glass eel.

Actual European market

The mean value of 1996-2006 EUROSTAT trade statistics have been used to analyse volumes exchanged across Europe and towards Asia.

RESULTS

For the OFIMER database, 129 annual exports or imports have been identified as eel, 155 as glass eel, and 296 as a blend of glass eel and eel data. In the EUROSTAT database, 2,263 monthly exports or imports have been identified as glass eels, 6,474 as eel and 3,830 as a blend of glass eel and eel.

The glass eel prices show an exponential rise from around 5 € in the 1960's to a maximum of € 500 per kilogramme in 2005 (Figure 1). The peak in 1969 corresponds to the onset of Japanese buying on the French market.

The mean eel price drops abruptly from 5 to 1 €/kg in the 1970's due to the import to Japan of large volumes of eel from New Zealand . From this low level, the price rises back progressively to € 7 at the beginning of the 1990's (Figure 2). A more detailed analysis from the EUROSTAT database shows that the prices are highly variable within a single year ranging, for instance, from € 1 to 13 per kg in 1995.

The data identified as a blend of glass eel and grown eel represent 56 % of the total glass eel export weight. For some years, the Spanish trade, which represents the largest volume, has been identified as a blend. Indeed for these years, large volumes of exports are recorded at a low price. This might have been the consequence of the trade of frozen glass eel sold at a lower price for the food market, but also could have been the consequence of a blend of glass

eel and yellow eel in the exports. However, the analysis of the glass eel trade towards Spain shows the consistency of the time series and of the calculations of glass eel volumes.

The OFIMER and EUROSTAT statistics series show consistent results during their common period. The trade statistics from OFIMER show that official exports have decreased from a maximum of 1,200 t in 1978 to less than 100 t in 2006 (Figure 3). Two phases of export towards Asia are reported in the series. The first, to Japan from 1969 to 1980, corresponds to the first increase in prices and the second, towards China via-Hong-Kong which started in 1994, was responsible for the second rise in prices (Figure 1).

The landings collected from the marine administration are, as in the case of commercial data, a blend of glass and yellow eel (Figure 4). The landings are detailed precisely by maritime region. Over the period 1902 to 1938, they display a steady catch, with values ranging from 86 to 280 t. After World War II, in 1947, a first peak in catch (444 t) is reported. It is followed by low landings in the 1950's and a resumption after 1958.

These landings are far lower than the commercial data on the glass eel trade collected by the railway administration before 1936. For instance, in 1924 the total landings of both glass eel and eel are estimated at 168 t while the export of glass eel by train is estimated as 420 t. Similarly, marine Landings data are also underestimated in the 1970's. After the 1975 "official" opening of the Spanish trade market, there is more consistency between these two sources but landings data remain about half the true size of the rail trade reported.

A series consistent with contemporary expert estimates (Table 1) has been built to generate a more realistic time series than using underestimated data. Different coefficients have been applied to correct the export towards Spain, considered as biased, by expert estimates. The final export towards Spain covers both Spanish and French consumption. These coefficients have been assessed as following: before 1936, the export statistics are considered accurate, from 1965 to 1973 we assume a constant trade of 1,000 t towards Spain to be able to reach 1970 level (Table 1). From 1974 to 1983 the export towards Spain is multiplied by 3, from 1980 to 1997 export towards Spain multiplied by 1.3, after 1998 export towards Spain multiplied by 1.2 (Figure 4).

The EUROSTAT statistics provide an overview of European trade. Most of the European trade goes to Asia with a mean value of 123 t per year during the period 1996-2006. In addition, 38 t are transported by truck to northern Europe mostly for aquaculture. Out of this 38 t, the weight of glass eel used for restocking is estimated as 3 t (ICES, 2007). These statistics also describe well the internal trade between glass eel traders, with large exchanges to and from Spain, and to a lesser extent, cross trade between the continent and the UK, glass eel being exchanged to constitute lots before plane shipment (Figure 5).

There is some inconsistency between French, Spanish and UK EUROSTAT datasets. The sum of French and Spanish export to the UK, minus the export from the UK (net export) ranged from -21t in 2000 to 20t in 2004.

Discussion.

An historical overview of glass eel fisheries and trade

The development of the glass eel fisheries may be divided into five phases :

1850-1936 : development of commercial fisheries

Glass eel fisheries in France were already active at the end of the 19th century with landings estimated around 200 t (VAILLANT, 1889). Fishermen used hand nets from the banks of the river or from an anchored boat (ELIE and FONTENELLE, 1982; CASTELNAUD *et al.*, 1994) and the destination of glass eel was mostly local. In 1908, the glass eel fishery was already well developed in the south of France due to the proximity of the Spanish market (ARNE, 1908). The volumes exported by train from the two southernmost regions, Landes and Basses Pyrénées were 73 t in 1906. Some years later, in 1923 they were still at the same level, (GANDOLFI HORNYOLD, 1933), suggesting that the southernmost fishery was already fully developed by the beginning of the 20th century. In fact, from this southern point, the market has progressively expanded along the Atlantic coast, leading to the development of glass eel fisheries that were already at this time shifting from traditional and local to commercial ‘international’ activities (GANDOLFI HORNYOLD, 1933; GASCUEL, 1987).

From 1920 to 1936, a precise description of the weight of glass eels transported by train and of volumes sold at the San Sebastian market, permits the building of a time series of glass eel landings (Figure 4, GANDOLFI HORNYOLD, 1933, 1936). From both series, it is possible to conclude that total glass eel production has varied from 531 t (1925) to 199 t (1936). The level of production from the marine administration, which sums glass eel and yellow and silver eel reported for the Atlantic coast, is steady around 140 t, so this source of data is clearly underreported and completely irrelevant (Figure 4). The price values from the marine administrations have been steady around € 15 for half a century. Their analysis against other data series collected in the 1960’s prove again that they are too high to be reliable.

1936-1969 : the Spanish ghost trade and transition to push net fisheries

After 1936, the Spanish war and Franco’s regime closed the Spanish borders and hence restricted the trade of eel to Spanish buyers. This market “officially” disappeared until 1975 although smugglers still supplied the Spanish Basque market and buyers crossed the frontier. However, international troubles at that time suggest that the glass eel fisheries were probably restricted to a local market until 1945.

From 1945 to 1969 the main export routes were for glass eel consumption in France, Spain and Mexico. The fishery progressively shifted from hand nets to push nets, which were allowed by a decree in 1952 (ELIE and FONTENELLE, 1982) and extended in many areas on the Atlantic coast in 1958 (CASTELNAUD *et al.*, 1994). The attractiveness of the glass eel prices remained low for this period. Our earliest reliable records indicate that the market price was between € 6 and €12 (2006 equivalent values) per kg before the onset of the Japanese market. Fishing power of glass eel fishing boats also increased during the 1960s and ’70s (ELIE and FONTENELLE, 1982).

1969-1979: golden years and first onset of Asian market

The change in fishing practises initiated during the 1960's resulted in a large increase in glass eel landings. Commercial statistics (Figure 4) and expert estimates (Table 1) agree with observation that landings peaked around 1976. The landings of glass eel in Europe at their greatest were estimated at 2,700 t, with France at more than 2,000t, Spain 200 to 300 t, Portugal 220 to 250 t, the United Kingdom 40 to 50 t and Morocco 10 to 30 t (ELIE and FONTENELLE, 1982). An analysis of the catch in the Gironde River (Figure 6) shows that local landings could already have been diminishing in the 1960's, and that the apparent increase of landings in the 1960's and 1970's might be both the consequence of a large increase in effort on a fishery turned profitable by the international demand and the onset of the Japanese market in 1969, and also a more accurate reporting of catches (see below).

During Franco's regime, the glass eel trade to Spain was forbidden and does not appear in the official trade statistics until 1975. However, it was probably the largest trade route and represented around 80 % of the total (POPELIN, 1971). After Franco's death, this trade route appears in the official statistics (Figure 4), but the level of exports, reported from 378 to 555 t between 1975 and 1979, is surely still underestimated by factor 3. Indeed, POPELIN (1971) indicates that this level was already 1,070 T in 1970.

Export for the consumption market also took place to Mexico and Venezuela. France exported glass eel to many countries, either for restocking purpose (Germany, the Netherlands, Russia, Poland), or for use in intensive or extensive aquaculture (Denmark, Germany, United Kingdom, Benelux). It is noteworthy that Germany was also a transit country for live glass eel to restock eastern European countries such as Hungary. The market for live glass eel represented probably 10 to 20 % of the total trade.

1980-1994: landings falling down

In the 1980's, the European glass eel recruitment suddenly declined. Japan ceased to import glass eel from France in 1982 because of the high mortality rate of exported glass eels. These mortality rates were mainly due to new French traders who wanted to export live glass eels but had no skills in maintaining glass eels alive for more than 30 hours in aircraft. In addition, Japanese aquaculture had progressively shifted to Taiwan with lower handling prices, and the Asian market resumed only in 1994. The opening of the Chinese market at that time enabled Japanese industrialists to invest massively in China, whether in huge extensive farms and transformation industries. These investments were mainly motivated by the huge space available that Japanese farms could not afford, by low labour costs, and by financial incentives to invest in China. The number of fishing licences had dropped slightly at that time indicating that during this period of still high abundance, the fishery was probably less profitable (ICES, 2007). The export towards Spain is more accurately covered than in the preceding period. The sum of local consumption and under-reporting in trade statistics is estimated to have been about a third of the total trade.

1994-2006: Back to the Asian market

From 1994, glass eel landings have continued to decline, but glass eel prices have shown an unprecedented rise. Two major events have disrupted the trend in glass eel price: in 1997, the Asian financial crisis; and in 2006, the export closure of Chinese eels to many markets due to the presence of residues of malachite green) in the flesh of eels (ANON. 2008).

. The highest prices were attained in 2005 because of the coincident high demand of Spanish, North European, and Asian markets. Two other factors may have played a key role in this price explosion. Firstly, the licence regime of glass eel imports has been opened to Chinese farmers. They were thus allowed to import glass eels directly and were not constrained to buy only from authorized Chinese importers. Second, the year 2004 was a very low recruitment year in Europe (the landings fell below 100 t in France for the first time), Chinese farms therefore could not produce enough eel to supply the Japanese market. This led in the following year (2005) to strong competition between Chinese farms to fill their ponds and to the peak in price.

The current trade across Europe

Three countries are the main producers and traders of glass eel: France, Spain, and the United Kingdom (in order of importance). Portugal is also a producer as well, despite the fishery is being illegal. Portuguese glass eels have a high attractiveness since they are of a smaller size than in other countries and are caught mostly with hand nets. In 2006, the export routes are to Asia (50%-36t of live glass eels), Northern Europe (44%-32t of live glass eels), Spain (4%- of 3t glass eels for consumption) and restocking (2% or 1t of live glass eel).

When compared with mean 1996-2006 EUROSTAT trade statistics (Figure 5), the volume of trade has clearly decreased due to the shortage in resource, and that part of the glass eel trade with a final use in aquaculture has progressively increased to reach 94 % in 2006.

From 2000 to 2006, the statistics available from the database for small vessels add up to between 57 and 76.8 t. These values represent only half of true landings. The catch is largely underreported, both by understatement of reports and lack of computation, so we considered those data as not relevant to analysis. The latest accurate estimation of the size of landings in the season 2003-2004 indicates that total landings were 92.5t. This level is consistent with the total export from France from EUROSTAT 97t or OFIMER 92t. One must be reminded that a statistical year from EUROSTAT or OFIMER mixes two glass eel season which last from October to March, precluding a full comparison of the two series.

The network for glass eel trade is complex since there are several products and markets: dead glass eel for food consumption, living glass eels for Chinese and Northern Europe aquaculture and for restocking. Few companies share these markets, and there is a significant black and under-reported dealings.

The frozen glass eel market is the most opaque part of the market as it is used to replace dead glass eels with glass eels caught from poachers. Prices for that market are lower than the price for living glass eels as illustrated by Spanish trade series (Figure 1). The frozen glass eel market facilitates the sale of dead glass eel arising from fishing injury during their preparation for the Asian market.

The Illegal fisheries present a double advantage for unscrupulous traders. Firstly, buying prices are lower than official prices since the traders risk detection when buying and can bring pressure on illegal fishermen to reduce prices. Secondly, the quality of “hand-caught” glass eels is far better than those caught by professional fishermen using towed nets and thus mortality rates are far much lower using this product.

In 2004 the part of glass eel purchased from “non licensed fishermen” was estimated as 16% but this value did not include glass eel caught by poachers and sold by fishermen. The volume of illegal trade is estimated between 20 to 40 % by our contact trader (Bonhommeau com. pers.).

It is thus possible that the frozen glass eel shipments to Spain and for other local consumption are underestimated in the official statistics. This market, initiated during the Franco years, still remains opaque and is the highest source of uncertainty over the true scale of the glass eel trade. However, given the high prices attainable for living glass eel, and that live glass eel outnumber dead glass eel dead after fishery, (mortalities reach 40 % in the case of the most impacting fishery in the Vilaine and the Loire), major under-reporting through sale of dead frozen glass eel seems unlikely in the recent period. An underreported trade volume of around 20 % would be plausible and consistent with the correction applied to export statistics, also estimated at about 20 % of the total trade from 1998 (Figure 4, corrected trade series).

PROUZET and NIELSEN (in press) have provided data from T. Nielsen’s own inquiry among the traders. The volumes estimated for shipment towards Asia or Northern Europe agree well with our series. The main difference is the volume of glass eel used as local consumption, for instance 100t estimated in 2002 where our trade statistics to Spain only sum up to 12t.

Glass eel prices maintain profitability of fisheries

Standard economic theory predicts that exploitation alone is unlikely to result in species extinction because of the escalating costs of finding the last individuals of a declining species (CLARK, 1990; COURCHAMP *et al.*, 2006). For eel, there are 3 reasons for concern that this might not apply. Firstly, the costs of finding the fish do not increase since the fishing methods have remained unchanged since the 1960’s. While increasing oil prices have impacted on fishermen’s income, glass eel fisheries require little power and fishing grounds are close to home. Secondly, the international demand described above has led to an explosion in prices (Figure 7). The similarity between the prices extracted from various sources of data shows that the glass eel price is set by the worldwide demand (Figure 1). Hence, the sharp decrease in volumes has been more than counterbalanced by the increase in price. The price paid to the fisherman at the beginning of 2008 was 750 € per kilo. A fisherman fishing 0.5 kg per day will have a turnover of 11 250 € per month, and most catches are larger than this. Thirdly a possible ecological Allee effect has been pointed out in eel as the recruit to spawner ratio has been decreasing since the 1970’s (DEKKER, 2004; ICES, 2005) .

We postulate that unless a proper mechanism of regulation takes place, as rarity makes the European glass eel more attractive, glass eel fisheries might remain sufficiently efficient to drive the species to extinction, as a large part of the European resource is concentrated in the estuaries where glass eel fisheries occur. Such a phenomenon is called an Anthropogenic Allee effect (COURCHAMP *et al.*, 2006).

An insight on the changes to come

From the actual level of 2% the percentage of glass eel used for restocking will have to increase to 35 % in 2008 and then to 60 % in 2012. The maximum level affordable for European aquaculturists is 700 € (PROUZET and NIELSEN, in press). Prices can reach a higher level in Asia due to low labour costs, as illustrated by prices already reached in 2005.

The affordable price for those buying for restocking is probably less than 100 €/Kg. The difference in price between aquaculture and restocking markets will clearly affect the profitability of glass eel fisheries, and prices for restocking will surely be too low to maintain a sufficient profitability of fishing activities. A further reduction in glass eel available for aquaculture will provoke a further rise in price, and an incentive for a black market, placing even greater pressure on availability of glass eel for restocking.

ICES (2005) argued that there was a risk of an Allee effect or compensatory mechanism on the spawner recruitment curve, and that because of this risk transporting glass eel throughout Europe would be an option to enhance the stock in a short while, and overcome the compensatory trap. However, this analysis did not account for the fact that the current level of landings was already too low to permit a pan European restocking as proposed by (MORIARTY and DEKKER, 1997). The next year ICES drew up a decision tree, whose first choice was the demonstration of a local surplus. One outcome of the evaluation of risks associated with restocking, is indeed that sending glass eel for restocking is justified, if it is concluded that the global survival at the stock level will be increased.

Though the recruitment level in the French estuaries is still high when compared to rest of Europe, yellow eel densities have been now diminishing for more than two decades (Briand, unpublished), and from our point of view it is improbable that current recruitment could lead to the achievement of carrying capacity in estuaries.

The European commission has set up the objective of restoring the eel stock at a safe biomass level of 40% of its pristine state in the long term, i.e. several eel generations. To reach this objective, each basin will have to enhance the spawner output, and the European result will have to achieve a spawner escapement larger than the replacement level, to reverse the declining trend in recruitment. The CITES listing of eel will have further consequence for glass eel trading. Each lot of glass eel traded outside Europe will have to be accompanied by a certificate showing that the commercial use of those glass eels does not endanger the stock.

Within each basin, anthropogenic mortalities will have to be restricted to a level permitting a level of escapement larger than the replacement level, and permitting the achievement of the long term goal. This means that achieving proper management of a glass eel fishery requires analysis of other sources of mortalities in addition to the glass eel fishery mortality (BEAULATON and BRIAND, 2007), in order to get a picture of the total mortality in a basin. A pan European analytical assessment of the stock will also be necessary to compute the mortality level permitting the achievement of the long term objective.

Conclusion

Checking and cross checking different sources of data is a long and tedious task. So in the end, describing only a part of the real total trade might be considered a poor result. Due to the limited quality and quantity of data available, it would have been unrealistic to attempt to check catch and glass eel trade statistics against each other, in a single long series covering the XXth century. Nevertheless, the analysis brings knowledge of the increasing quality of trade data, and allows a picture of evolving changes in landings, and trade.

Listing the European eel in Annex IIB of the Convention on Trade of Endangered Species (CITES) and the European eel Management Plans that will force European Union member states to allocate 60% of their glass eel catch to restocking by 2013 are a necessity for glass

eel fisheries, even more than for grown eel fisheries. Indeed, the reduction of glass eel landings has been compensated for by higher market prices to such an extent that fishermen have kept on harvesting, thus increasing the pressure on stocks.

In the short term, a further increase in prices is highly probable on the international glass eel market as the quantity of glass eel available decreases. In Europe, the combination of reduced recruitment and the lower price affordable for restocking than for the East Asian market or for EU aquaculture will probably not maintain the profitability of the glass eel fishery. As a consequence, a strong incentive for a black market will probably develop.

To our mind, as the carrying capacity of French basins is no longer achieved, achieving and controlling a sustainable local anthropogenic impact is probably more important than building up a massive export of glass eel throughout Europe, because of the risks associated with the latter. Either way, a large change in the glass eel fisheries is probably to come.

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Table 1 : Expert estimates of landings and trade volume.

Year	Quantity Marine Fishermen (T)	Quantity fluvial Fishermen (T)	Total landings/ export	Description	Reference
1895			200 t	France	(VAILLANT, 1889)
1906			73 t	Landes (South of France only)	(ARNE, 1908)
1927			350.6	St Sebastian Market	(GANDOLFI HORNYOLD, 1936)
1927			362.5	Export by train from the Loire to the Bidassoa	(GANDOLFI HORNYOLD, 1933)
1933			202.6	St Sebastian Market	(GANDOLFI HORNYOLD, 1936)
1933			271.3	Export by train from the Loire to the Bidassoa	(GANDOLFI HORNYOLD, 1933)
1970	450	895	1345	Loire to Adour (Brittany not included)	(POPELIN, 1971)
1976	1455	700	2150	French glass eel fisheries	(ELIE, 1979)
1979	1175	675	1850	French glass eel fisheries	CIPE (CASTELNAUD <i>et al.</i> , 1994)
1983	591		1000 (?)	French glass eel fisheries	CIPE (CASTELNAUD <i>et al.</i> , 1994)
1986	260		500	French glass eel fisheries	CIPE, ((CASTELNAUD <i>et al.</i> , 1994), ((DÉSAUNAY and AUBRUN, 1988)
1989			300	French glass eel fisheries	(CASTELNAUD <i>et al.</i> , 1994)
1997			410.5	French glass eel fisheries	(CASTELNAUD, 2000)
1999	222 t	17.4 + 5.6	245	French glass eel fisheries	(CASTELNAUD, 2002)
2000	180	16.6	196.6	French glass eel fisheries	(CASTELNAUD, 2002)
2004			92.5		Trade overview (Anonymous)

Figure 1.- Trend in glass eel prices

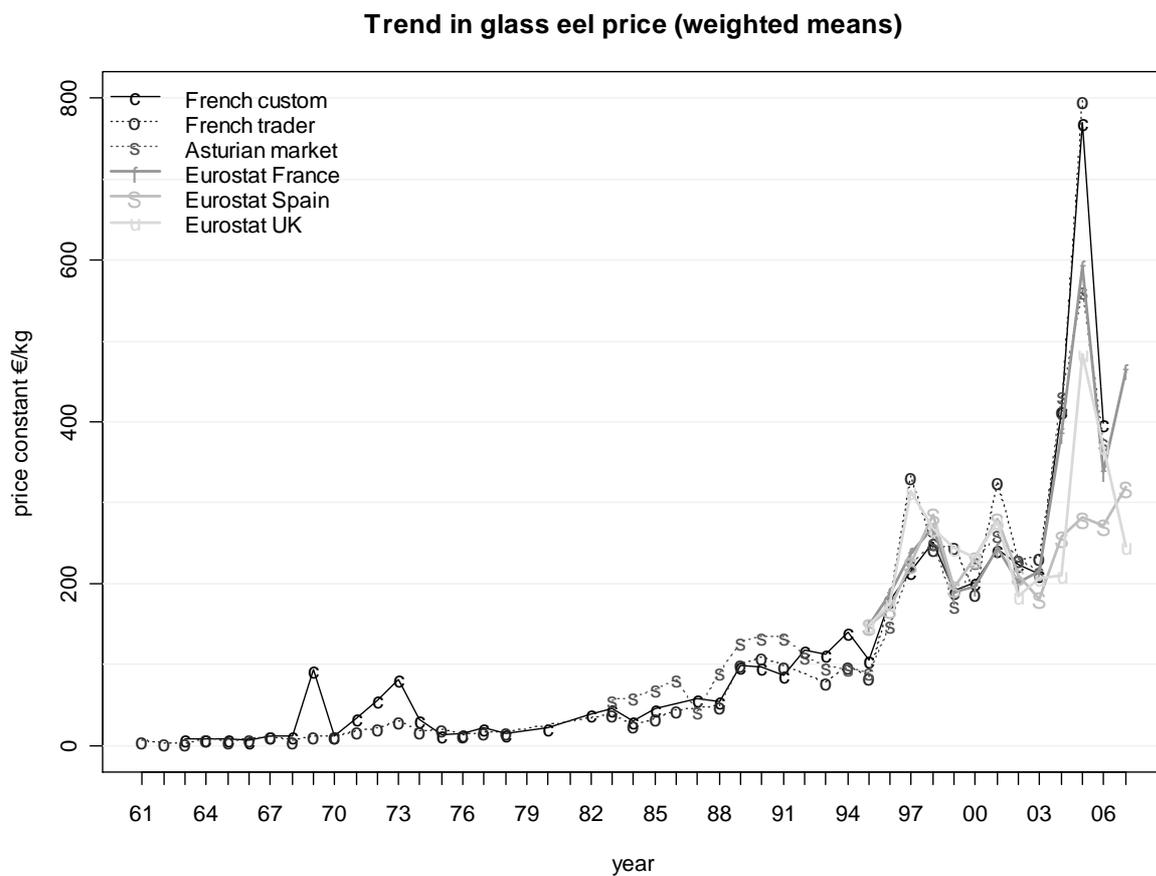


Figure 2.- Trend in yellow eel prices computed from EUROSTAT and OFIMER trade data. Single circles indicate interpolation for a missing value. Solid line indicate the smoothed trend (€ 2006).

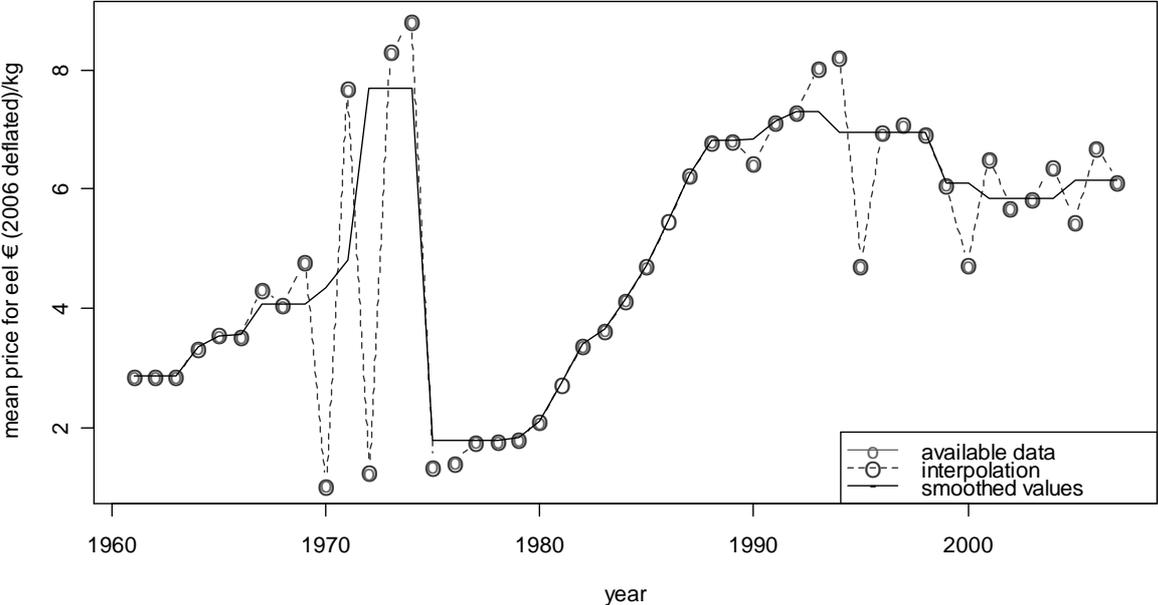


Figure 3.- Historical trend in weights of glass eel exported from France, data computed from OFIMER statistics.

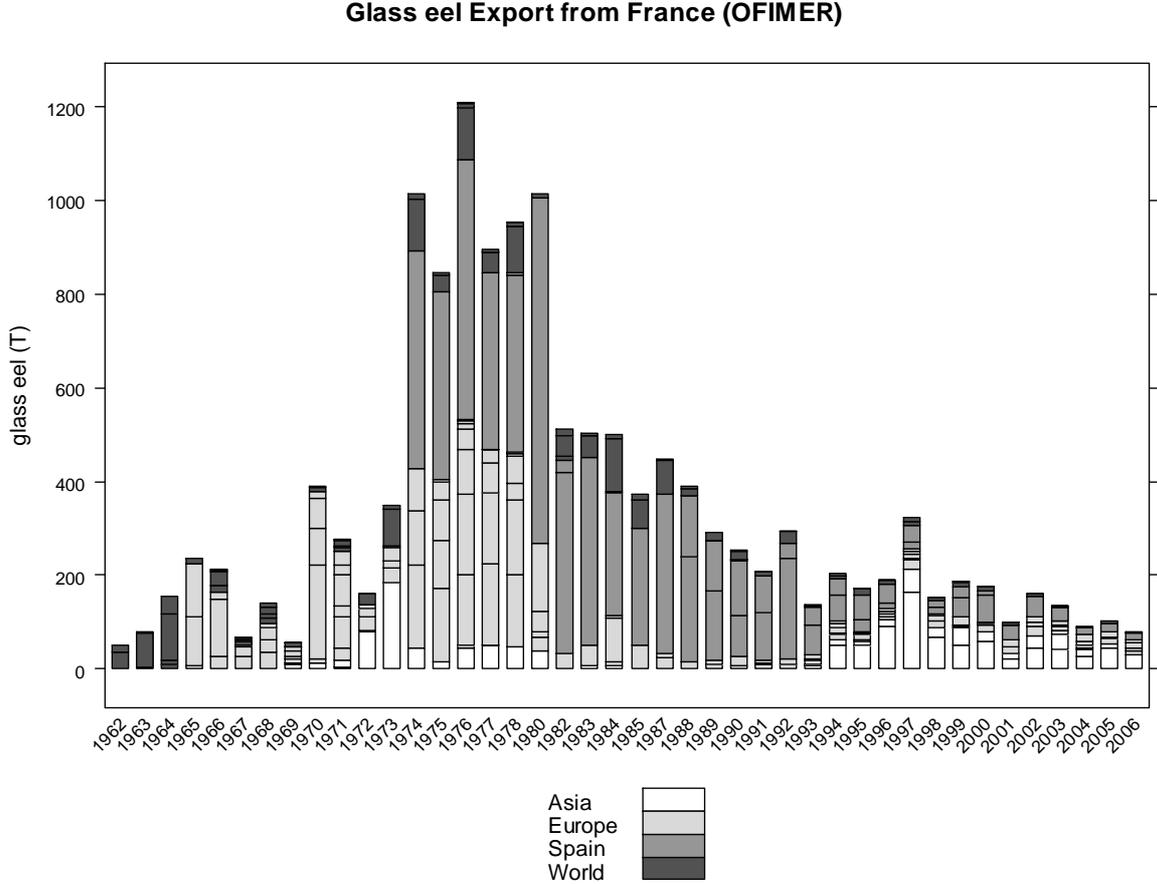


Figure 4. – Landings and export of glass eel from France. Series of landings from the administration and official export from EUROSTAT and OFIMER. The corrected trade series represents an attempt to rebuild the historical landings from corrected trade data.

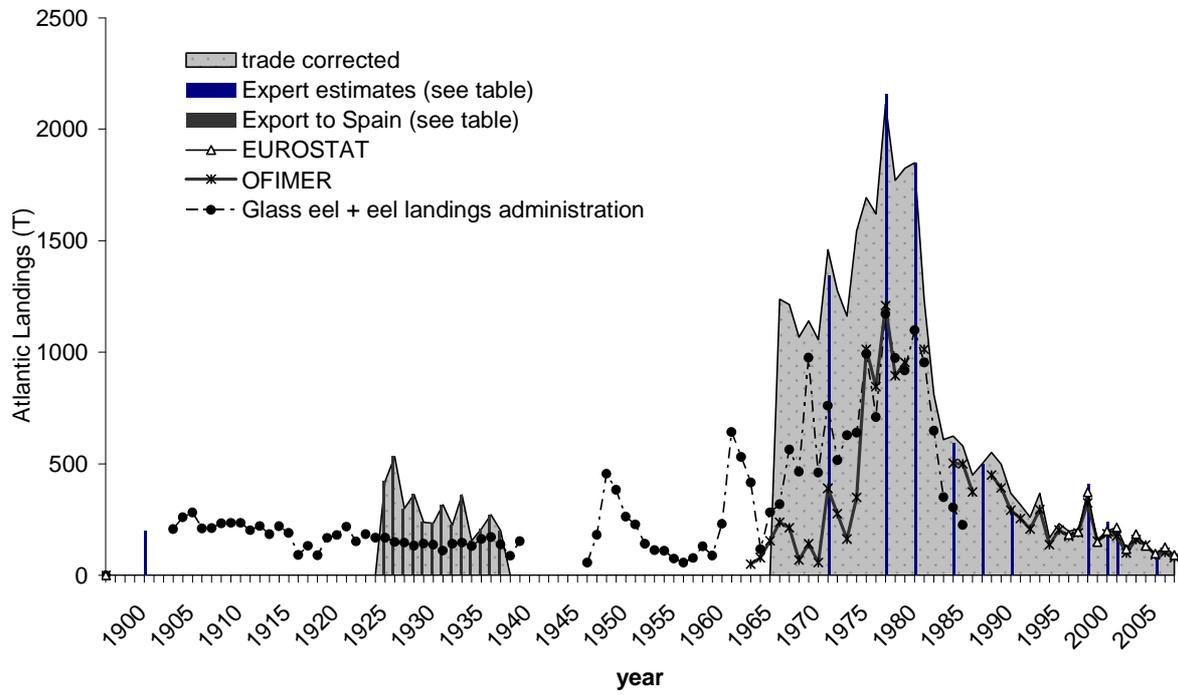


Figure 5.- Mean trade volumes of glass eel (T) 1996-2006 in Europe analysed from EUROSTAT database.

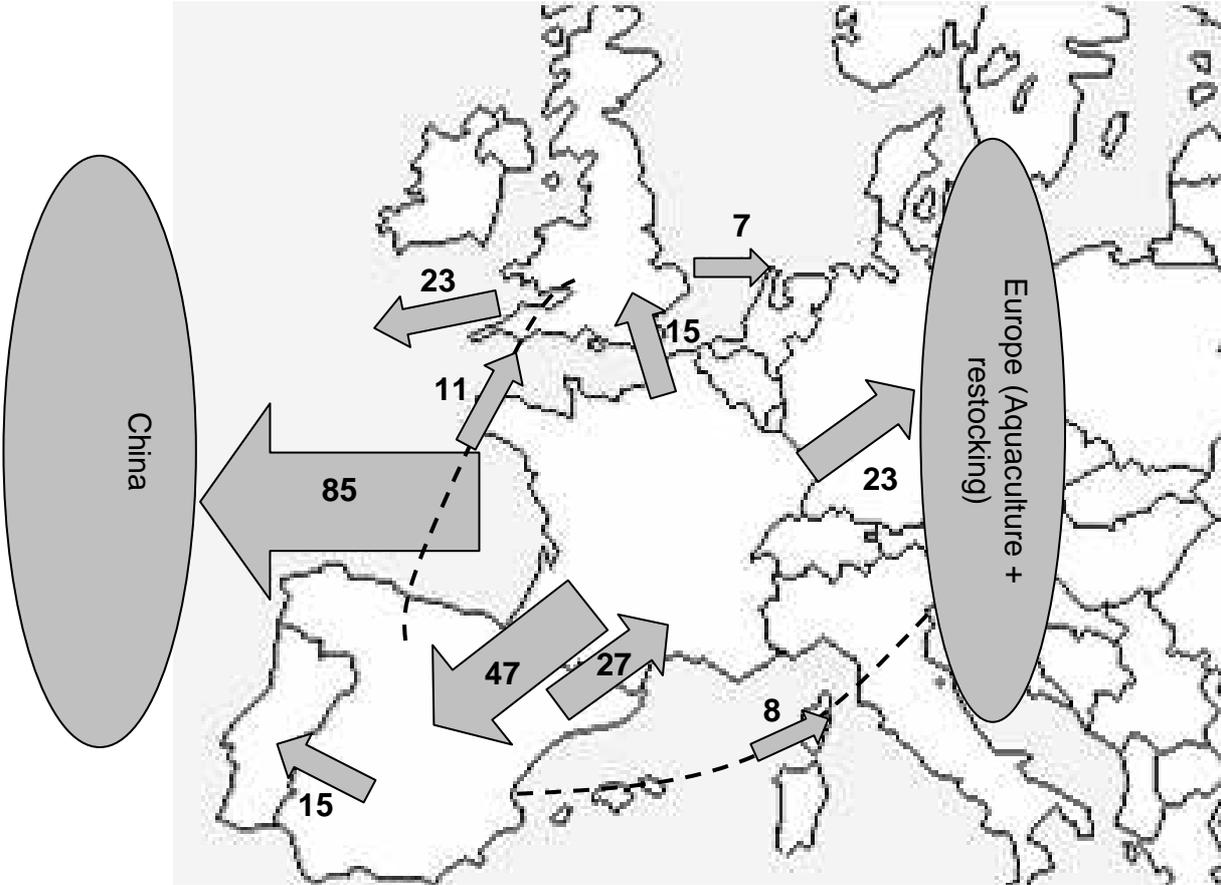


Figure 6. -Trend in glass eel catch in the Gironde, Beaulaton in prep., (analysis of cooperative fisherman data) , expert estimates (VAILLANT, 1889; GANDOLFI, 1933 and 1936; POPELIN, 1971).

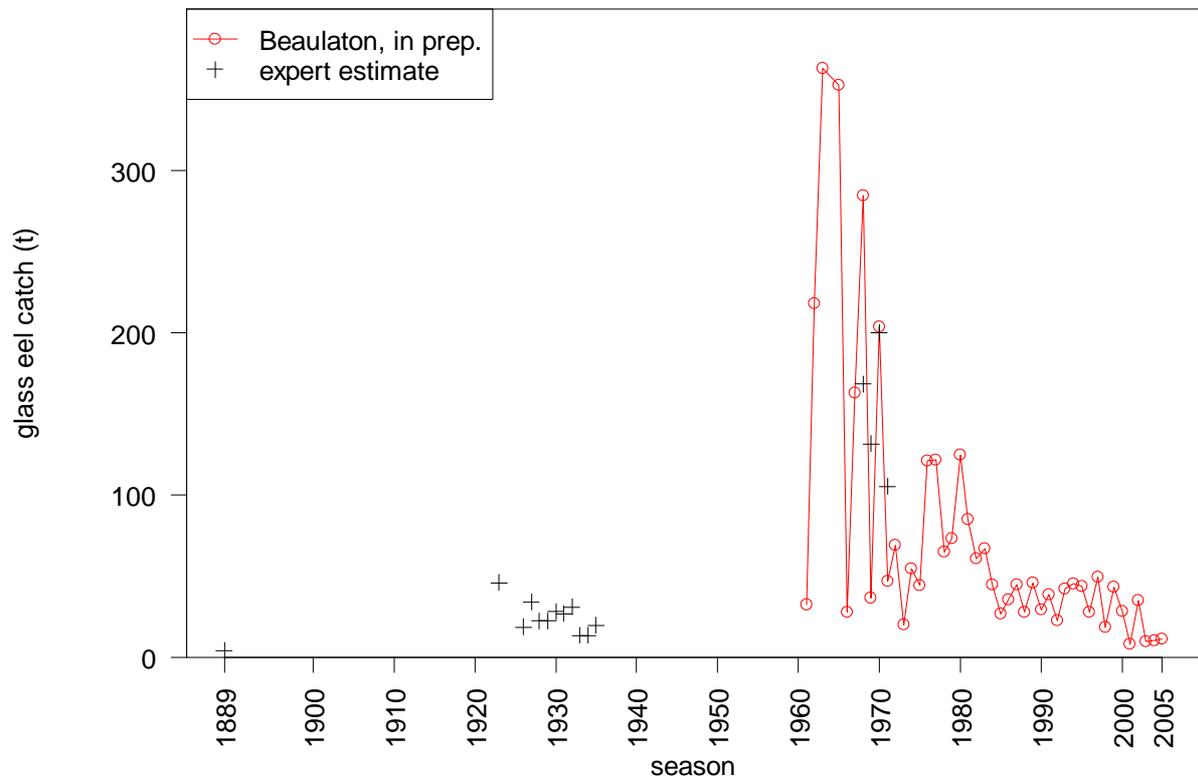


Figure 7.- Relationship between landings, computed from the corrected export data series (see text) and glass eel prices. Prices are corrected from inflation and expressed as 2006 values.

