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Leuven, Belgium, 3–9 September 2008

ICES CIEM International Council for the Exploration of the Sea Conseil International pour l'Exploration de la Mer

FAO FIAT PANIS

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Food and Agriculture Organization of the United Nations
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This publication is the report of the 2008 session of the Joint European Inland Fisheries Advisory Commission (EIFAC) and International Council for the Exploration of the Sea (ICES) Working Group on Eels which was held in Leuven, Belgium from 3 to 9 September 2008.

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Abstract

Available information on recruitment, stock and fisheries continues to support and reinforce the advice that the European eel stock has declined in most of the distribution area and is outside safe biological limits. Recruitment of glass eel to the continental stock continues to decline with no obvious sign of recovery. Current levels of anthropogenic mortality are not sustainable and there is an urgent need that these should be reduced to as close to zero as possible, as soon as possible. All glass eel recruitment series demonstrate a clear decline since about 1980 with no sign of recovery. The Baltic indices of young yellow eel recruitment demonstrate a clear decline since about 1950. The decline in recruitment appeared stronger in the more northern and southern parts of the distribution.

In the 1970s, recruitment of glass eel was still at historically high levels indicating that Spawning Stock Biomass was not limiting the production of recruits at that time. Quantifying the 1970s spawner escapement therefore is the simplest derivation of a restoration threshold. The reference threshold should be set at 100% of the 1970s silver eel escapement where data are available, or in the absence of data, at a percentage (40%) of the notional pristine state which would have existed if no anthropogenic mortalities had impacted on the stock.

It is of utmost importance that existing recruitment monitoring is continued and improved, easing the dependence on commercial fisheries, and extended where inadequate. A radical improvement in the assessment of the current state of the stock, including quantification of the impact of anthropogenic mortalities, is urgently needed. Although comprehensive datasets exist in some river basins, this assessment will not be achievable in most river basins from currently limited data. Data discontinuities are likely to occur simultaneously and unlike in the past, statistical modelling will not be able to correct for this.

The first post-evaluation of the EU Regulation is required by mid-2012. Timely development of stock-wide assessment procedures is required, geared to the data becoming available, while indicating the progress towards recovery of the stock. The absence of any internationally driven requirement to maintain a recruitment dataseries needs to be corrected, with reference to the recommendations of the EU contract 98/076: Establishment of a recruit monitoring system for glass eel. The current legislative instruments including the Eel Regulation, DCR, CITES and WFD do not, either individually on in combination, contain sufficient provisions to ensure adequate data supply for such assessments.

It is suggested that managers define interim targets for the management measures in order to integrate local action efficiently to the aim of long-term recovery of the European eel stock. For this purpose sub-targets defining the magnitude of management measures will be linked with eel sub-targets reflecting the expected short-term response of the local eel population. Eel sub-targets should therefore allow a fairly rapid evaluation of the management measures taken but sensitivity and time response of some of the proposed eel sub-targets would need further investigation before their application would be operational. Eel sub-targets should finally be integrated into the evaluation of the status of the whole eel stock. However it has to be recognized that adequate methods, or modelling approaches, for achieving this are still lacking.

There are few quantitative estimates of pristine (pre-1980) and current silver eel production (Regulation EU 1100/2007) to allow comparisons to be made between systems

and there is few data on the importance of estuarine and coastal populations to overall production. Modelling will be needed to transfer estimates from data rich to data poor systems. Some approaches have been outlined by this Working Group which compliment those presented in previous working groups and in EU SLIME (Dekker *et al.*, 2006).

Implementation of EMPs requires the development of methods to obtain silver eel escapement data. They can include either direct (e.g. mark-recapture) or indirect measures (yellow eel proxies to determine habitat-based silver eel production). Use of direct methods, though preferable in many respects, will be severely restricted by uneven distribution of silver eel fisheries within and between regions, limited fishery monitoring resources and extreme fluctuations in river flows during migratory runs affecting the efficiency of capture methods.

A variety of indirect methods, mostly dependant on yellow eel proxies and modelling, are available for areas where direct measurements of silver eel escapement are not possible and should be extensively used to estimate regional and national silver eel escapement. Validation of indirect methods should be undertaken on an ongoing basis for a network of river systems where reliable direct estimation of silver eel escapement biomass is possible. Direct assessment of silver eel may, however, not inform on the impacting factors that require management, where yellow eel monitoring and assessment would be more informative.

Estimation of effective spawner biomass requires quantification of the adverse effects of contaminants, parasites, diseases, low fat levels, non-lethal turbine damage, along the lines previously proposed for *Anquillicola crassus*, as well as other mortality rates throughout the river basin. Present knowledge does not fully permit quantitative assessment of the effects of these factors on the overall stock. The European Eel Quality Database (EEQD) has been updated with data on contaminants, parasites and fat levels in eel, allowing the compilation of an overview of the contaminant load in eel over its distribution area. The data are highly variable within river basin districts, according to local anthropogenic pollution, linked with land use. Persistently elevated contamination levels, above human consumption standards, are seen in many European countries. Fat content of the yellow eels (i.e. in Belgium and the Netherlands) has decreased over the last number of years, which raises concern regarding the migratory and reproductory success of silver eels. *A. crassus* is spreading further into new areas and new data indicate the presence of the nematode in Canada for the first time.

At present, it is estimated that around 7.5 to 15% of the glass eel catch is used for stocking, either directly or as on-grown eels. Estimates suggest an insufficient supply of glass eel from the total fishery for stocking to full capacity at the European level. Nevertheless, the Regulation 1100/2007 requires that 35%, rising to 60%, of glass eel catches are made available for stocking to enhance the stock. If these percentages were applied to recent annual catches of glass eel, the potential lifetime effect of this increased level of stocking, in the absence of anthropogenic mortalities, could be in the same order of magnitude as current fisheries or eel culture. However, there is a continuing and urgent requirement for robust evidence of the extent to which stocking and transfers on local, national and international scales can increase silver eel escapement and spawner biomass.

The risks remain of disease and parasite transfer via stocked material, both from stocking glass eel and on-grown eels. For example, eels in aquaculture infected with pathogens (viruses, etc.) should not be used for stocking purposes. At least half the countries surveyed (17) do not have formal stocking protocols. These should include procedures to prevent the introduction and spreading of parasites and diseases, and eel should be included in the European fish disease prevention policies to help minimize the risks.

Sufficiently long time-series of glass eel recruitment, covering several periods of the natural climatic oscillation over the North Atlantic, reflect the same periodicity. However, the causal link between climate and recruitment strength, is unknown, as well as where and when ocean environmental factors operate on the eel. As long as the causal factors of oceanic influence are unknown, it is not safe to assume that the decline is explained by climate alone, especially while anthropogenic influences are known to be large and better understood. The fact that oceanic climate may contribute to recruitment variation is not grounds for abstaining from all possible measures to increase silver eel escapement to boost spawning-stock biomass. The recent, prolonged strong decline in eel recruitment is out of phase with the dominating climate cycle, the North Atlantic Oscillation.

FAO European Inland Fisheries Advisory Commission; International Council for the Exploration of the Sea.

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Executive summary

This report summarizes the presentations, discussions and recommendations of the 2008 session of the Joint EIFAC/ICES Working Group on Eels which took place in Research Institute for Nature and Forest, Leuven, Leuven (Belgium) from 3 to 9 September 2008.

In this section, the main outcomes from the report are summarized, a forward focus is proposed in the light of the EU Regulation for the Recovery of the Eel Stock and the main recommendations are presented.

It is clear from this report that recruitment is still low, the stock is in decline and urgent protection measures are required. Significant pressures have been placed on the scientific and technical system to support the delivery of Eel Management Plans by December 2008 with parallel processes and undetermined actions resulting in some uncertainties to be coped with by the Working Group in 2008.

Summary of this report

Reviewing the available information on recruitment, stock and fisheries continues to support and reinforce the advice that the global European Eel stock has declined in most of the distribution area and is outside safe biological limits. Recruitment of glass eel to the continental stock continues to decline with no obvious sign of recovery. Current levels of anthropogenic mortality are not sustainable and there is an urgent need that these should be reduced to as close to zero as possible, as soon as possible. All glass eel recruitment series demonstrate a clear decline since about 1980 with no sign of recovery. The Baltic indices of young yellow eel recruitment demonstrate a clear decline since about 1950. The decline in recruitment appeared stronger in the more northern and southern parts of the distribution. It is recommended to use recruitment indices per area (Baltic, North Sea, British Isles, Atlantic Coast, eastern and western Mediterranean), and to collect and analyse additional data to confirm the spatial pattern, and to establish the reliability and bias in the different sampling methods.

In the 1970s, recruitment of glass eel was still at historically high levels. This indicates that SSB was not limiting the production of recruits at that time. Quantification of the 1970s spawner escapement therefore is the simplest derivation of a restoration threshold. Note that in this case, the full escapement of the silver eels in the 1970s (given the anthropogenic mortality of that time) corresponds to the escapement level advised by ICES (2002). That is: one should either set the reference threshold at 100% of the 1970s silver eel escapement where data are available, or in the absence of data, at a percentage (40%) of the notional pristine state which would have existed if no anthropogenic mortalities had impacted on the stock.

It is of utmost importance that existing recruitment monitoring is continued and improved, easing the dependence on commercial fisheries, and extended where inadequate. A radical improvement in the assessment of the current state of the stock, including quantification of the impact of anthropogenic mortalities, is urgently needed. Although comprehensive datasets exist in some river basins, this assessment will not be achievable in most river basins from currently limited data. Data discontinuities are likely to occur simultaneously and unlike in the past, statistical modelling will not be able to correct for this. Therefore, discontinuities will have to be taken for granted.

The first post-evaluation of the EU Regulation is required by mid-2012. Timely development of stock-wide assessment procedures is required, geared to the data becoming available, while indicating the progress toward recovery of the stock. The absence of any internationally driven requirement to maintain a recruitment dataseries needs to be corrected, with reference to the recommendations of the EU contract 98/076: Establishment of a recruit monitoring system for glass eel. The current legislative instruments including the Eel Regulation, DCR, CITES and WFD do not, either individually on in combination, contain sufficient provisions to ensure adequate data supply for such assessments.

It is suggested that managers define interim targets for the management measures in order to integrate local action efficiently to the aim of long-term recovery of the European eel stock. For this purpose sub-targets defining the magnitude of management measures will be linked with eel sub-targets reflecting the expected short-term response of the local eel population. Eel sub-targets should therefore allow a fairly rapid evaluation of the management measures taken but sensitivity and time response of some of the proposed eel sub-targets would need further investigation be-

fore their application would be operational. Eel sub-targets should finally be integrated into the evaluation of the status of the whole eel stock. However it has to be recognized that adequate methods, or modelling approaches, for doing this exercise are still lacking.

There are few quantitative estimates of pristine (pre-1980) and current silver eel production (Regulation EU 1100/2007) to allow comparisons to be made between systems and there is few data on the importance of estuarine and coastal populations to overall production. Modelling will be needed to transfer estimates from data rich to data poor systems. Some approaches have been outlined by this Working Group which compliment those presented in previous working groups and in EU SLIME (Dekker *et al.*, 2006).

Implementation of EMPs requires the development of methods to obtain silver eel escapement data. They can include either direct (e.g. mark-recapture) or indirect measures (yellow eel proxies to determine habitat-based silver eel production). Use of direct methods, though preferable in many respects, will be severely restricted by uneven distribution of silver eel fisheries within and between regions, limited fishery monitoring resources and extreme fluctuations in river flows during migratory runs affecting the efficiency of capture methods.

A variety of indirect methods, mostly dependant on yellow eel proxies and modelling, are available for areas where direct measurements of silver eel escapement are not possible and should be extensively used to estimate regional and national silver eel escapement. Selection of models should take account of SLIME conclusions (Dekker *et al.*, 2006) and advice given elsewhere in this report. Validation of indirect methods should be undertaken on an ongoing basis for a network of river systems where reliable direct estimation of silver eel escapement biomass is possible. Direct assessment of silver eel may, however, not inform on the impacting factors that require management, where yellow eel monitoring and assessment would be more informative.

Estimation of effective spawner biomass requires quantification of the adverse effects of contaminants, parasites, diseases, low fat levels, non-lethal turbine damage, along the lines previously proposed for *Anquillicola crassus*, as well as other mortality rates throughout the river basin. Present knowledge does not fully permit quantitative assessment of the effects of these factors on the overall stock.

The European Eel Quality Database (EEQD) has been updated with data on contaminants, parasites and fat levels in eel, allowing the compilation of a comprehensive overview of the contaminant load in eel over its distribution area. Results demonstrate highly variable data within river basin districts, according to local anthropogenic pollution, linked with land use. Persistently elevated contamination levels, above human consumption standards, are seen in many European countries. The most important reported impact is seen on the fat content of the yellow eels (i.e. in Belgium and the Netherlands) which has decreased over the last number years and which raises concern regarding the migratory and reproductory success of silver eels. There is growing evidence that *A. crassus* is spreading further into new areas and new data indicate the presence of the nematode in Canada (not included in the EEQD yet) for the first time.

At present, it is estimated that around 7.5 to 15% of the glass eel catch is used for stocking, either directly or as on-grown eels. Estimates suggest an insufficient supply of glass eel from the total fishery for stocking to full capacity at the European level. Nevertheless, the Regulation 1100/2007 requires that 35%, rising to 60%, of glass eel catches are made available for stocking to enhance the stock. If these percentages were applied to recent annual catches of glass eel, the potential lifetime effect of this increased level of stocking, in the absence of anthropogenic mortalities, could be in the same order of magnitude as current fisheries or eel culture. However, there is a continuing and urgent requirement for robust evidence of the extent to which stocking and transfers on local, national and international scales can increase silver eel escapement and spawner biomass.

The risks remain of disease and parasite transfer via stocked material, both from stocking glass eel and on-grown eels. For example, eels in aquaculture infected with pathogens (viruses, etc.) should not be used for stocking purposes. At least half the countries surveyed (17) do not have formal stocking protocols. These should include procedures to prevent the introduction and spreading of parasites and diseases, and the eel should be included in the European fish disease prevention policies to help minimize the risks.

Sufficiently long time-series of glass eel recruitment, covering several periods of the natural climatic oscillation over the North Atlantic, reflect the same periodicity. However, the causal link between climate and recruitment strength, is unknown, as well as where and when ocean environmental factors operate on the eel. As long as the causal factors of oceanic influence are unknown, it is not safe to assume that the decline is explained by climate alone, especially while we know that the anthropogenic influences during the continental life stage of the eel are large and better understood. The fact that oceanic climate may contribute to recruitment variation is not grounds for abstaining from all possible measures to increase silver eel escapement to boost spawning-stock biomass. More research is needed to compare the relative impact of climatic effects and continental factors on reproductive success. The recent, prolonged strong decline in eel recruitment is out of phase with the dominating climate cycle, the North Atlantic Oscillation.

Forward focus

This report constitutes a further step in an ongoing process of documenting eel stock status and fisheries and developing a methodology for giving scientific advice on management to affect a recovery of the European eel. A European plan for recovery of the stock was adopted in 2007 by the EU Council of Ministers. This plan obliges the Member States to develop Eel Management Plans by the 31st December 2008. This will require further scientific advice, on the national and international level. The implementation of these plans, foreseen in 2009, will improve and extend the information on stock and fisheries. Improved reliability and better spatial coverage, however, will also generate a breakpoint in several currently available time-series; correction procedures need to be considered. In 2012, Member States will report on protective measures implemented in their territories, and their effects on the stock, for which methodology is currently limited. International post-evaluation requires that data, gathered within this framework of national/regional management plans, become available to the Working Group, although gaps have been identified where these data may fall short of that required. Establishment of an international database and the development of international post-evaluation procedures for measuring the impact on the stock will be required.

The Eel Regulation and eel management plans, CITES and the DCR for Eel will likely radically change management of eel and the Working Group is therefore entering into a dynamic period in which it is difficult to be categorical on it's future focus. The future focus of the Working Group might concentrate on:

- the assessment of the trends in recruitment and stock, for international stock assessment, in light of the implementation of the Eel Management Plans;
- the development of methods to post-evaluate effects of management plans at the stock-wide level;
- the development of methods for the assessment of the status of local eel populations, the impact of fisheries and other anthropogenic impacts, and of implemented management measures;
- the establishment of international databases on eel stock, fisheries and other anthropogenic impacts, as well as habitat and eel quality related data, and the review and development of recommendations on inclusion of data quality issues, including the impact of the implementation of the eel recovery plan on time-series data, on stock assessment methods;
- reviewing and developing approaches to quantifying the effects of eel quality on stock dynamics and integrating these in stock assessment methods;
- responding to specific requests in support of the eel stock recovery Regulation, as necessary; and
- reporting on improvements to the scientific basis for advice on the management of European and American eel.

Main recommendations

1) Since recruitment remains at an all time low since records began, the stock continues to decline and stock recovery will be a long-term process for biological reasons, all exploitation and other negative anthropogenic factors impacting on the stock and affecting the production/escapement of silver eels should be reduced to as low as possible, until long-term stock recovery is achieved.

2) Assessment of the current and future status of the European spawning stock, in light of implementation of EMPs, including an assessment of the impact of anthropogenic mortalities and management actions, is urgently needed. This process should include:

   2.1) The aggregation of river basin specific data and assessments, into stock-wide assessments;

   2.2) The further development of models to assess compliance with the recovery target and evaluate management actions;

   2.3) The development of coherent local stock assessment procedures;

   2.4) The development of proxies for mortality rates;

   2.5) The international assessment of recruitment and stock trends to assess the response of the stock to management actions.

3) Eel Management Plans and their accompanying data should be made available to the joint EIFAC/ICES Working Group on Eel at the earliest opportunity to facilitate the assessments of the stock.

A toast to Leuven, by WGEEL

There are many ways to measure eel
Length, weight, number found in creel
But if the numbers were your only policy
Don't forget to test the *quality*.

We tried to do this, here in Belgium
Without drinking to delirium
Writing decision trees on table mats
While beer flowed fast from the taps.

Our SPR curves were made from chips
And designed us surveys for big ships
To re-search the uncertain ocean
For leptocephali in motion.

Now -Instead of moving down the text
We back-track from what should come next
So go back to line nineteen-twenty
For targets set when eels were plenty.

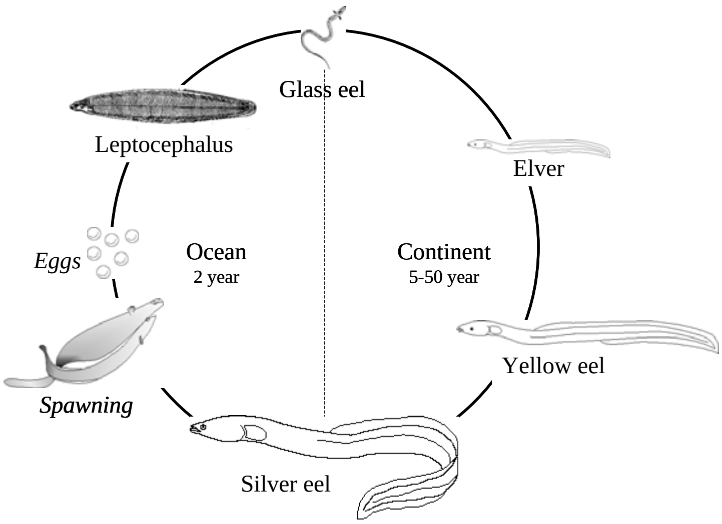
But all this thought is much too hard
For the inebriated bard
So let us re-check the strength of drink
Before our research vessels sink.

Yes, the best beer's rather strong
Best drunk from glasses short, not long
Test them all-find what you like
But don't ride home on a condemned bike.

Or you'll fall on Leuven's cobbled lanes
Tear your *stockings*, or rip your *genes*
So after an evening of perfect libation
Take a taxi home-in *assisted migration*.

Glossary

Eels are quite unlike other fish. Consequently, eel fisheries and eel biology come with a specialised jargon. This section provides a quick introduction for outside readers. It is by no means intended to be exhaustive.



The life cycle of the European eel. The names of the major life stages are indicated. Spawning and eggs have never been observed in the wild.

Glass eel	Young, unpigmented eel, recruiting from the sea into continental waters
Elver	Young eel, in its 1st year following recruitment from the ocean. The elver stage is sometimes considered to exclude the glass eel stage, but not by everyone. Thus, it is a confusing term.
Bootlace, fingerling	Intermediate sized eels, approx. 10–25 cm in length. These terms are most often used in relation to stocking. The exact size of the eels may vary considerably. Thus, it is a confusing term.
Yellow eel (Brown eel)	Life stage resident in continental waters. Often defined as a sedentary phase, but migration within and between rivers, and to and from coastal waters occurs. This phase encompasses the elver and bootlace stages.
Silver eel	Migratory phase following the yellow eel phase. Eel characterized by darkened back, silvery belly with a clearly contrasting black lateral line, enlarged eyes. Downstream migration towards the sea, and subsequently westwards. This phase mainly occurs in the second half of calendar years, though some are observed throughout winter and following spring.

Eel River Basin	"Member States shall identify and define the individual river basins lying within their national territory that constitute natural habitats for the European eel (eel river basins) which may include maritime waters. If appropriate justification is provided, a Member State may designate the whole of its national territory or an existing regional administrative unit as one eel river basin. In defining eel river basins, Member States shall have the maximum possible regard for the administrative arrangements referred to in Article 3 of Directive 2000/60/EC [i.e. River Basin Districts of the Water Framework Directive]."
River Basin District	The area of land and sea, made up of one or more neighbouring river basins together with their associated surface and groundwaters, transitional and coastal waters, which is identified under Article 3(1) of the Water Framework Directive as the main unit for management of river basins. Term used in relation to the EU Water Framework Directive.
Stocking	Stocking is the practice of adding fish [eels] to a waterbody from another source, to supplement existing populations or to create a population where none exists.

Contents

1 Introduction

1.1 The 2008 WGEEL

At the 95th Statutory Meeting of ICES (2007) and the 25th meeting of EIFAC (2008) it was decided that:

2007/2/ACOM15 The **Joint EIFAC/ICES Working Group on Eels** [WGEEL] (Chair: Russell Poole, Ireland), will meet in Leuven (INBO/KUL), Belgium, 3–9 September 2008, to:

(i) assess the trends in recruitment, stock and fisheries indicative of the status of the European stock, and of the impact of exploitation and other anthropogenic factors; analyse the impact of the implementation of the eel recovery plan on time-series data (i.e. data discontinuities). This might also include the establishment of an international database for data on eel stock and fisheries, as well as habitat and eel quality (update EEQD) related data; review and make recommendations on data quality issues;

(ii) develop methodologies for the assessment of the status of the eel stock, the impact of fisheries and other anthropogenic impacts and of implemented management measures; this might include, for example, support for EMPs on the determination of "pristine" spawner production levels and relative contribution of stocking;

(iii) review hypotheses and information on the possible relationships between the European (and American?) eel stock(s), recruitment patterns and climatic and oceanic factors;

(iv) respond to specific requests in support of the development and implementation of the stock recovery Regulation as necessary;

(v) report on progress in work on improvements in the scientific basis for advice on management of European eel fisheries.

WGEEL will report by 16 September 2008 for the attention of ACOM and DFC.

41 people attended the meeting, from seventeen countries (see Annex 1).

The current Terms of Reference and Report constitute a further step in an ongoing process of documenting the status of the European eel stock and fisheries and compiling management advice. As such, the current Report does not present a comprehensive overview, but should be read in conjunction with previous reports (ICES, 2000; 2002; 2003; 2004, 2005a, 2006, 2007).

In addition to documenting the status of the stock and fisheries and compiling management advice, in previous years the Working Group also provided scientific advice in support of the establishment of a recovery plan for the stock of European Eel by the EU. In 2007, the EU published the Regulation establishing measures for the recovery of the eel stock (EC 1100/2007). This introduced new challenges for the Working Group, requiring development of new methodologies for local and regional stock assessments and evaluation of the status of the stock at the international level. Implementation of the Eel Management Plans will likely introduce discontinuities to data trends and may require a shift from fisheries-based to scientific survey-based assessments.

The structure of this report does not strictly follow the order of the Terms of Reference for the meeting, since different aspects of subjects were covered under different headings, and a rearrangement of the Sections by subject was considered preferable. The meeting was organized using the Agenda in Annex 2. Five subgroups, under the headings of "Data and International Stock Assessment", "Methods and Methodologies", "Stocking", "Eel Quality" and "Oceans and Climate" addressed the Terms of Reference.

Chapter 2 presents trends in recruitment, stock, fisheries and aquaculture (ToR a).

Chapter 3 introduces the concept of post-evaluation and stock assessment at the international level, discusses data sources and gaps and presents a decision structure for stock assessment. (ToR a, b and e).

Chapter 4 discusses methods for the estimation of pristine and current escapement, (ToR a and e).

Chapter 5 reviews the data for stocking and aquaculture and updates previous advice on best practice for stocking (ToR a and b).

Chapter 6 updates the European Eel Quality Database (EEQD) and discusses the importance of the inclusion of spawner quality parameters in stock management advice (ToR a).

Chapter 7 reviews the hypotheses and information on possible relationships between recruitment, and climatic and ocean factors (ToR c.).

Terms of Reference a. (revision of catch statistics) is the follow-up of the analysis made in the report of the 2004 meeting of the Working Group (ICES 2005, specifically Annex 2). Following that meeting, a Workshop was held under the umbrella of the European Data Collection Regulation (DCR), in September 2005, Sånga Säby (Stockholm, Sweden). The Workshop report presented catch statistics in greater detail than had been handled by this Working Group before. Additionally, a further improvement of the catch statistics is foreseen, when the DCR is actually implemented for the eel fisheries across Europe.

It is envisaged that additional data and improved data will become available under the Eel and Data Collection Regulations.

2 Trends in recruitment, stocking, yield and aquaculture

2.1 Data

This Section collects the time-series datasets for the analysis of the status of the European eel population through the trends in recruitment, commercial landings, non-commercial and recreational catches stocking and aquaculture production of eel.

2.1.1 Recruitment

Information on recruitment is provided by a number of datasets, relative to various stages (glass eel and elver, yellow eel) recruiting to continental habitats (Dekker, 2002). Data of recruiting glass eels and elvers (young of the year) and yellow eels from 28 rivers in 11 countries are updated to the last season available (2007 and in some cases 2008) and provide the information necessary to examine the trends in recruitment. These data were derived from fishery-dependent sources (i.e. catch records) and fishery-independent surveys across much of the geographic range of European eel, and cover varying time intervals. Some of them date back as far as 1920 (glass eel, Loire France) and even the beginning of 20th century (yellow eel, Göta Älv Sweden). All of them, however, date back as far as 1970. The recruitment time-series data in European rivers are presented in Annex 3 (Tables 1 and 2).

Declining trends were evident over the last two decades for all time-series. After the high levels of the late 1970s, there was a rapid decrease that still continues to the present time. The trend is similar in recruitment dataseries for glass eels in estuarine areas (Figure 2.1) and in time-series for yellow eel colonization, monitored in northern countries where transition to yellow eel stage occurs before entering fresh waters (Figure 2.2).

Latest data for 2007 and 2008 demonstrates that recruitment continues to be at a very low level in most catchments. Although some series demonstrated a slight increase, most series remained at similar or lower levels to the previous season for both eel developmental stages.

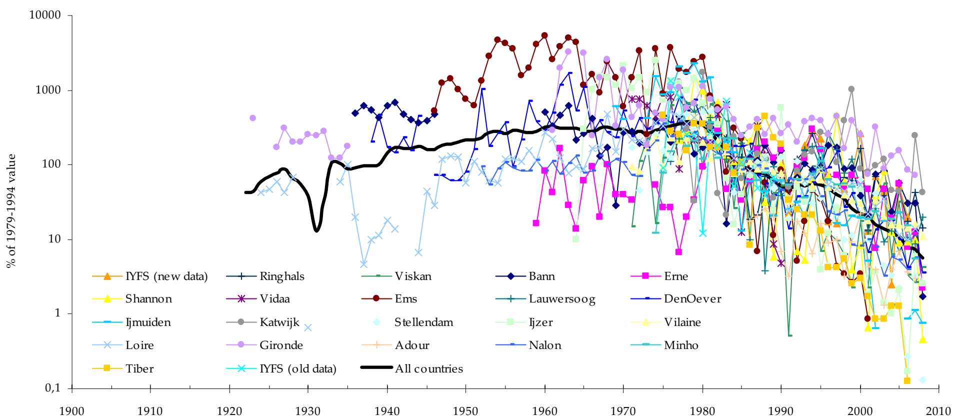


Figure 2.1: Time-series of monitoring glass eel recruitment in European rivers. Each series has been scaled to its 1979–1994 average. Note the logarithmic scale on the y-axis.

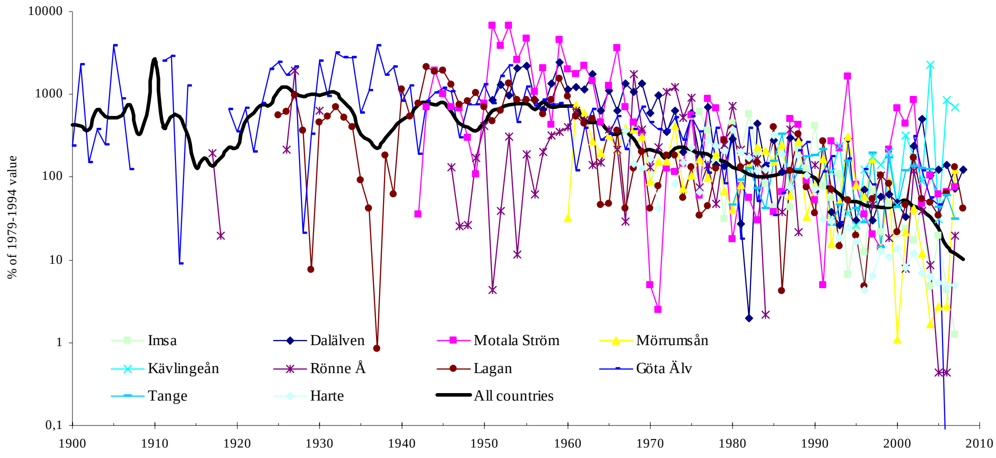


Figure 2.2: Time-series of monitoring yellow eel recruitment in European rivers. Each series has been scaled to the 1979–1994 average. Note the logarithmic scale on the y-axis.

2.1.2 Data on landings

Data on yellow/silver eel landings obtained from country reports 2008 are presented in Annex 3 (Table 3) and in Figure 2.3. Data on official eel landings from FAO sources are presented in Annex 3 (Table 4) and in Figure 2.4. Those two datasets do not include aquaculture production. To compare the two datasets the mean values for corresponding periods were compared (Figure 2.5).

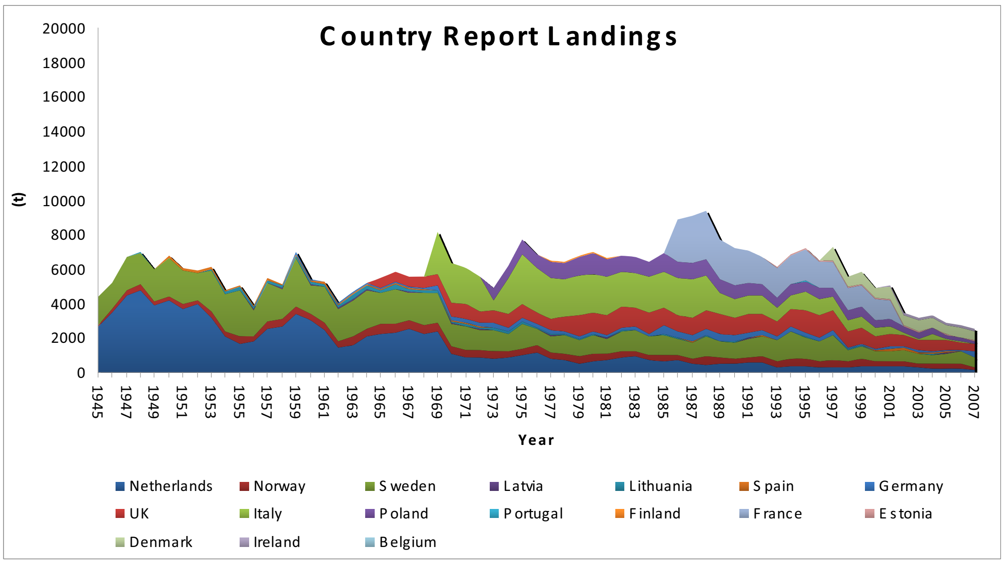


Figure 2.3: Landings of European eel in Europe (tonnes). Source: Country Reports 2008.

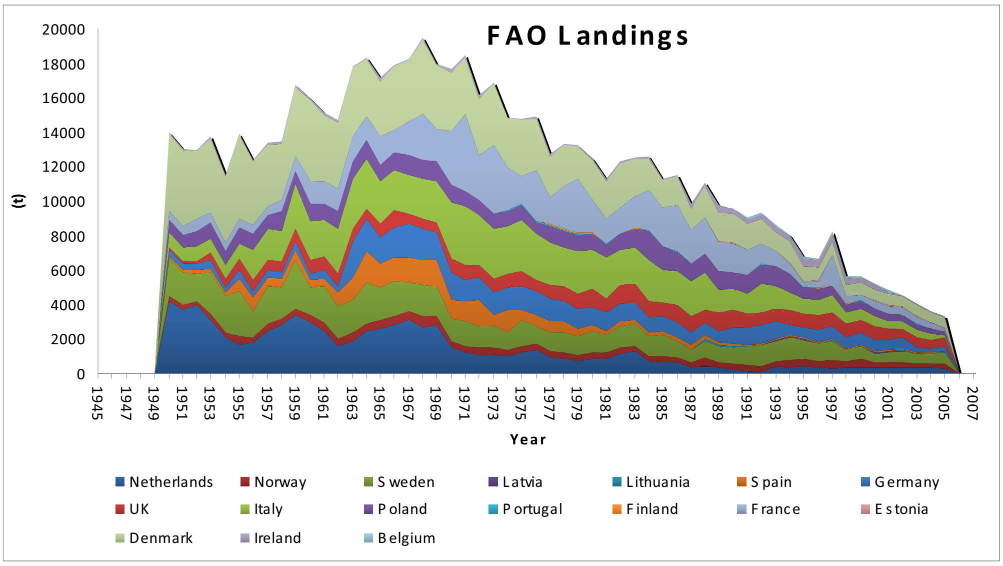


Figure 2.4: European eel landings in Europe (tons). Source: FAO.

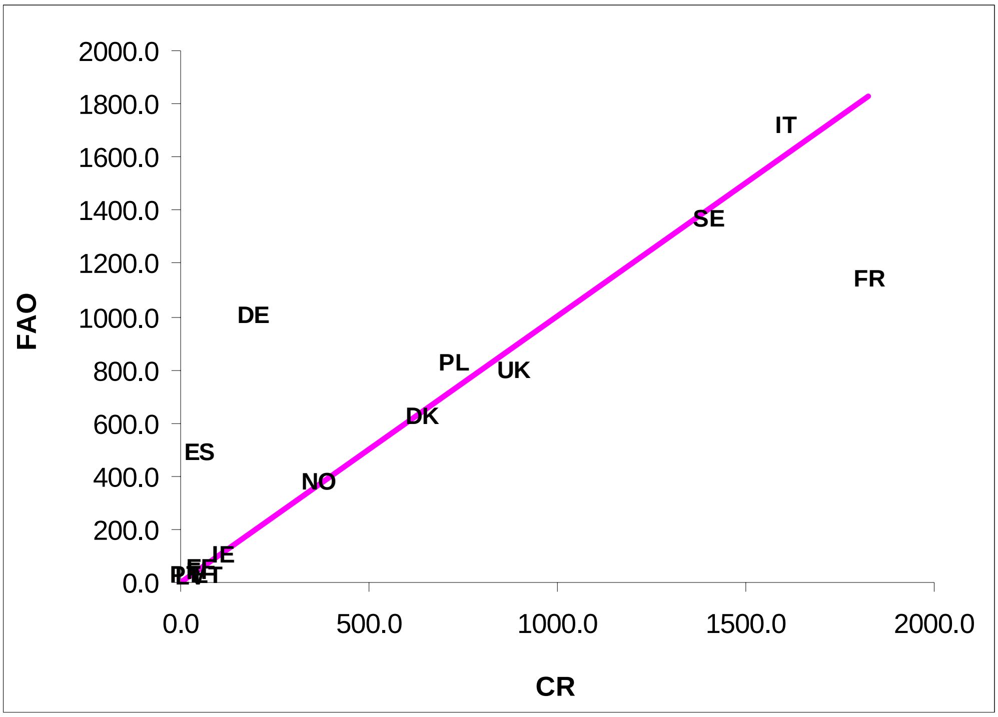


Figure 2.5: Differences in data on European eel landings in Europe obtained from FAO and similar data presented in country reports.

2.1.2.1 Data discontinuities

Both the data officially reported to FAO and the best estimates presented in the Country Reports suffered from reporting discontinuities in the past. Implementation of the EU Eel Regulation will require Member States to implement a full catch registration system. This will lead to considerable improvement of the coverage of the fishery, i.e. underreporting will probably reduce markedly. Dekker, 2003 analysed the trend in historical catch records, correcting for historical discontinuities on the basis of a series of increasingly complex statistical models. Since the discontinuity caused by the implementation of the EU Eel Regulation will affect all dataseries in the same year, statistical analyses will not be able to cope with this. Consequently, the discontinuity will have to be taken for granted.

However, future assessment of the status and trends in the stock, the anthropogenic impacts and the effect of recovery and restoration measures will heavily depend upon new data, which will be collected from the implementation of the Regulation onwards (see also Chapter 3). It seems not that likely, that before/after-comparisons will be achievable. Consequently, the discontinuity in landings data might be of relative minor importance. Direct stock estimates, such as scientific stock surveys, will not suffer from discontinuities, and these might therefore be used to mend the gap. It is therefore of utmost importance, that existing monitoring series will be continued, and additional series be implemented long before the first post-evaluation in 2012.

2.1.3 Recreational and non-commercial fisheries

Non-commercial (i.e. non-commercial usage of fishing gear except angling, which is classed as recreational fishing) catch data of glass eel were made available by France and Spain (Basque Country). For the Gironde Basin in France, non-commercial catches 1978–1982 exceeded commercial landings of glass eel (given in Table 2.1), but thereafter the dominance changed to commercial landings. Non-commercial fishery catches of glass eel have decreased over the time-series available.

Table 2.1: Non-commercial glass eel catches (t) for 1978–2007. FR Total applies to total catch of non-commercial fisheries in France.

GLASS EEL					
Year	FR Adour	FR Gironde	FR Loire	FR Total	ES Basque country
1978		107.8		647	
1979		116.2		697	
1980		217.1		1303	
1981		150.6		904	
1982		36.5		219	
1983		26.9		161	
1984		26.0		156	
1985		11.8		71	
1986		14.4		87	
1987		28.6		172	
1988		6.7		40	
1989		17.3		110	
1990		9.0		54	
1991		14.5		87	
1992		12.8		77	
1993		21.7		130	
1994	18	12.4		74	
1995	10	18.9		113	
1996	12	4.2		25	
1997	6	6.4		39	
1998	7	1.0		6	
1999	2	2.7	1	6	
2000		0.3	1	2	

GLASS EEL			
2001	0.1	1	
2002	6.2	37	
2003	0.1		0.9
2004	0.1		1.2
2005	0.5	2	1.3
2006			0.7
2007	0.1		

There is a lack of data on eel catches by non-commercial fisheries. Where estimates are available for some countries or regions it appears that commercial catches are generally dominating non-commercial catches but latter may comprise up to one third of total yields (Figure 2.6). Therefore, recreational yields and other non-commercial catches are a very important source of mortality in fresh-water eel stocks and reliable estimates are urgently needed.

Estimates of yellow eel catches of anglers were available only for four countries/rivers (Table 2.2). National angling catches of yellow eels of between 86 and 3300t have been reported and can comprise a relatively important part of the total yield.

Table 2.2: Yellow eel landings (t) of anglers from River Elbe, Germany (DE), Netherlands (NL), France (FR) and Poland (PL).

YELLOW EEL (ANGLING)				
Year	DE Elbe	NL	FR	PL
1970				3300
1971				
1972				
1973				
1974				
1975				
1976				
1977				
1978				
1979				
1980				
1981				
1982				
1983				
1984				
1985	114.5			
1986	116.9			
1987	117.5			
1988	118.4			
1989	112.2			
1990	104.6			
1991	92.1			
1992	83.7			
1993	88.0			

YELLOW EEL (ANGLING)				
1994	86.5			
1995	87.8			
1996	89.9			
1997	91.1			
1998	106.0			
1999	108.3			
2000	103.8			
2001	111.2			
2002	112.2			
2003	113.6			
2004	107.5			
2005	105.1		508.655	
2006	104.1			
2007	111.2	200		100

Data for non-commercial catches on yellow eel are given in Table 2.3. In contrast to Norway, where catches have been remaining in the same order of magnitude since 1989, they collapsed in the Gironde Basin.

Table 2.3: Yellow eel landings (t) of non-commercial fisheries other than angling from Norway (NO) Denmark (DK), Netherlands (NL) and France, Gironde Basin (FR).

YELLOW EEL (NON-COMMERCIAL)				
Year	NO	DK	NL	FR Gironde
1978				204.1
1979				229.5
1980				155.7
1981				148.8
1982				133.1
1983				76.2
1984				164.1
1985				170.3
1986				160.5
1987				134.3
1988				97.7
1989	124.9			40.2
1990	133.9			28.3
1991	130.6			15.8
1992	143.0			27.7
1993	116.3			21.4
1994	180.5			21.1
1995	297.6			18.4
1996	178.2			7.7
1997	242.3			9.7
1998	171.9			7.3
1999	187.4			1.5
2000	108.6			1.4

YELLOW EEL (NON-COMMERCIAL)				
2001	127.9			0.6
2002	138.5			1.1
2003	107.2			0.5
2004	97.3	138.1		1.3
2005	106.0			0.6
2006				1.3
2007			25.0	1.3

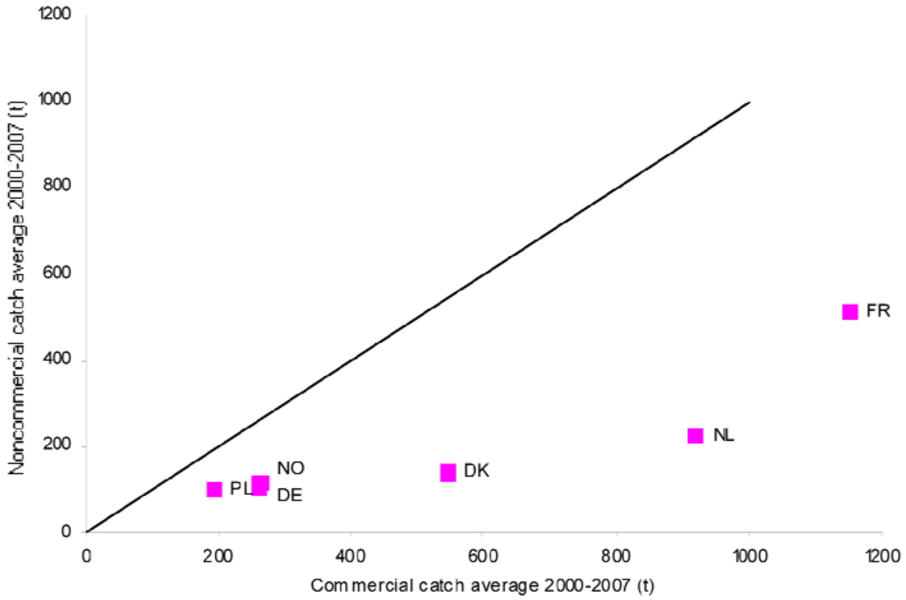


Figure 2.6: Non-commercial catches (Sum of angling and other fishing gear) against commercial catches as an average in 2000–2007. Note that there are inconsistencies in the data quality for commercial vs. non-commercial catches.

2.1.4 Trends in stocking

Data on stocking were obtained from a number of countries, separated for glass eels and for young yellow eels. The size of 'young yellow eel' varies between countries. Most data available were on a weight base. Weights were converted to numbers, using estimates of average individual weights of the eels at the size stocked. These were 3.5 g for Denmark, 10 g for Poland, 33 g for the Netherlands, 20 g for (eastern) Germany, 30–60 g for Elbe RBD (up to 2005, after which actual counts are available), and 90 g for Sweden. An overall number of 3000 glass eels per kg was applied to data from Belgium and Northern Ireland. An overview of data available up to 2008 is compiled in Annex 3 (Tables 5 and 6). Stocking in other EU countries, for which there are no time-series data, and hence are not included in Tables 5 and 6, are also summarized in Annex 3.

In the 2007 report of the WGEEL a sharp drop in glass eel stocking series around 1969 was mainly explained with the fact that Polish stocking figures ceased to be recorded. However, now the old Polish data have been included, but the graph still demonstrates a remarkable drop in glass eel stocking at that time. Obviously, there must have been other causes for the observed decrease.

Stocking with glass eel has decreased strongly since the early 1990s and appears now to be on a very low level with a still decreasing trend (Figure 2.7). However, this has partly been compensated for by an increasing number of young yellow eels stocked since the late 1980s. During the 1990s stocking of young eel demonstrated an increase but dropped again in the late 1990s (Figure 2.8). During the last years, a slight increase could be observed again. If several countries use stocking as a management option in their EMP's, an increasing tendency in stocking numbers may be expected, if sufficient glass eels are available on the market.

Figures 2.9 and 2.10 give a country by country breakdown of glass eel and young yellow eel numbers stocked respectively. Poland, Germany and the Netherlands stocked the largest numbers of glass eel and Germany, Denmark and the Netherlands stocked the largest numbers of young yellow eel.

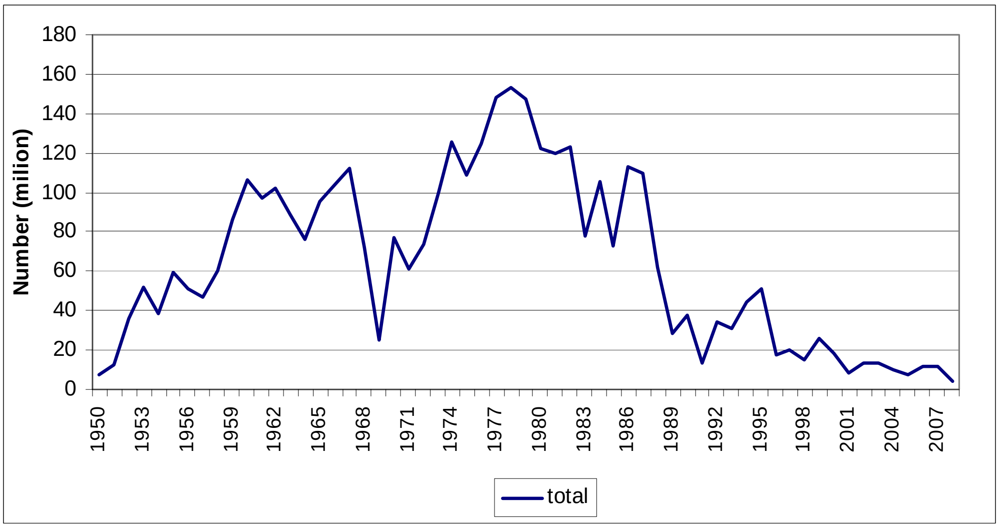


Figure 2.7: Stocking of glass eel and young yellow eel in Europe (East Germany and Elbe RBD, Lithuania, Netherlands, Denmark, Poland, Sweden, Northern Ireland, Belgium, Finland, Estonia and Latvia), in millions re-stocked.

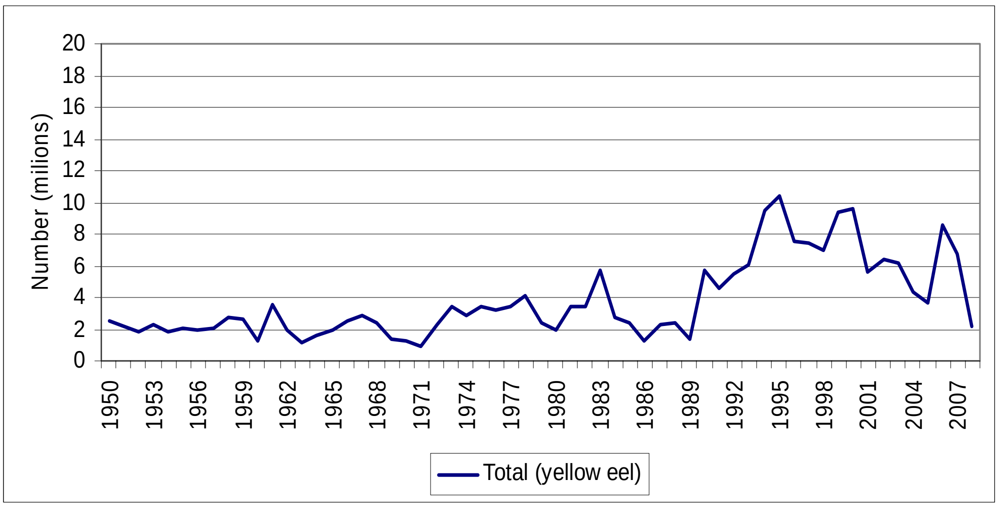


Figure 2.8: Stocking of young yellow eel in Europe (East Germany and Elbe RBD, Lithuania, Netherlands, Denmark, Poland, Sweden, Belgium, Finland, Estonia and Latvia), in millions stocked.

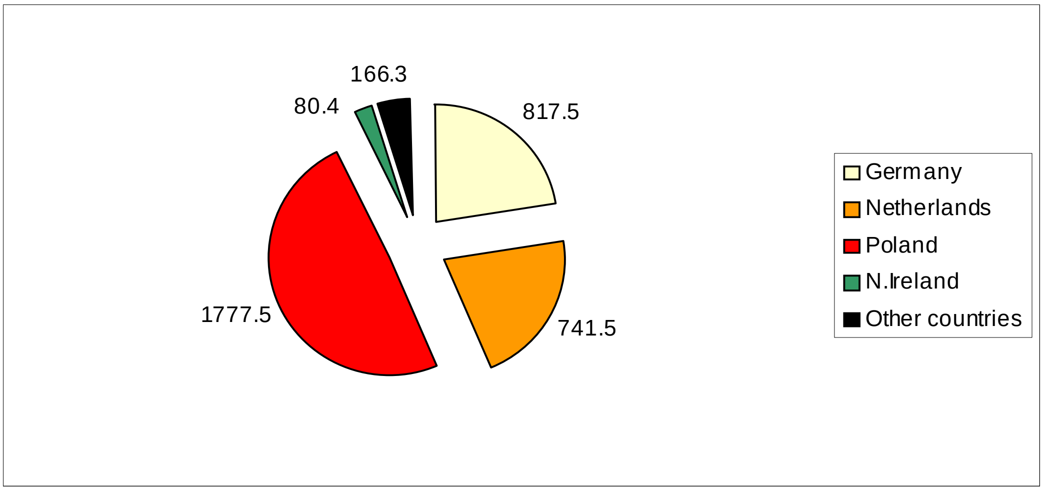


Figure 2.9: Total numbers of stocked glass eels in Europe (former East Germany and Elbe RBD, Netherlands, N. Ireland, Poland and other countries) cumulated for all reported years, in millions stocked.

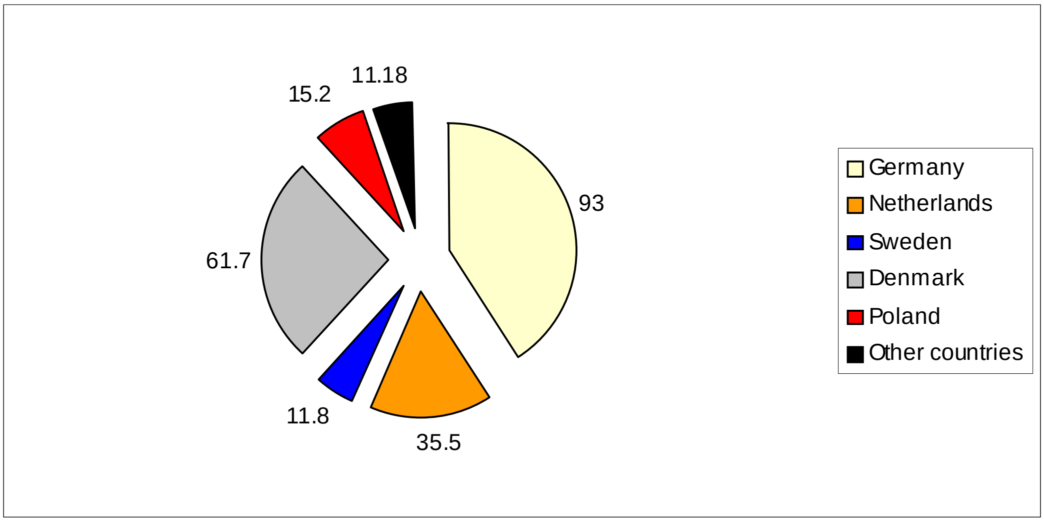


Figure 2.10: Total numbers of stocked young yellow eels in Europe (former East Germany and Elbe RBD, Netherlands, Sweden, Denmark, Poland and other countries) cumulated for all years reported, in millions stocked.

2.1.5 Aquaculture

Aquaculture production data for European eel limited to European countries from 1996 to 2007 are compiled by integrating different sources, FAO (Table 2.4), FEAP (Table 2.5), and Country Reports to WGEEL 2008 (Table 2.6). Some discrepancies still exist between databases and the national reports annexed to this report. These differences are, in some cases, caused by different purposes of using aquaculture production. For example, the total aquaculture production of eel in Germany in 2007 was 740 tons, where 300 tons was used for stocking and 440 tons for human consumption. The peak of production in Europe was reached in 2000 (11 000 tons), although most recently it seems to be fluctuating around 8000–9000 t. Fifty-nine eel farms were estimated to exist in 2006, twenty-nine of which were in the Netherlands, nine in Denmark and the rest scattered in other countries.

Table 2.4. Aquaculture production of European eel in Europe. from 1996 to 2006, in tonnes. ***Source: FAO.***

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Belgium	125	125	125	100	100	100					
Czech	4	3	3	1	1	1	1	1	<0.5	1	1
Denmark	1400	1689	2468	2717	2674	2100	1166	2012	1883	1673	1739
Estonia							5	15	7	40	40
France	160	160	42	42	42	42					
Germany					150	150	150	150	322	329	567
Greece	584	545	681	518	602	639	433	544	557	372	385
Hungary						73	36	11	11	6	
Ireland			20	25	1						
Italy	3000	3100	3150	3200	2700	2500	1699	1550	1220	1132	807
Malta	<0.5										
Netherlands	2800	2443	2634	3228	3700	4000	3868	4200	4500	4000	4200
Portugal	5	4	6	2	4	7	4	5	2	1	1
Romania			1								
Serbia	2	2	3	7	5	7	4	6	9	9	
Spain	249	335	347	383	411	339	424	339	424	427	403
Sweden	161	189	204	222	273	200	167	170	158	222	191
Total	8491	8595	9684	10445	10663	10158	7957	9003	9094	8212	8334

Table 2.5. Aquaculture production of European eel in Europe from 1996 to 2007, in tonnes. Source: Aquamedia (FEAP).

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Belgium	150	150	150	40								
Denmark	1200	1700	2468	2700	2675	2100	2300	2050	1500	1700	1900	2100
Estonia					5	5	13		24	17	23	30
France	160											
Germany	140	150	150		150	150		350	350	350	350	400
Greece	350	312	500	500	300	550	500	500	500	500	450	450
Hungary				19	13	104	48					
Italy	3000	3100	3100	3100	2900	2400	1400	1400	1200	1200	1000	1000
Lithuania			2	2	1	5	17	20	9	8	14	40
Netherlands	1800	1800	3250	3800	4000	4000	4000	4200	4500	4400	3800	4200
Norway	200	200	200									
Portugal	200	200	200	200	200	200						50
Spain	210	266	270	300	425	330	355	325	350	400	400	450
Sweden	184	215	250	250	250	230	230	230	230	230	230	230
Turkey		200	200	200	200							
Croatia											25	50
Total	7594	8293	10740	11109	11111	10074	8863	9075	8663	8805	8192	9000

Table 2.6. Aquaculture production of European eel in Europe from 1996 to 2007, in tonnes: Country reports (CR 2007 and 2008).

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Denmark	1568	1913	2483	2718	2674	2000	1880	2050	1500	1700	1900	2100
Estonia					5	7	15	18	26	19	27	52
Germany	204	221	260	400	422	347	381	372	328	329	567	740
Netherlands	2800	2450	3250	3500	3800	4000	4000	4200	4500	4500	4200	4000
Portugal	21		13	3	4	7	4		2	1		1
Sweden	161	189	204	222	273	200	167	170	158	222	191	175
Total	4754	4773	6210	6843	7178	6561	6447	6810	6514	6771	6885	7068

2.2 Analysis of trends in recruitment

The trends in recruitment data available were analysed in relation to life stage, type of monitoring and geographical area. The objective of this analysis is to derive a reliable index of recruitment, both for the assessment of the stock-to-recruit phase, as for the management and assessment of the recruit-to-stock phase. The available dataseries were qualified regarding:

- life stage (unpigmented glass eel; pigmented young-of-the-year; immigrating yellow eel older than 1 year);
- sampling type (trapping all incoming recruits in a river, trapping the recruits only partially, commercial total landing figures, commercial cpue, scientific survey estimates);
- geographical area (Baltic Sea including Kattegat and Skagerrak, North Sea, Channel, British Isle, Atlantic Ocean, Mediterranean Sea). No datasets are available at the moment for the Channel area.

Considering the small number of datasets, the dataseries for glass eel and for young-of-the-year were merged, and analysed together. Given the spatial distribution of different sampling techniques in Europe (commercial fisheries in the South, trapping mostly in the north), the effect of sampling type and of area can not be analysed concurrently; for young yellow eel older than 1 year only trapping dataseries exist. Consequently three analyses were feasible:

- area effect on glass eel and young-of-the-year (combined);
- sampling type effect on glass eel and young-of-the-year (combined);
- area effect on young yellow eel older than 1 year.

The analyses used generalized linear models (GLMs) with a site effect as a scaling parameter, a log link (site effect and other effects are assumed to be multiplicative) and a gamma error (variance is varying with the square of the mean, i.e. a constant coefficient of variation). The resulting time-trends are scaled to the 1970–1979 geometric mean. Figure 11 and Table 2.7 gives the main characteristics of the 40 datasets used.

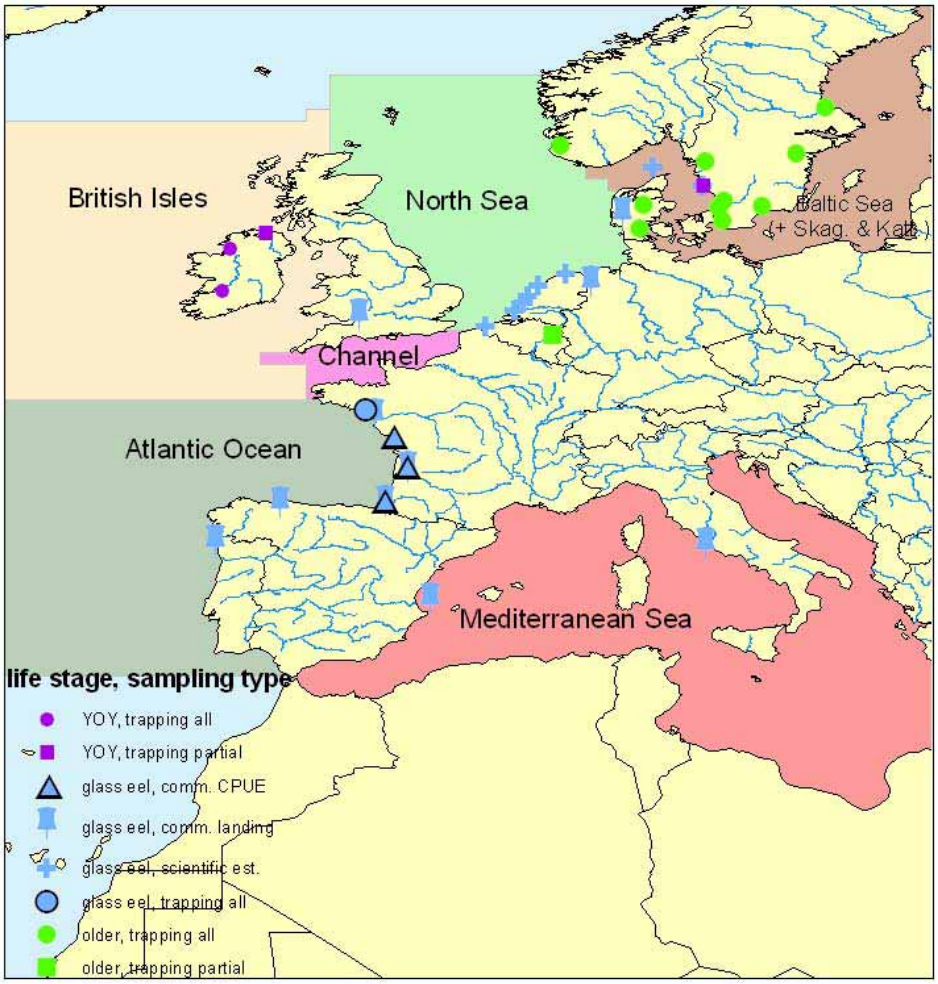


Figure 2.11: Map of the recruitment monitoring sites across Europe. Life stage and sampling method are indicated by the symbols.

Table 2.7: Data sets used for recruitment analysis. YOY = Young-of-the-year.

LIFE STAGE	AREA	MONITORING TYPE	COUNTRY	RIVER	LOCATION	LATITUDE	LONGITUDE
glass eel	North sea	scientific est.	Belgium	Ijzer	Nieuwpoort	51.08	2.45
glass eel	North sea	comm. landing	Denmark	Vidaa	Højer sluice	55.58	8.4
glass eel	North sea	comm. landing	Germany	Ems	Herbrum	53.02	7.2
glass eel	North sea	scientific est.	Netherlands		Lauwersoog	53.25	6.12
glass eel	North sea	scientific est.	Netherlands	Rhine	IJmuiden	52.27	4.36
glass eel	North sea	scientific est.	Netherlands	Oude RIjn	Katwijk	52.12	4.24
glass eel	North sea	scientific est.	Netherlands	Haringvliet	Stellendam	51.50	4.02
glass eel	North sea	scientific est.	Netherlands	Rhine	DenOever	52.56	5.03
glass eel	North sea	scientific est.	Sweden		IYFS	58	10
glass eel	North sea	scientific est.	Sweden		IYFS2	58	10
glass eel	North sea	scientific est.	Sweden	Kattegat-	Ringhals	57.15	12.07
glass eel	British Isle	comm. landing	UK	Severn	EA	51.36	-2.42
glass eel	British Isle	comm. landing	UK	Severn	HMRC	51.36	-2.42
glass eel	Atlantic Ocean	comm. cpue	France	Sèvres	Estuary	46.18	-1.08

LIFE STAGE	AREA	MONITORING TYPE	COUNTRY	RIVER	LOCATION	LATITUDE	LONGITUDE
glass eel	Atlantic Ocean	comm. landing	France	Adour	Estuary	43.32	-1.32
glass eel	Atlantic Ocean	comm. cpue	France	Adour	Estuary	43.32	-1.32
glass eel	Atlantic Ocean	comm. cpue	France	Gironde	Estuary	45.02	-0.36
glass eel	Atlantic Ocean	comm. landing	France	Gironde	Estuary	45.02	-0.36
glass eel	Atlantic Ocean	comm. landing	France	Loire	Estuary	47.18	-2.00
glass eel	Atlantic Ocean	trapping all	France	Vilaine	Arzal	47.3	-2.24
glass eel	Atlantic Ocean	comm. landing	Portugal	Minho	portugese	41.52	-8.51
glass eel	Atlantic Ocean	comm. landing	Spain	Minho	spanish part	41.52	-8.51
glass eel	Atlantic Ocean	comm. landing	Spain	Nalon	Estuary	43.31	-6.04
glass eel	Mediterannean	comm. landing	Italy	Tiber	Fiumara	41.44	12.14
glass eel	Mediterannean	comm. landing	Spain		Albufera de	39.20	0.23
YOY	Baltic Sea	trapping	Sweden	Viskan	Sluices	57.12	12.07
YOY	British Isle	trapping all	Ireland	Shannon	Ardnacrusha	52.42	-8.36
YOY	British Isle	trapping all	Ireland	Erne	Ballyshannon	54.3	-8.15
YOY	British Isle	trapping	Northern	Bann	Coleraine	55.12	-6.42
older	Baltic Sea	trapping all	Sweden	Dalälven		60.34	17.26
older	Baltic Sea	trapping all	Sweden	Mörrumsån		56.20	14.40
older	Baltic Sea	trapping all	Sweden	Lagan		56.31	13.03
older	Baltic Sea	trapping all	Sweden	Motala		58.35	16.11
older	Baltic Sea	trapping all	Sweden	Göta Älv		58.16	12.16
older	Baltic Sea	trapping all	Sweden	Kävlingeån		55.43	12.59
older	Baltic Sea	trapping all	Sweden	Rönne Å		56.16	12.50
older	North sea	trapping	Belgium	Meuse	Lixhe dam	50.45	5.40
older	North sea	trapping all	Denmark	Guden Å	Tange	56.21	9.36
older	North sea	trapping all	Denmark	Harte		55.21	9.25
older	North sea	trapping all	Norway	Imsa	Sandnes	58.54	5.59

2.2.1 Area effect on glass eel and young of the year recruitment

The model explains 72% of deviance (Table 2.8) and all effects were highly significant ($p<0.001$). Table 2.9 and Figure 2.12 give results from this model, i.e. a recruitment index per year by area. Every area demonstrates a declining trend since the end of 1970s or the beginning of 1980s. Before, no particular trend is detected. In recent years, recruitment is continuously declining in all areas. The mean recruitment for the past 5 years (2004–2008) is 10%, 9%, 3%, 3% and 1% of the 1970s reference level, for the British Isles, Atlantic Ocean, Baltic Sea, Mediterranean Sea and North Sea respectively. Apparently, the decline is stronger in northernmost and southernmost area of the species distribution than in the central part. A unique and uniform recruitment index all over the distribution area would require weighing the specific contributions by area, which is not achievable at the moment. More importantly, however, such an index would incorrectly represent the actual trend in each area.

Table 2.8: Analysis of deviance of the area effect on glass eel and young of the year GLM.

MODEL	RESIDUAL DF	RESIDUAL DEVIANCE
NULL	1051	1763.27
Site effect	1023	1545.73
Year x area effect	776	501.83

Table 2.9: Recruitment index per area. Each series have been scaled to 1970–1979 average = 100%.

YEAR	BALTIC SEA	NORTH SEA	BRITISH ISLES	ATLANTIC OCEAN	MEDITERRANEAN SEA
1950		32.7		25.2	
1951		34.6		48.6	
1952		129.9		48.2	
1953		112.2		30.8	
1954		181.8		41.1	
1955		172.8		61.4	
1956		133.0		57.5	
1957		71.9		51.7	
1958		124.5		61.1	
1959		170.2		63.2	
1960		209.2	121.4	87.5	394.2
1961		130.2	76.5	60.7	255.1
1962		228.0	142.4	127.4	371.0
1963		308.2	123.3	214.2	255.1
1964		129.4	44.1	63.5	92.8
1965		98.7	68.7	158.0	139.1
1966		94.2	110.2	59.7	115.9
1967		107.8	30.8	93.6	92.8
1968		132.2	66.9	156.3	92.8
1969		92.2	19.4	70.6	115.9
1970		112.4	63.9	117.2	23.2
1971	3.9	79.8	63.6	60.4	23.2
1972	28.5	118.7	70.9	62.8	23.2
1973	57.3	57.5	90.0	77.2	46.4
1974	4.2	154.1	140.9	82.2	23.2
1975	32.1	69.9	59.4	81.3	220.4
1976	162.3	114.8	48.7	131.4	149.8
1977	275.4	105.1	106.4	138.8	161.7
1978	172.6	85.8	131.0	112.2	98.7
1979	163.7	101.8	225.2	136.5	230.3
1980	23.5	80.4	165.6	104.7	224.8
1981	104.1	58.7	144.0	116.1	70.0
1982	94.0	30.0	179.1	73.1	62.3
1983	63.6	31.1	37.0	80.4	82.5
1984	7.7	12.5	63.5	68.5	59.2
1985	41.8	11.5	55.3	42.3	38.9
1986	25.6	12.6	60.4	50.4	35.7
1987	24.1	15.9	90.0	43.5	150.8
1988	19.1	9.2	74.0	46.1	173.1
1989	9.8	4.4	49.4	39.6	90.7
1990	11.4	17.1	69.0	27.2	72.8
1991	3.5	2.9	14.8	23.2	20.6
1992	18.4	5.8	31.8	31.5	11.7

YEAR	BALTIC SEA	NORTH SEA	BRITISH ISLES	ATLANTIC OCEAN	MEDITERRANEAN SEA
1993	16.3	6.2	40.4	31.3	10.4
1994	28.0	7.9	73.8	33.2	9.2
1995	7.7	8.7	59.5	40.9	7.3
1996	2.7	7.9	57.1	24.8	5.6
1997	4.1	6.6	80.8	27.6	2.7
1998	4.9	3.7	38.5	18.7	8.9
1999	3.9	8.0	32.8	24.5	4.6
2000	12.2	5.3	20.1	25.7	8.8
2001	1.1	1.0	14.5	8.7	5.9
2002	8.5	2.7	13.1	15.6	4.4
2003	9.6	1.9	26.7	8.2	3.0
2004	1.6	0.9	13.7	8.8	2.8
2005	6.9	1.1	18.9	11.2	0.8
2006	1.5	0.5	9.4	7.8	3.8
2007	2.9	2.3	8.4	7.2	3.8
2008	1.7	0.8	1.0	8.2	
mean 2004–2008	2.9	1.1	10.3	8.6	2.8

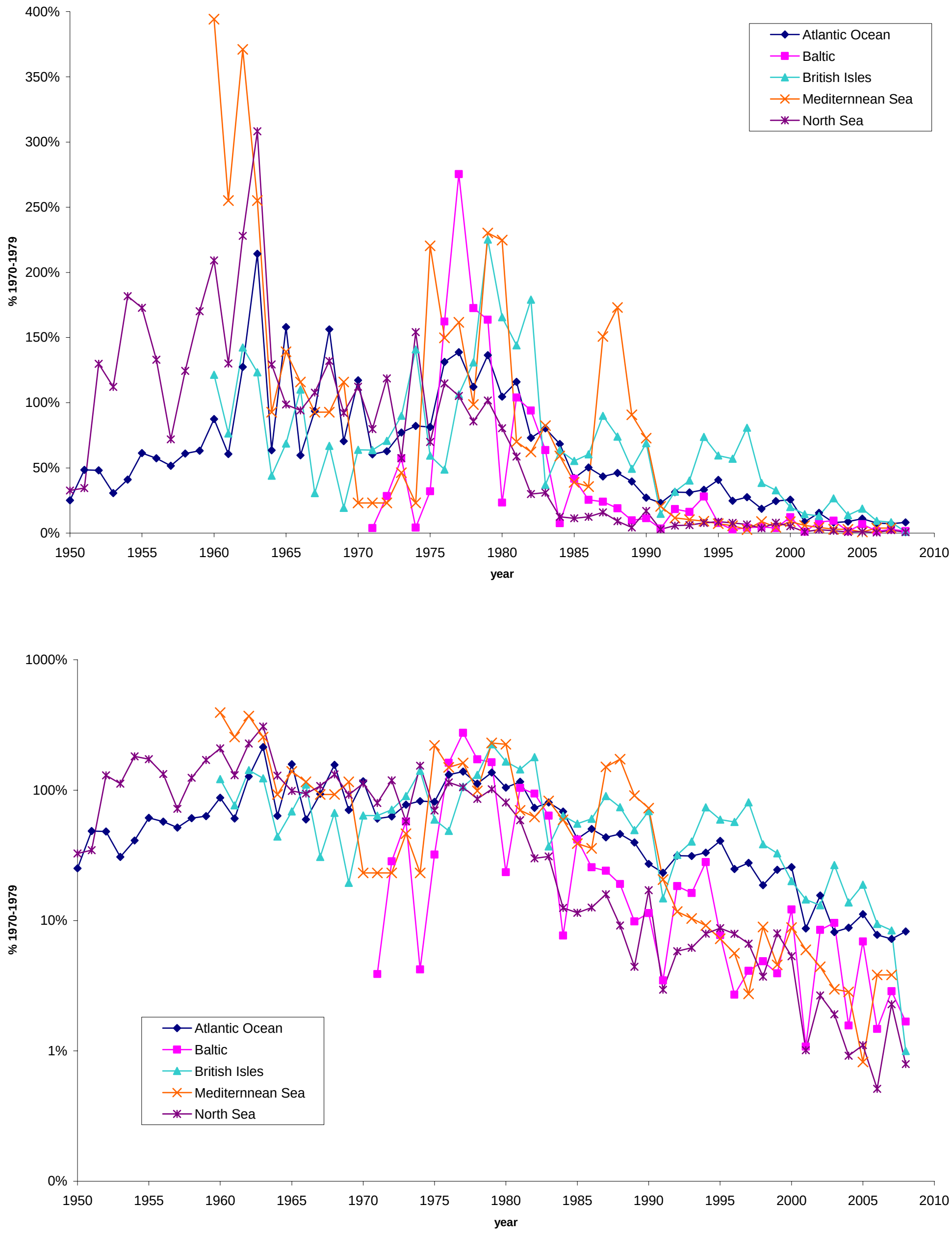


Figure 2.12: Recruitment (glass eel and young of the year) index per area in regular (upper panel) and in logarithmic scale (lower panel). Each series have been scaled to 1970–1979 average.

2.2.2 Sampling type effect on glass eel and young of the year recruitment

This model explains 66% of deviance (Table 2.10) and all effects are highly significant ($p<0.001$). Table 2.11 and Figure 2.13 give results from this model. Recruitment indices per sampling type demonstrate the same trend as recruitment index per area: decreasing trend since the end of 1970s or the beginning of 1980s. Depending on sampling type the present level is between 1% and 11% (2004–2008 average) of 1970–1979 level. Commercial cpue and trapping all, only represented by datasets in the central part of the eel distribution, have the highest present level (11% and 10%). Commercial catch and trapping partial, represented in the central and extreme part of the eel distribution, have intermediate present level (5%), while scientific sampling, only taking place in North Sea, has the lowest present level (1%). The analysis did not suppose any particular distribution pattern of the recruitment; we can thus build an index of recruitment of all Europe. The European index is calculated as the geometric mean of each of the monitoring indices, i.e. the least-squares mean (Table 2.11 and Figure 2.12). This combined index demonstrates that the present recruitment is only 5% of the 1970–1979 level.

Table 2.10: Analysis of deviance of the area effect on glass eel and young of the year GLM.

MODEL	RESIDUAL DF	RESIDUAL DEVIANCE
NULL	1051	1763.27
Site effect	1023	1545.73
Year x monitoring type effect	764	593.15

Table 2.11: Recruitment index per monitoring type and geomean. Each series have been scaled to 1970–1979 average.

YEAR	COMMERCIAL CATCH	COMMERCIAL CPUE	SCIENTIFIC ESTIMATE	TRAPPING ALL	TRAPPING PARTIAL	GEOMEAN
1950	39.5		12.0			21.8
1951	45.7		24.3			33.3
1952	62.8		156.1			99.0
1953	88.4		26.6			48.5
1954	139.0		39.5			74.1
1955	139.9		54.7			87.5
1956	124.8		14.3			42.2
1957	71.5		31.9			47.8
1958	86.6		105.0			95.3
1959	138.1		57.6			89.2
1960	246.6		43.5	56.4	94.9	87.1
1961	130.2	45.7	75.1	28.9	63.2	60.6
1962	186.6	181.2	176.5	113.3	86.3	142.3
1963	198.3	346.7	251.9	19.7	116.2	131.8
1964	135.3		39.8	9.6	40.2	38.0
1965	114.2	201.8	101.3	41.3	48.7	85.9
1966	76.9	73.8	87.6	64.2	79.2	75.9
1967	87.7	90.3	131.6	13.8	24.3	51.1
1968	147.3	145.7	118.3	68.8	32.3	89.2
1969	79.4	88.2	92.0	27.5	5.4	39.5
1970	81.4	113.0	138.9	27.5	51.1	71.0
1971	79.1	67.4	69.3	43.3	29.7	54.4
1972	94.6	70.6	89.5	55.0	41.2	67.0
1973	67.6	87.2	63.9	112.9	61.7	76.5
1974	95.9	92.1	161.5	95.8	40.9	89.0
1975	111.3	65.5	64.9	41.0	55.2	64.0
1976	130.6	149.2	95.0	85.9	147.6	118.6
1977	121.9	112.6	118.9	65.2	260.0	122.6
1978	100.7	119.2	91.3	105.9	169.3	114.5
1979	116.8	123.2	107.0	367.2	143.4	152.0
1980	101.8	107.2	77.7	241.0	34.6	93.3
1981	85.2	105.1	62.0	152.9	151.4	105.1

YEAR	COMMERCIAL CATCH	COMMERCIAL CPUE	SCIENTIFIC ESTIMATE	TRAPPING ALL	TRAPPING PARTIAL	GEOMEAN
1982	63.9	64.1	24.7	235.8	146.1	81.0
1983	65.8	54.1	26.4	67.2	80.9	55.2
1984	51.3	60.6	10.5	53.5	15.1	30.5
1985	31.1	34.7	12.3	69.5	58.0	35.2
1986	37.5	31.3	11.5	75.8	50.7	34.9
1987	51.7	45.1	13.9	118.8	47.0	44.8
1988	51.4	45.0	8.5	74.2	40.6	35.8
1989	32.4	51.1	5.7	46.4	18.5	24.1
1990	27.4	21.0	20.9	72.2	25.5	29.4
1991	16.3	20.2	3.4	18.5	4.4	9.8
1992	18.0	36.7	7.6	36.8	24.4	21.4
1993	18.4	38.0	8.5	43.3	20.9	22.2
1994	22.6	28.6	11.3	91.6	27.6	28.4
1995	25.2	38.6	10.5	66.5	10.4	23.4
1996	19.1	23.3	8.6	39.3	19.7	19.7
1997	17.1	32.5	7.4	109.6	18.2	24.1
1998	15.0	15.8	4.9	31.3	9.5	12.8
1999	14.6	30.2	10.0	24.7	9.1	15.8
2000	12.8	46.0	7.8	22.4	7.2	15.0
2001	5.9	7.8	1.3	22.2	2.5	5.0
2002	8.3	20.5	3.4	16.3	13.7	10.5
2003	6.2	7.9	2.3	29.7	19.4	9.2
2004	6.8	9.1	1.0	10.4	3.5	4.7
2005	7.2	14.3	1.6	17.9	12.1	8.2
2006	5.5	11.7	0.7	6.6	3.6	4.1
2007	4.8	9.9	2.7	8.6	3.4	5.2
2008	0.6	11.7	0.9	4.4	0.3	1.5
mean 2004–2008	5.0	11.4	1.4	9.6	4.6	4.7

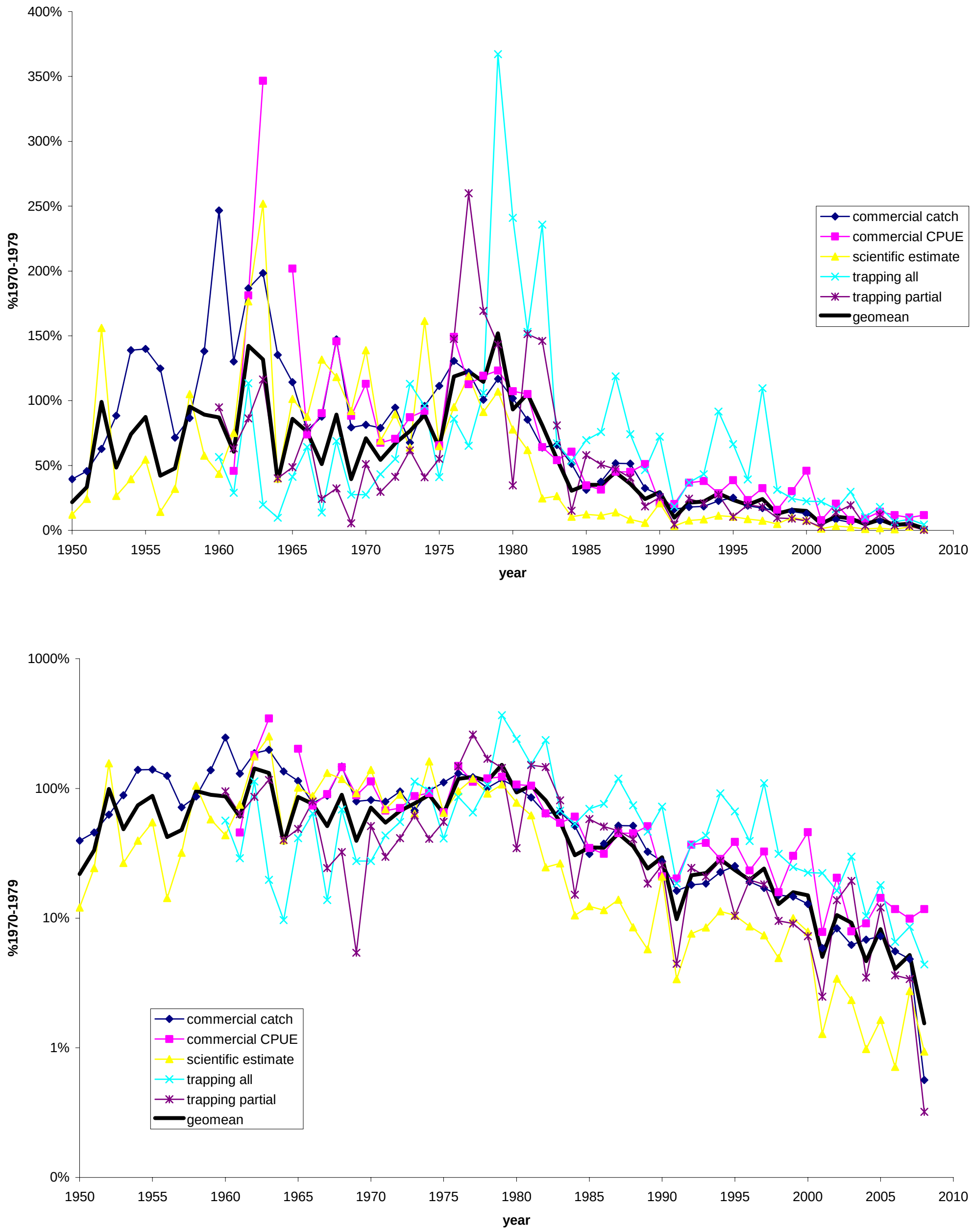


Figure 2.13: Recruitment (glass eel and young of the year) index per monitoring and geomean of these series in regular (upper panel) and in logarithmic scale (lower panel). Each series have been scaled to 1970–1979 average.

2.2.3 Area effect on young yellow eel older than 1 year

Data of two areas only (Baltic Sea including Kattegat, Skagerrak and North Sea) are available to fit this model. It explains 59% of deviance (Table 2.12) and all effect are highly significant ($p<0.001$). Table 2.13 and Figure 2.14 give results from this model, i.e. a young yellow eel older than 1 year recruitment index per area. The Baltic Sea (including Kattegat and Skagerrak) index demonstrates a continuous decline since the beginning of the period (1950). The North Sea index demonstrates the same trend, at least since the mid 1970s. The current level (2004–2008) is only 25% and 6% of the 1970s level for Baltic Sea (including Kattegat and Skagerrak) and North Sea respectively and the Baltic Sea (including Kattegat and Skagerrak) is at 8% of the 1950s level. None of theses series demonstrates any sign of recovery.

Table 2.12: Analysis of deviance of the area effect on young yellow eel older than 1 year GLM.

MODEL	RESIDUAL DF	RESIDUAL DEVIANCE
NULL	448	886.01
Site effect	438	725.79
Year x area effect	342	363.41

Table 2.13: Young yellow eel older than 1 year index per area. Each series have been scaled to 1970–1979 average.

YEAR	BALTIC SEA (INCLUDING KATTEGAT AND SKAGERRAK)	NORTH SEA		BALTIC SEA (INCLUDING KATTEGAT AND SKAGERRAK)	NORTH SEA
1950	269		1980	122	134
1951	360		1981	38	70
1952	356		1982	60	116
1953	572		1983	62	51
1954	290		1984	42	38
1955	431		1985	68	78
1956	207		1986	32	65
1957	226		1987	72	25
1958	232		1988	82	72
1959	492		1989	38	47
1960	245		1990	30	78
1961	249		1991	62	29
1962	244		1992	27	16
1963	214		1993	17	21
1964	82		1994	94	15
1965	152		1995	14	10
1966	214		1996	17	4
1967	117	213	1997	25	19
1968	245	85	1998	22	7
1969	166	74	1999	27	18
1970	68	100	2000	28	9
1971	92	25	2001	24	11
1972	146		2002	66	11
1973	197	50	2003	31	13
1974	77	90	2004	40	7
1975	155	175	2005	11	5
1976	49	139	2006	21	4
1977	79	152	2007	36	8
1978	73	101	2008		
1979	64	68			
			mean 2004–2008	27	6.2

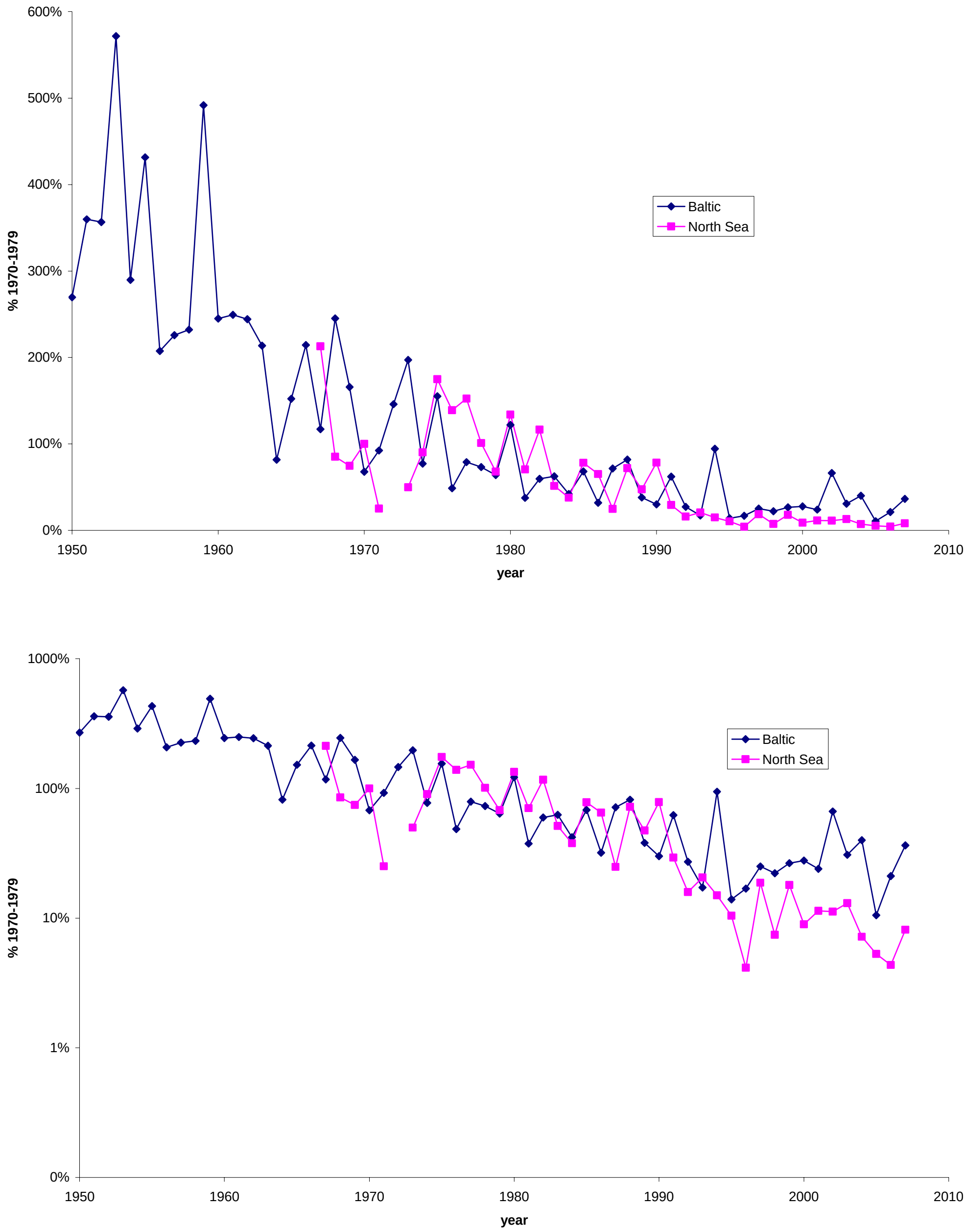


Figure 2.14: young yellow eel older than 1 year index per area in regular (upper panel) and in logarithmic scale (lower panel). Each series have been scaled to 1970–1979 average.

2.2.4 Discussion

Area effect and sampling type effect on glass eel and young of the year recruitment models are fitted on the same data. The area effect model explained more deviance while using fewer degrees of freedom than sampling type effect. On a statistical basis, the geographical pattern seems to fit the data better than the sampling effect, but the difference is not very clear. The geographical pattern can also be explained by the difference found in sampling type. When comparing datasets in different areas with the same sampling type (trapping partial in Baltic Sea including Kattegat and Skagerrak and in British Isles or commercial catches in the North Sea, British Isles, Atlantic Ocean and Mediterranean Sea), the geographical pattern is confirmed. Although sampling biases may exist, geographical pattern (stronger decrease in extreme part of the species distribution area) is the more likely interpretation.

The implementation of the EU Eel Regulation might result in discontinuities in the data on recruitment. First, commercial fisheries might be reduced, affecting the series based on commercial landings and commercial cpues. Second, the Regulation obliges Member States to implement a full registration programme for landings and fishing efforts, probably resulting in more complete coverage of the fishery. The recruitment series based on trapping (all or partial) and the scientific estimates will not be affected. For the (international) analysis of trends, the dataseries suffering from discontinuities will have to be split into "before" and "after", reducing the continuity of the overall analysis. Since this (unwanted but unavoidable) breakpoint will occur in just some sampling methods, it is all the more important to settle the area/sampling problem, i.e. to collect additional unpublished archive dataseries, strengthening the discriminating power of the above analyses.

The Baltic Sea (including Kattegat and Skagerrak) index of young yellow eel older than one year and to a lesser extent the North Sea index for this stage demonstrates a quite different pattern with a decrease starting earlier (at least since 1950 for the Baltic). Unfortunately, the Baltic Sea index for glass eel begins in 1971 only. This index does not differ from other area indices. Two hypotheses can explain these observations;

- the Baltic Sea including Kattegat and Skagerrak glass eel and young of the year index does not start early enough to strongly distinguish from other areas;
- young yellow eel older than 1 year in the Baltic Sea including Kattegat and Skagerrak area started to decline whereas glass eel and young of the year recruitment was constant. The reason for the yellow eel decline is unclear.

The first hypothesis better fits the data, although further information (young yellow eel data in the rest of Europe, or glass eel/young-of-the-year data in the Baltic Sea including Kattegat and Skagerrak area) will be needed to confirm this.

2.3 Conclusions and recommendations for Chapter 2: Trends in recruitment, stocking, yield and aquaculture

2.3.1 Conclusions

All glass eel and young of the year recruitment series demonstrate a clear decline since about 1980 with no sign of recovery. Recruitment is currently at only 5% of the 1970–1979 level. The Baltic Sea, including Kattegat and Skagerrak indices of young yellow eel recruitment, demonstrates a clear decline since about 1950. The decline in recruitment appeared stronger in the more northern and southern parts of the distribution. It is recommended to use recruitment indices per area (Baltic, North Sea, British Isles, Atlantic Coast, eastern and western Mediterranean), and to collect and analyse additional data to confirm the spatial pattern, and to establish the reliability and bias in the different sampling methods.

There needs to be an improvement in the data collected and data reported, particularly on landings and on stocking. Hopefully, the traceability requirements under the EU Regulation and CITES will improve this situation.

2.3.2 Recommendation

The analysis of aquaculture is complicated by the existence of three different datasets. We recommend that the collection of such data are centrally coordinated to provide a single dataset.

The situation is even more complicated for stocking, since in some countries no central databases exist. Therefore, information on stocking is incomplete. This situation should be improved in order to obtain a more comprehensive picture of the stocking activities in Europe.

It is recommended to use glass eel indices per area (i.e. Baltic, North Sea, British Isles, Atlantic Coast, Mediterranean), and to collect and analyse additional data to confirm the spatial pattern, and to establish the reliability and bias in the different sampling methods.

3 International stock assessment and data needs

3.1 Introduction on stock assessment and data needs

The European Union has decided on a protection and restoration plan (Eel Regulation) in 2007, aiming at the protection of 40% of the silver eels, relative to a situation without human influence. At the heart of the Regulation is the obligation for all Member States to develop a (national or river basin specific) management plan for the eel stock and fisheries, aiming at the agreed 40% target. Each management plan should contain an assessment of the current status of the local stock, a description of future monitoring and registration of catch and fisheries for future assessments of the stock and anthropogenic impacts.

The WGEEL considers its tasks (ICES and EIFAC ToRs) to assess and evaluate the overall status of the stock, and the impact of protection measures taken. There is an apparent overlap with the obligation in the Eel Regulation, to report on the status of the stock in individual Eel Management Units, and with the evaluation by the Commission. However, the assessment of the working group will focus on the total population, independent of the split over jurisdictions and management units. Only where the biological processes are inherently spatially diversified, will the assessment of the working group go into disaggregate analyses.

This chapter will elaborate the concepts of an international assessment of a regionally managed stock (Section 3.2), and derive criteria for a minimally required dataset on eel (Section 3.3).

3.2 International stock assessment

3.2.1 International management and stock assessment

The EU Regulation on eel sets a common target for the escapement of silver eels, at 40% of the natural escapement in the absence of anthropogenic impacts. In accordance with the precautionary advice provided by ICES (2002), it is assumed that a stock recruitment relationship exists. Member States are obliged to implement protective measures to achieve the escapement target, and should provide a time schedule for the attainment of this target. This time schedule is certainly much more determined by the slow biological restoration of the stock (decades; Åström and Dekker, 2007), than by the time required to implement the protection measures completely (years?). The Regulation sets no limit on the time frame for restoration. Implicitly, this rules out the hypothesis that the stock–recruitment relationship is determined by depensatory processes, as tentatively found in historical data (Dekker, 2004; ICES 2007). As an alternative to the depensation hypothesis, it has been hypothesized, that the decline of the stock might have been caused by climate factors (Chapter 7 of this report), pollution or parasitism (chapter 6 of this report), and others acting in the oceanic phase.

Noting that the EU Eel Regulation has set targets for the quantity (biomass) of silver eels escaping from the continent, and obliges Member States to take protective measures primarily focusing on the quantities escaping, but has not set targets and does not oblige to take actions with respect to other processes (related to silver eel quality, or climate change) in relation to eel management (if possible), the international assessment of the status of the stock will presently focus on the dynamics of stock in numbers and quantities, and on the effect of protection and restoration measures taken. This does not, in principle, rule out potential effects of other factors, including silver eel quality and/or climate factors. However, since the mechanisms involved have not been cleared up, and the quantitative impact on the stock is unclear, there is no way forward to include these aspects in international stock assessment at this moment in time. Further research will be needed, to elucidate the processes, to quantify the impacts, to find mitigation measures, to advise management targets, and to assess the net effects of measures taken on the eel stock. Until that has been done, prime focus in the stock assessment will necessarily rest with "classical" fish stock assessment, which for the eel case, will be complex enough.

Under the EU Eel Regulation, an international assessment will be required of the population-wide status of the stock, and an assessment of the impact of the management measures taken. The Regulation focuses on stock dynamics in terms of quantities and biomass and thus the assessment leaves aside scientific debates on the impact of spawner quality and/or climate factors. A decision tree diagram for this assessment is presented in Figure 3.1. The indicated steps are elaborated in the text below;

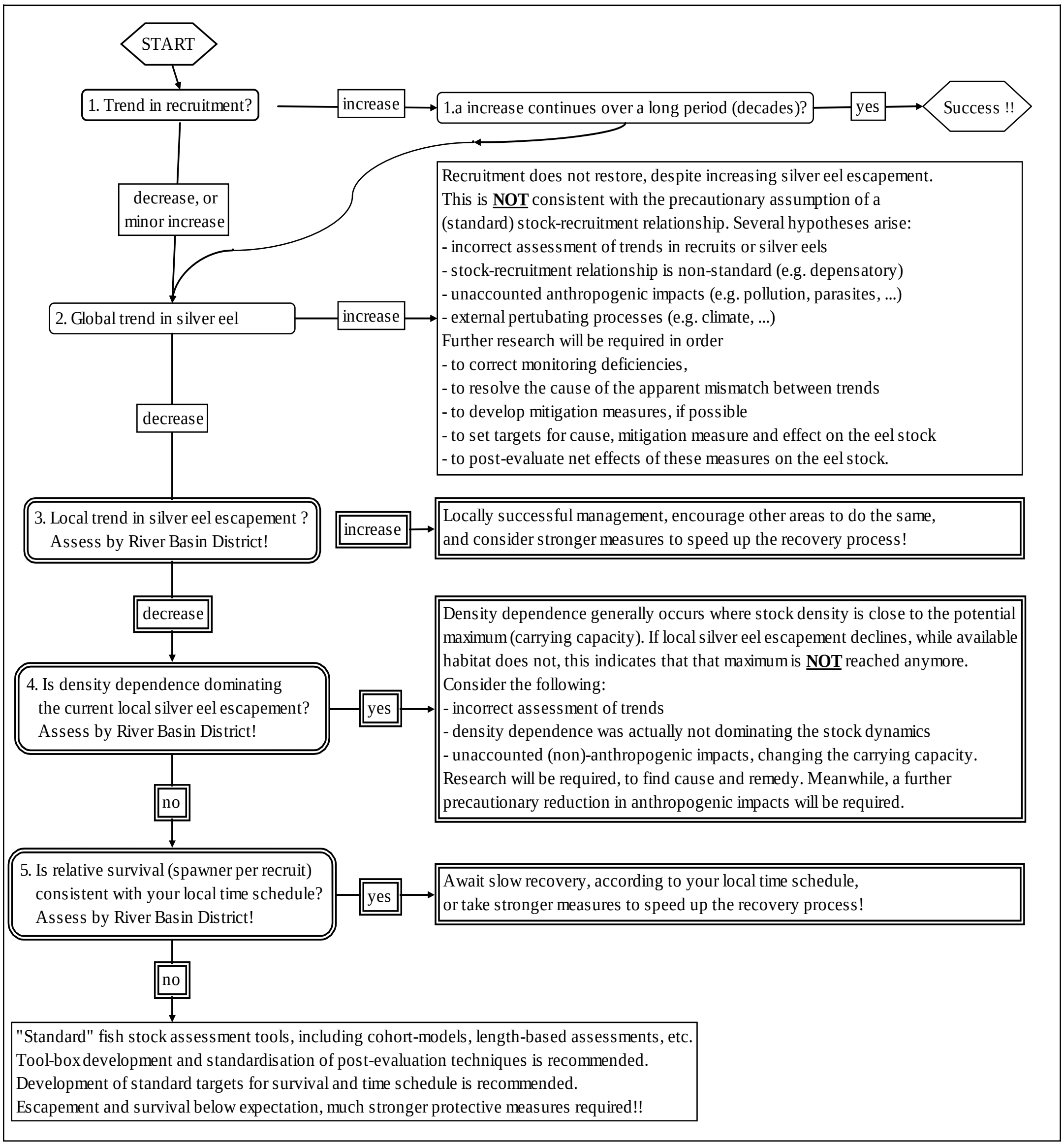


Figure 3.1: Decision tree for international assessment of the impact of protective measures taken under the EU Eel Regulation. International issues are depicted in a single-lined box, whereas River Basin Specific issues are in a double-lined box.

3.2.2 Only recruitment and escapement trends?

Taking a superficial view on first examination of the task of international stock assessment, it might appear that the time-series data on spawner emigration and glass eel recruitment are the only data items of information essential to international assessment of eel stock and recruitment. This view, however, ignores the reality of the current and probable future situation. Only if recruitment were to recover rapidly following measures to increase spawning stock, resulting in confidence that recovery is underway, would these two data items suffice. Such a rapid recovery is an unlikely scenario, given that our ability to increase spawning stock escapement significantly will be limited for at least an eel generation, as a consequence of the past 15 to 25 years of low recruitment yet to feed through to spawner emigration (Chapter 2 of this report). It is quite probable, therefore, that recruitment will continue to decline for some time, and it will be almost unavoidable that silver eel escapement will also decline considerably further for at least some years. The effectiveness of protection and restoration measures taken under the EU Eel Regulation will therefore have to be judged on a relative scale: the relative improvement of survival from recruit to silver eel. This necessitates the analysis of the full continental phase of the life cycle.

3.2.3 Issues of time-scale

The principal objective of WGEEL at its future meetings will be assessment, renewed annually, of the state of the stock and recruitment at an international level. The desired objective of current management is clearly that measures taken to protect and enhance spawner escapement result in increased recruitment. The time-scale for full evaluation of such success is long, and for assured confidence that recovery is underway, any recovery will have to be successfully tracked through the generations, that is: over decades.

3.2.4 If recruitment continues to decline

Should recruitment not respond positively to increased spawner biomass, and continue to fall whereas spawning-stock biomass is rising, then there are other factors operating than those included in the assumptions (that eel will follow classical stock–recruitment relationships).

Where such conclusion is reached, at any point in the assessment and study of eel, it would be evident that unknown factor(s) are acting on the stock–recruitment relationship. This brings in possibilities such as a problem in oceanic processes affecting migration, eel "quality" factors affecting spawning ability, genetic issues, or a new and unforeseen problem resulting in depensation in the S-R process. These scenarios would all force an urgent search through research programmes on possible additional causes of decline, which is of course an option at any stage where new evidence of detrimental factors arises. These "new" problems, however, have always to be researched through a process involving data gathering, correlation, quantification of cause and effect, development, proposal and adoption of mitigation measures, and post evaluation before they can be fully built in to the assessment of S-R or R-SSB processes. It is therefore necessary that the "new" lines of potential impact research are continually progressed through research programmes alongside the annual stock assessment process, so that when and if numerical estimates of their impact are available, these can be taken into account.

If recruitment does not respond to spawner enhancement measures, and spawning stock continues to decline, then the assessment process is required to investigate biological and mortality processes at a spatially disaggregated level. In principle, the analysis could proceed, at a biologically meaningful disaggregated level. In practice, however, the RBD level will be much more easily achievable. At this level, management measures have been taken, and data on stock, fisheries and other anthropogenic impacts have been gathered. Indeed, the probable situation over the coming two decades is at best continued low spawner emigration protected to some degree by measures to be taken under management plans required the eel regulation, with glass eel recruitment at best displaying a slow recovery but perhaps continuing its decline. Management plans may fail to generate any increase in spawners, some through no fault of the plans but simply as a consequence of the history of low recruitment, and some through inadequacy in the plan. In this scenario, it will become necessary to carry out a spawner-per-recruit analyses at the international level (that is probably the simple sum of river basin specific analyses) to distinguishing between these two possible causes of unpredicted low spawner production. This analysis will require access to data to examine processes operating at least at the eel management unit, and preferably the river basin level.

3.3 Data requirement

An internationally coordinated international stock and recruitment assessment for European eel has a minimum data requirement, which is not yet met. The data needed for future international stock–recruitment assessment are a minimum of:

1) Escapement estimates from all Eel River Basins, in absolute terms (biomass and numbers, by sex), combined with
2) Recruitment indices indicative of recruitment strength over the whole distribution area.

3.3.1 River Basin vs. international uses of data

The sum of the escapement estimates over the distribution area provides a proxy estimator of the spawning stock size, whereas recruitment indices quantify the offspring. The combination of spawning stock size and recruitment index facilitates assessments of stock status and analysis of the stock–recruitment relationship and potential effects of climatic factors on the oceanic life phase.

The analysis of the stock dynamics in the continental phase, i.e. a spawner-per-recruit analysis, requires data from the continental phase, which resides within national waters, within Eel Management Units (EMUs). Since the biological characteristics, as well as the anthropogenic impacts on the stock vary from region to region, a single unified assessment of the status of the stock will not be feasible, other than on an EMU by EMU basis.

Neither the Eel Regulation, nor the Water Framework Directive programmes oblige Member States to make the basic data available, though they do contain an obligation to report on the results to the Commission. The Data Collection Regulation, in contrast, does require Member States to make data available upon request, but no central database exists. A future WGEEL might have to specially request these data from the Commission. As indicated above, partial spatial coverage may allow for an analysis of trends in recruitment, but neither the assessment of the trend in silver eel escapement, nor the assessment of the relative survival over the continental life stages, will be feasible. A formal requirement, and a practical procedure to present and store the data, will have to be developed. Development of protocols, exchange procedures and databases will not be feasible within the framework of the international assessment working group.

3.3.2 Use of yellow eel data

Therefore, data on the growing yellow eel phase are not directly applicable to the first level of an international scale stock assessment. They are, however, essential to individual member states, or regions, for example as inputs to modelling silver eel escapement, or for providing interim data check points during the long growth term between recruitment and silver eel production. If the national or regional stock assessments are to be checked at an international level, the data on which these are based must be available in an accessible form.

3.3.3 The EU Eel Regulation

The EU eel recovery regulation requires specific national actions including the gathering of some eel data, and the supply of these data to the EU Commission upon request. It does **not** specify or require that this information is directly available to the WGEEL or to any organization except the EU commission. Furthermore, the data to be gathered as part of the management plan and subsequent reporting to EC under the stock recovery regulation is to be supplied to the EC at relatively long intervals of at least three years. The reporting cycle starts with the detail of management plans by the end of 2008, with subsequent reporting every three years, reducing in frequency to every six years after 2021. The Commission itself will make its first report to the EU Parliament in 2013.

Notwithstanding the fact that there is no built-in obligation to report these data to the WGEEL for stock assessment, the intervals in the reporting cycle under the EU Regulation are far too long to enable any rapid progress by WGEEL. For an assessment working group to make significant progress toward bringing eel in line with other international species stock assessments, annually updated data are required. The cross-compliance requirement between the recovery regulation and the CFP fishery data collection regulation obliges countries to make some data available annually. However, the DCR does not (yet) cover all data sources required for an assessment of the status of the stock, either at EMU or wider scales.

3.3.4 Checklist of actions required under the Eel Regulation and associated guidelines

Where data may be useful to international stock assessment this is displayed in **bold text**.

- Establishment of management plans by country or other eel management unit by end 2008, including:
- A list of management units and authorities responsible.
- An inventory or individual basins in each management unit.
- Justification for the use of a national scale plan if this option is selected.
- Maps revealing eel management units in relation to WFD river basin districts.
- **Annual catch, if fished, in Kg for each RBD of glass, yellow and silver eel. (this is not included in the regulation itself but is included in the Commission implementation guidelines).**
- Quantitative and qualitative description of eel fishery units.
- A list of fishers, licences, vessels licensed to local and EU waters, plus auctioneers and licensed dealers.
- **Quantitative and qualitative descriptions of eel fishery effort reflecting local situation and any reductions imposed.**

- A quantitative description of recreational eel fishing, i.e. numbers of fishers and their catches of eels.
- **Statement of which optional method(s) is used to define silver eel escapement of target 40%.**
- **A description of the silver eel 40% escapement target mode of measurement system used including its precision and accuracy.**
- A description of habitat condition, including non fishery mortalities e.g. caused by pollution, migration obstacles (**quantify this mortality if possible**).
- **An indication of the proportion of each life stage affected by contaminants, pathogens, parasites and degree of contamination.**
- **Qualitative and quantitative descriptions of past restocking and any intended as part of the management plan, with stocked areas.**
- **A quantitative estimate of how stocking, if to be used, will contribute to achieving the 40% escapement.**
- The proportion of captured less than 12 cm eel to be used for restocking.
- **Actual or estimated escapement relative to the 40% target, at time of plan submission (2008) with description of estimation methods used.**
- Price monitoring for glass eel markets.
- Description of the sampling system for catches and effort concerning all life stages of eel, with regard to Regulation (EC) No 1639/2001 (DCR).
- Measures to identify origin and traceability of live imports and exports.
- Determination that eel imported and exported from territory are captured within national (EMP) and international (CITES) rules.

In summary, this checklist identifies several items of potential use to future working groups, assuming that the WGs have access to all data, preferably in the year produced, rather than having to wait for the reporting cycle. By far the most relevant data for international use will be the silver eel potential and actual escapement estimates.

There are, however, very significant deficiencies in this data source as an aid to international stock assessment. Perhaps the most obvious gap is the failure of the regulation to secure a fishery-independent glass eel recruitment dataseries. The reliance on catch monitoring focuses the relevant part of the regulation on commercial glass eel fisheries, which may change markedly, resulting in loss of individual dataseries. As outlined above, the reporting cycle of three years is at intervals too long for any rapid progress to be made on international scale stock assessment. Many of the data highlighted, while of supporting interest, are not core requirements. The absence of a requirement for eel quality data are noted.

3.3.5 Data Collection Regulation

The cross-compliance link between the Eel regulation and the DCR process is a useful provision for stock assessment purposes. The DCR driven data provision is, however, dependent on continuation of commercial and recreational eel fisheries. There is no requirement for any fishery-independent eel sampling in the DCR or for any sampling to continue where and when fisheries close. Continuation of commercial eel fishing is far from guaranteed given the continuing downward trends in catches, the possibility of approaching economic extinction, and the probability of widespread cuts in eel fishing activity as a consequence of MS or RBD scale failure to meet the "40%" silver escapement targets required in the eel regulation.

Even while the DCR does apply and forces data collection, the minimum prescribed sampling is unlikely to provide sufficient data to compile a meaningful international scale eel stock assessment, as it does not contain yellow eel surveys. Although there will be some silver eel data where fisheries still exist, most DCR data will be on yellow eel fisheries, and as such will be of indirect value to international stock assessment. Silver eel fisheries are also likely to be the first target for closure when escapement targets are failed.

According to the DCR minimum stipulation for data precision level, the "fallback" option is to measure 100 eels for every 20 t landed. A dedicated workshop on national data collection of European eel (Dekker *et al.*, 2005) concluded that "… one sample per 20 t catch … was found to be inadequate …" and recommended that "15 samples per life stage, per management unit would be more appropriate". This workshop also stated that "The number of individuals per sample for length analysis was examined and there has been no analysis to date determining the precise levels required. Common practice would indicate that 100 individuals per sample may not be adequate for length and this should be increased to 200 per sample. SGRN (STECF) have strongly endorsed this recommendation in its December 2007 meeting. However, for some RBDs with small fisheries, the DCR sampling requirement exceeds the typical annual catch of yellow or silver eel, but as the EU Eel Regulation constitutes an international recovery plan, normal exemption rules do not apply.

The DCR on its own will not provide a framework to estimate the size of the spawning stock as the programme does not provide estimates of eel abundance in small fisheries or in those waters not fished.

3.3.6 Recruitment dataseries are not secured

EU concerted action 98/076 (Dekker, 2002) brought together the Europe-wide dataseries of recruitment sampling which now form the basis of the recruitment data reported annually to this WG. It was concluded at the time that better coverage was needed and proposals were made to establish new sites. Only two of these new sites (research sites in Greece) have been started, and some of the formerly active sites are now effectively stopped as a consequence of their dependence on fisheries now not commercially viable or a lack of glass eel produced for restocking.

3.3.7 Water Framework Directive

The WGEEL has noted on many occasions that the requirement for MS to monitor eels as part of inland fish populations under Water Framework Directive provisions may also aid stock assessment. Such monitoring is likely to gather some data on yellow eel and as such will be a data input to silver eel output models. However, given the broader aims of the Water Framework Directive, there is a high risk that the monitoring related to the WFD will be inadequate for the assessment of the eel stock. Inadequate spatial coverage, low selectivity for eel, underreporting actual eel catches and non-reporting for eel, have been observed.

3.3.8 Data availability for international analyses

Table 3.1 summarizes the assistance that currently active initiatives, including the eel regulation, DCR provisions, and WFD monitoring, may bring to international stock assessment. It is concluded that these, while welcome, will not provide any rapidly available source of data for a full international eel stock assessment. This objective can only be achieved by the establishment of nationally maintained database, made available for international compilation, of the key stock descriptors. These descriptors are emigrating silver eel numbers, biomass and sex ratio, and recruitment in terms of glass eel or young of the year numbers and biomass. The component and compiled data must be annually updated to enable examination of any stock–recruitment relationship. Only when such data exist will it be possible to bring eel population and stock- recruitment assessments to the level given to most other major internationally exploited fish species.

The list of data elements and supply in Table 3.1 includes the EMU or RBD level data as a requirement, over and above the simple need for aggregated total spawner emigration and glass eel recruitment indices. In almost all cases, these data do not currently exist and new dataseries need to be commenced, with international coordination ensuring a compatible approach end allowing future analyses of the disaggregated individual area components of the aggregated spawner production per recruit relationship.

Table 3.1: Summary of potential data provision as required by EU and other international legislative instruments, and WG data requirements for post-evaluation of the Regulation.

Data Element	EC Eel recovery regulation 1100\2007	Guidance document for preparation of EMPs	DCR	WFD	CITES requirement (if international trade exists)	Adequate coverage? Ok Not ok.	Required for stock–recruitment analysis (ocean)	Required for survival analysis (continent)	Not in assessment (further research required).
EMUs and River Basins	Y	Y		Y	(Y)	Listavailable 2009		+	
List commercial Fishermen	Y				(Y)				
Catch by recreational fishers	Y		Y			Tri-annual insufficient		+	
List of primary sellers	Y				(Y)				
Traceability in trade	Y	Y			Y				
Fishing Capacity		Y	Y		(Y)				
Silver eel escapement	Y	Y			(Y)	Tri-annual insufficient	+	+	
Potential SE escapement	Y	Y			(Y)	One off in 2008/9	+	+	
Fishing effort by métier	Y	Y	Y		(Y)	From DCR		+	
Landings, glass eel	Y	Y	Y		(Y)	From DCR		+	
Landings, yellow eel		Y	Y		(Y)	From DCR		+	
Landings, silver eel		Y	Y		(Y)	From DCR		+	

Data Element	EC Eel recovery regulation 1100\2007	Guidance document for preparation of EMPs	DCR	WFD	CITES requirement (if international trade exists)	Adequate coverage? Ok Not ok.	Required for stock–recruitment analysis (ocean)	Required for survival analysis (continent)	Not in assessment (further research required).
Catch composition -Length			(+)			From DCR		+	
Biological sampling for length, age, sex, maturity			+	(Y)		DCR, but only where fisheries exist		+	
Recruitment surveys						Incomplete, and no obligation!	+	+	
Yellow eel surveys				Y		WFD, low coverage and detail		+	
Silver eel "surveys"		Y				Tri-annual insufficient	+	+	
Hydropower mortality – No Stations		Y		Y	(Y)	EMP ,WFD Hydromorph data		+	
Hydropower mortality		Y – If info available			(Y)	Not for all sites		+	
Predation Losses		Y – If info available			(Y)	only partial coverage		+	
Eel Quality data[1]		Y				Only local data		+	

[1] e.g. fat content, contaminants, parasites and diseases.

Y =Required as a primary function; (Y)=Required as cross-compliance; + =Adequately covered; (+) =Partially covered but inadequate; entries in bold indicate data deficiencies, while entries in italics meet requirements. Eel quality includes pollution, parasites, pathogens and fat levels.

3.4 Stock assessment vs. research needs

The EU Regulation on eel aims at the restoration of the spawning stock and recruitment. Implicitly, it assumes that a stock–recruitment-relation (of the standard type) exists for the total stock. In Figure 3.1, a decision tree diagram is presented, in which the international assessment of the state of the stock and of the impact of protective measures under the EU Regulation are evaluated, on the basis of trends observed at the global and local level.

The EU Eel Regulation has set targets for the quantity (biomass) of silver eels escaping from the continent, and obliges Member States to take protective measures primarily focusing on the quantities escaping. No targets have been set with respect to other processes (e.g. related to silver eel quality, or climate change) in relation to eel management (if possible). The international assessment of the status of the stock therefore focuses on the dynamics of stock in numbers and quantities, and on the effect of protection and restoration measures taken.

However, the evaluation process depicted in Figure 3.1 (left hand column), provides diagnostics at several points in the evaluation process, judging the adequacy of the focus on quantities escaping only. When these diagnostics indicate a deviation from expectation, further research will be required to clear up the processes, to quantify their impacts, to find mitigation measures, etc. The right hand column of the decision diagram of Figure 3.1 presents a bare skeleton for the decision processes for these cases.

The final two columns in Table 3.1 reflect the current state of development of data and quantitative knowledge of how they affect processes, separating those data items essential now for database building to feed SPR analyses from those where there may be an impact on eel biology but where current and further research programmes need to be completed to quantify impacts and to allow these to be incorporated into mathematically based analyses of stock and recruitment processes.

3.5 Stock assessment

3.5.1 Mortality based management targets

If and when recruitment continues to decline and silver eel escapement is not improved (which situation is quite likely to occur in the coming years) a critical assessment of the stock status will be required for each River Basin District, indicating whether or not the targets of the EU Eel Regulation have been met. The target of the Eel Regulation has been set in terms of silver eel escapement biomass (40% in relation to a notional pristine production). There are many areas where that target can not be reached in the foreseeable future, as a consequence of the low recruitment in recent years, even if all anthropogenic mortality would have been removed immediately. Additionally, a phased implementation of protective measures might slow down the recovery in the earlier years following implementation of the Regulation.

However, the Regulation also requires Member States to specify a time schedule for the attainment of the target. The Regulation does not specify what time schedules will be accepted. Restoration times are more likely to be in the order of decades or centuries, than in terms of years (Åström and Dekker, 2007); if total anthropogenic mortality remains above a critical threshold (fishery mortality *F* plus other anthropogenic mortality H is 0.08 in that analysis), no long-term recovery is expected. Preliminary re-assessment of the time till recovery for specific parts of the distribution area (notably the southern areas with higher growth rates), presented during the working group meeting, confirms a decadal or centennial recovery period, and a threshold mortality level for long-term recovery, though the results differ in absolute values.

Since the Eel Regulation biomass target is not achievable in the near future in many areas, the mortality threshold for recovery is expected to represent the effective target to which the stocks, the anthropogenic impacts and the protection measures will have to be judged. The implicit character of this mortality threshold (being derived from the time schedule, as an unacceptable "keep steady" limit) pleads for the derivation of an explicit mortality target, corresponding to the time schedule requirement and/or the biomass target of the EU Eel Regulation. A general, area-independent target is recommendable, e.g. %SPR. Whether this index of life time mortality actually suffices for eel, needs to be investigated.

3.5.2 Density dependence and stock assessment

The long continued and widespread decline of the European eel stock has led to adoption of a protection and recovery plan, based on classical concepts in fisheries biology for precautionary reasons. This concerns, first and foremost, the assumption of a classical stock–recruitment relationship in the oceanic phase. In its continental phase, however, the eel is scattered over a multitude of small water bodies (Dekker, 2000), in almost all EU Member States and surrounding areas, often under local management. Biological characteristics of the continental waters vary, both at short distance (e.g. from the coast, via rivers and lakes, to headwaters, marshes and ditches) and between geographical areas (from productive lagoons in the Mediterranean, via densely populated rivers in the Bay of Biscay, to extensive cold waters in the Baltic, producing low densities of large old females). Because of the wide variety of ecosystems in the continental phase, no single uniform approach to protection and assessment will suffice. Some local stocks will be adequately represented by classical population models such as life table models, but others will not. Perhaps the most conspicuous deviation is found in places where density-dependence dominates the local stock dynamics. Where this occurs, an increase in recruitment, as strived for by the recovery plan, will not result in a (proportional) increase in the stock and in the silver eel escapement. Where and when this occurs, the classical models of (density independent) stock dynamics will not be applicable. Loss of production potential can occur in these waters as a consequence of habitat loss, or loss of accessibility (migration barriers). Otherwise, the presence of density-dependence indicates that the stock is at or, close to, its maximum density (carrying capacity), and restrictions of anthropogenic impacts will probably not increase silver eel escapement very much. Consequently, management actions should primarily focus on mitigation of habitat loss. However, we do not know in how many rivers density-dependence is evident, and the continued decrease in recruitment will decrease their number over the years. Where and when density-dependence is insignificant, classical concept in fish stock dynamics, such as life time survival, spawner per recruit, and maximum sustainable yield can be applied. Derivation of (standardized) criteria for density-dependence, and adaptation of (standard) fish stock assessment models to the peculiarities of the eel for density independent cases is required.

3.5.3 Assessment tools

The EU Eel Regulation obliges Member States to assess the current state of their stocks, and to assess the expected impact of proposed management actions. The international stock assessment, as discussed here, will post-evaluate the status of the stock, and the net effect of management measures taken. That is: the focus is on the actual state of the stock, rather than on expected impacts. The field of fish stock assessment is particularly well developed for marine fish stocks, including techniques such as cohort analysis, length frequency based assessments, survey based assessments, etc. Existing experience in post-evaluation assessment techniques for eel fisheries is extremely limited (see Dekker *et al.*, 2006 for an overview). Taking advantage of the experiences in marine fish stock assessments, the construction of adequate post-evaluation techniques for eel stocks is an achievable challenge. In contrast with "standard" marine fish stock assessment techniques, anthropogenic impacts other than fisheries (e.g. predation, hydropower, eel quality), the spatial distribution of local stocks within river systems, migration and migration barriers should also be taken into account. It is recommended to develop these tools internationally, making optimal use of available expertise and funding, and involving data and experts from various geographical areas.

The adoption and implementation of the EU Eel Regulation will set an unprecedented breakpoint in eel stock management, and will it is to be hoped lead to a major breakpoint in stock trends. Consequently, the application of the above mentioned post-evaluation assessment techniques will have to cope with unprecedented datasets. It is therefore suggested to explore the use of constructed reality, that is: to apply the tools being developed on data derived from (other) simulation models.

3.6 Conclusions and recommendations for Chapter 3: International stock assessment and data needs

The absence of any internationally driven requirement to maintain a recruitment dataseries needs to be corrected, with reference to the recommendations of the EU contract 98/076: Establishment of a recruit monitoring system for glass eel.

Internationally coordinated eel recruitment monitoring should be included in the requirements for the DCR.

The WGEEL notes that for future meetings it will need:

- The means to compile data on spawner emigration and glass eel recruitment,
- The means to assess RBD level spawner output per recruit relationships with the full access to EMU level data that entails.

The WGEEL further notes that:

- Current legislative instruments including the Eel Regulation, DCR, CITES and WFD do not, either individually on in combination, contain sufficient provisions to ensure adequate data supply for such assessments.
- There is an urgent need to develop assessment and post-evaluation tools adapted to the eel case.

4 Assessing stocks and management actions

4.1 Background theory on population dynamics

4.1.1 Introduction

The reproductive process is one of the main mechanisms that controls and maintains fish populations. In fisheries science, the phase from adult spawning stock to new-born recruits contributing to the stock is known as Stock-Recruitment (S/R) relationship. It is the evolutionary mechanism by which fish stocks "buffer" the effect of varying food and spatial resources. The S/R relationship is most often explored by examining the empirical relationship between the spawning stock size (or its proxy) and the subsequent recruitment output which results from a complex chain of events through spawning, ova deposition and larval and juvenile growth and survival. In fish stocks, the S/R relation is often the main resilient mechanism buffering the exploitation mortality.

The mechanisms that determine the S/R relationship can be categorized as density-dependent and density independent. Density independent mechanisms imply that the individual chance of survival for a youngster is independent of its parent's stock size and the number of eggs produced, giving rise to a linear relationship between the spawning stock size and the number of recruits produced across the range of spawning stock sizes. This model must have limits since no population can increase indefinitely given that resources are finite, and fully density independent relations are not observed in practice. At high spawning stock size, compensatory mechanisms ultimately limit population size by maintaining some ceiling on the level of recruitment, i.e. density-dependence becomes dominating. Several mathematical models have been used to describe the shape of S/R models (i.e. Beverton-Holt, Ricker) but these all take a similar general shape at low stock sizes and largely only differ in the upper ranges of stock size, which is of little concern for depleted stocks.

Figure 4.1 describes a theoretical S/R relationship of the Beverton-Holt type. The solid line describes the relation between the number of spawners and the subsequent number of offspring (recruits). This has an almost density independent phase (nearly linear) at low stock density (spawning stocks of 0 to 10, recruitment of 0 to 40) and an upper density-dependent phase, when the curve levels off (see above).

It is relatively simple to understand this relationship for local stocks such as salmon or sea trout where the spawning effort and juvenile production takes place in individual catchments and where density-dependent factors such as space for spawning and food availability are clearly finite resources. It is much more difficult to envisage how this might operate for eel which has an oceanic spawning and larval phase, given the lack of knowledge of the spawning and early life history of the eel in the Sargasso.

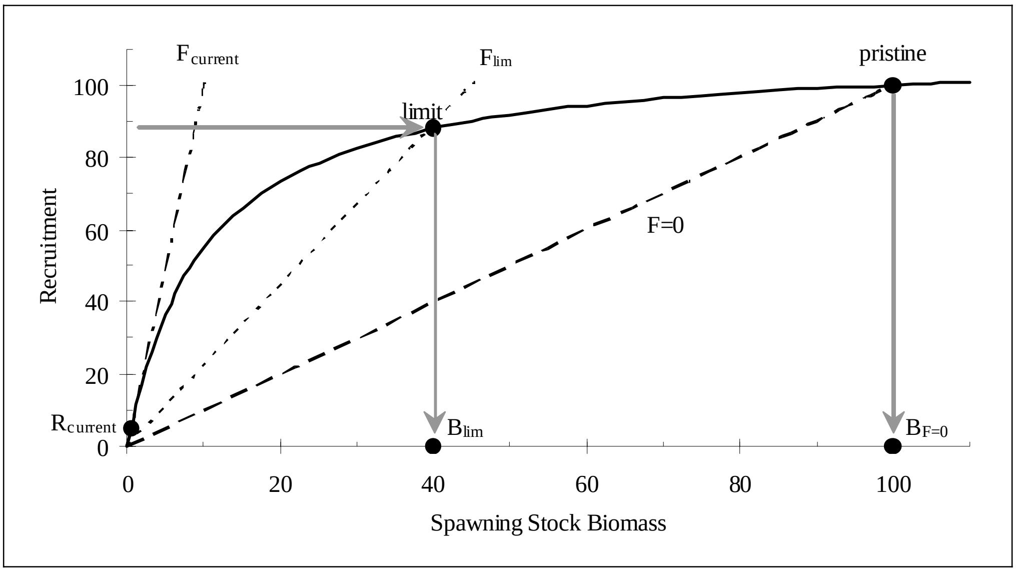


Figure 4.1: Hypothetical Stock-Recruitment relationship, showing a Beverton and Holt-type relationship, the solid line indicates what recruitment is produced at what spawning stock size; the broken lines indicate what spawning stock can be derived from a given recruitment, at no fishery (F=0, dashes line), at maximal, just sustainable fishery (F_{lim}, dotted curve) and current non sustainable fishery (and other anthropogenic sources of mortality) ($F_{current}$, dot-dashed curve). Both Recruits and Spawning Stock Biomass are given in arbitrary units. The EU Regulation sets the minimum target at 40% of the pristine spawning-stock biomass, which will keep recruitment close to its maximum, but on the brink of impaired recruitment. The intersections between the two types of curves determine equilibrium biomasses (densities).

So, population dynamics and resulting equilibrium levels can be analysed through the use of curves for SSB->R (from Spawning Stock Biomass to Recruitment) and R->SSB (from Recruitment to Spawning Stock Biomass) (see Figure 4.1) where:

- Recruitment in this context is assumed to be the biomass (or number) of glass eels that successfully arrive to continental waters after having survived juvenile density-dependent mortality in the oceanic phase. An alternative could be to define recruits as a somewhat later stage like: glass eels settling (or elvers) in continental waters, and thus include the possible local density-dependence in the early processes when glass eels arrive at the continent.
- Spawning stock biomass is the magnitude of the effective spawners, i.e. the ones that are successfully reaching the Sargasso Sea and actually spawning.

Equilibrium points correspond to intersections points between the two types of curves.

The SSB->R curve depends upon oceanic factors such as spawner, success, currents, food availability, etc, whereas the R->SSB curve depends upon mortality cumulated during continental lifespan. Particularly, mortality rates *F+M* (anthropogenic and natural) cumulated in the lifespan (from glass eel to spawner) determines the slope of the R->SSB relationship and consequently the equilibrium level. Higher levels of mortality rates determine equilibrium points corresponding to lower values of both R and SSB.

Note that spawner quality might be explicitly included in the SSB->R relationship as an additional mortality considered that "bad spawners" die before spawning, but after leaving the continent, or simply produce less offspring.

4.1.2 Eel stock and stock decline

In recent years[1], the development of the precautionary approach in fisheries management and the exploitation of stocks have received much attention along with the development of fisheries management tools and the provision of scientific advice. The precautionary approach dictates a risk-averse strategy, in which no fish stock is exploited at a rate higher than one that generates maximum yield, and no spawning stock is reduced to low levels, at which recruitment impairment occurs. In the absence of pertinent knowledge to the contrary, a S/R relationship should be assumed to exist, even for eel. The existing trends in eel landings and recruitment indices support this view, although the exact form of the S/R relationship has not been possible to determine so far.

Recruitment of European eel has been in decline since the early 1980s, and is below 5% of the historical level, since 2000. Total landings have revealed a gradual decline since the 1960s, down to approx. 25% of the former level (Dekker, 2003). The causes of the decline in recruitment are not well known, but might well be related to a low spawning stock. Given the continuously declining trend, data suggest that the present equilibrium point corresponds to extinction or very close to extinction. The ecology of eels makes it difficult to demonstrate a stock–recruitment relationship. However, the precautionary approach requires that such a relationship should be assumed to exist. Therefore, ICES (1999) advised to restrict fisheries and other anthropogenic impacts to the lowest level possible, in order to ensure that the spawning stock returns to then remains above the critical level B_{lim}, above which recruitment is not impaired by the size of the spawning stock. Classical fishery management set the critical spawning-stock biomass level (B_{lim}) at 30% of that in absence of fishery. Due to the fundamentally different biology of the eel (semelparous with high longevity, panmictic and scattered over the whole continent), the WGEEL suggested a higher B_{lim} of 50% for eels, and EU Regulation opted for a 40% objective.

As an alternative strategy to setting SSB target at an uncertain (30, 40 or 50%?) percentage of the notional pristine SSB (which is not easily estimated), with an unknown corresponding level of recruitment, another approach might be the following: In the 1970s, recruitment of glass eel was still at historically high levels. This indicates that SSB was not limiting the production of recruits at that time. Quantification of the pre-1980 spawner escapement therefore is the simplest derivation of a reference level. Note that in this case, the full escapement (100%) of the silver eels in the 1970s (given the anthropogenic mortality of that time) then is assumed to correspond to the escapement level advised by ICES (2002). That is, one could either set this interim reference threshold at 100% pre-1980 silver eel escapement where the data are available, or in the absence of data, at a percentage of the notional pristine state.

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[1] United Nations Convention on Law of the Sea (1982).

UN Conference on Environment and Development (Rio de Janeiro, 1992).

FAO, Code of Conduct for Responsible Fisheries (1995).

4.2 Targets

In general it can be expected that achieving the target defined by the European Council (council regulation No 1100/2007) through management actions will take a very long time. Åström and Dekker, 2007 estimated the time to full recovery of recruitment (the ultimate goal of the management of the eel) to be at least 80 years, if all eel fisheries were closed and none of the other mortality issues addressed. The long-term target defined by the EC then becomes hard to apply in practical management terms. So, for practical reasons short-term, management unit based, interim targets (here called interim targets) need to be defined in connection with management measures to be taken (Figure 4.2).

These interim targets need then to be translated into sub-targets for action on the local scale, which can range in geographical scale from a point source such as a hydropower plant or fishery to the catchment or the scale of the Eel management Unit. This is required as the efficiency of management action has to be evaluated in a short term compatible with the time-scale of the responsible managers and this is shorter than the expected time span for the recovery of the eel stock. Therefore short-term, sub-targets are needed to optimize regional management according to the long-term objective of full stock recovery (Figure 4.2). The sub-targets will be split into management sub-targets directly linked to the set-up of management and into eel sub-targets aiming at increasing the production of eel on a local or regional scale. Management sub-targets may be defined as the number or magnitude of actions taken, i.e. number of dams with passes installed, reduction of fishing mortality, number of habitats and amount of eel stocked. In contrast an eel sub-target could, as an example, be related to the abundance or density for 0+ eel in predefined sections of a catchment.

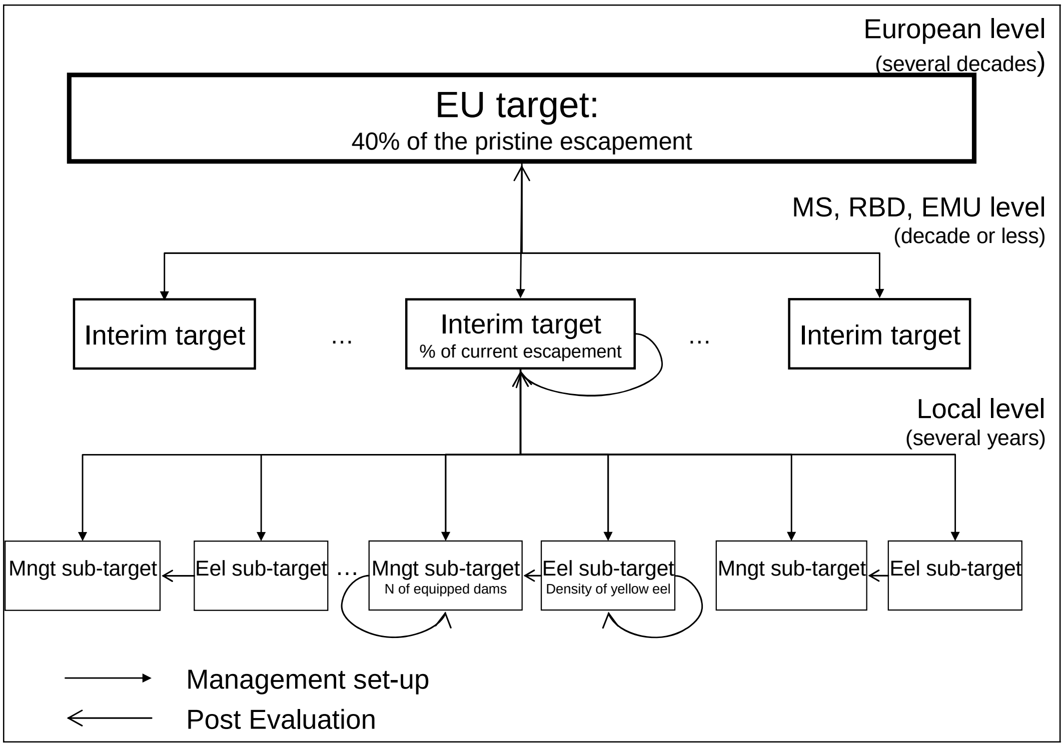

Figure 4.2: Schematic representation of different targets, interim targets and eel and management sub-targets.

Both types of target (eel life stage sub-target; management sub-target) should be possible to post-evaluate, i.e. it should be possible to empirically measure the outcome of the management effort relatively soon after it has been applied, and member states are required to collect relevant data to achieve this. For each type of management measures different time-scales for the response in the relevant eel life stage can be expected.

A link between the outcome of the post-evaluation and future management restrictions should be established. In principle, one could use a qualitative link; i.e. whenever the spawner production is below the sub-target, the managers increase their restrictions. However, a quantitative link is preferable, if not a prerequisite as the EC target is defined in quantitative terms; i.e. the post-evaluation method should indicate what level of restrictions is required to achieve the sub target.

The level of the interim and sub targets should be defined so that the long-term target defined by the council regulation No 1100/2007 ("… reduce anthropogenic mortalities so as to permit with high probability the escapement to the sea of at least 40% of the silver eel biomass relative to the best estimate of escapement that would have existed if no anthropogenic influences had impacted the stock. "), (or other relevant, stricter, targets), has a high probability of being reached, in reasonable time. The expected differences in time until different measures result in increased spawner escapement have to be considered in this context.

If reaching the long-term target is not possible, based on the current eel stock within an Eel Management Unit (EMU), and the time schedule for the attainment of the target level of escapement cannot be calculated (although such a time schedule is required by the council regulation No 1100/2007), managers might consider using a stepwise approach with increasingly more ambitious interim targets in sequence over time. This could mean starting out with interim targets and short-term measures based on currently achievable improvements in the eel stock, given the current low recruitment (e.g. a high % of current possible escapement) then moving to an interim target related to escapement of pre-1980 (e.g. 40% of possible (without anthropogenic impact) escapement of the pre-1980), then increasing the required percentage of pre-1980 escapement (e.g. 100% of escapement pre-1980) to finally be able to aim directly for 40% of pristine escapement.

It will need to be remembered that when calculating expected spawner escapement from each RBD/EMU, in response to management measures, it must be emphasized to consider information on the recent recruitment decline, which in most cases will impose a decreasing local stock of eels in the near future, and consequently a declining spawner escapement, which need to be counteracted by the level of the management measures. This also raise the risk of getting a situation where an escapement target might be reached one year, just to drop below the next year being in the risk of a continued decline despite the management measures taken.

4.3 Estimation of spawner escapement

The Regulation suggests three options for determining the target level of escapement (Article 2.5):

(a) using data collected in the most appropriate period prior to 1980 to estimate silver eel escapement, provided these are available in sufficient quantity and quality;

(b) a habitat-based assessment of potential eel production, in the absence of anthropogenic mortality factors;

(c) extrapolating with reference to the ecology and hydrography of similar river systems.

4.3.1 Estimation of silver eel escapement pre- and post-1980

The definition of silver eel needs to be standardized for escapement estimates. The difference between silvering and silver eels has to be clear and the adoption of the same criteria all over Europe is therefore required. These distinctions have been made clear by some authors (e.g. Acou *et al.*, 2005; Durif *et al.*, 2005) and following them we propose three criteria, which include eye diameter, state of lateral line (presence of black corpuscles) and body colour contrast. It is essential that a standardized method of silver eel identification is adopted for escapement studies.

Estimations of silver eel escapement are available from a number of studies; these are summaries in Tables 4.1a and b for assessments pre and post 1980, respectively. The geographical distribution of the studies data are shown in Figure 4.3. Silver eel escapement is defined as the total number or weight of silver eel that left the catchment, expressed per unit wetted area available to eel for comparison between catchments. Potential silver eel escapement is defined as the number, or weight, of silver eel that would leave the catchment, without anthropogenic mortality, and for Tables 4.1a and b, this has been calculated as the sum of silver eel escapement and the catches of silver and yellow eel and any mortality from other causes (hydropower, illegal fishing, etc).

Pre-1980 data are available from 25 locations (Table 4.1a). For river systems where lakes are a small proportion of the available habitat for eel production estimates ranged from 1.9–49 kg/ha (n=4). For catchments where there is a sizeable lake component to the overall wetted area (>50%) the estimates ranged from 0.3–17.4 kg/ha (n=4). For lakes, with the exception of the Ijsselmeer where production was estimated at 40 kg/ha only minimum estimates based on silver eel yields from fisheries suggest a range of 0.1–11.7 kg/ha (n=14). For marsh type habitat there is a minimum estimate of 43.7 kg/ha and for lagoons one estimate of 20 kg/ha.

Post-1980, the number of assessments of production has increased, but remains dominated by lake studies from Sweden; 66% of the 50 studies (Table 4.1b). Estimates of potential silver eel escapement for rivers varied from 2.7–16.4 kg/ha (n=3), for lake dominated catchments from 0.2–6.4 kg/ha (n=4) and for lakes from a minimum (based on silver eel yield) of 0.04–4.4 kg/ha (n=35). Of the 35 lake studies, two the Shannon and Ijsselmeer provide an estimate of potential silver eel production of 2.7 and 4.4 kg/ha, respectively. There are three lagoon studies with estimates ranging from 6.2–30 kg/ha.

Table 4.1a: Estimated silver eel yield and production (in kg/ha wetted area), pre-1980.

Years	Country	River	Latt.	Long.	Catchment surface area	wetted area available to eel	Waterbody type	Trophic status (*mg P per l)	Catchment geology	Stocked	Silver eel yield (kg/ha)	Potential spawner escapement (kg/ha)	Method of calculation of potential spawner escapement	Reference or contact
pre-1980	Sweden	Mälaren	59.5	17.0		87200	Lake	0.026*		Yes	0.30		minimum estimate	Håkan Wickström
pre-1980	Sweden	Hjälmaren	59.2	15.8		47691	Lake	0.026*		Yes	0.50		minimum estimate	Håkan Wickström
pre-1980	Sweden	Vombsjön	59.0	15.4		1197	Lake	0.082*		Yes	7.40		minimum estimate	Håkan Wickström
1975-1982	Norway	Imsa	58.9	6.0	12800	1160	Lake/River	meso/oligotrophic	Siliceous	No		2.27	Direct count	Maria Korta
pre-1980	Sweden	Ringsjön	58.9	17.4		3918	Lake	0.06*		Yes	2.70		minimum estimate	Håkan Wickström
pre-1980	Sweden	Vänern	58.9	13.3		269100	Lake	0.008*		Yes	0.10		minimum estimate	Håkan Wickström
pre-1980	Sweden	Ången	58.8	17.2		242	Lake	0.092*		Yes	0.40		minimum estimate	Håkan Wickström
pre-1980	Sweden	Glan	58.7	16.0		7390	Lake	0.033*		Yes	0.20		minimum estimate	Håkan Wickström
pre-1980	Sweden	Ymsen	58.7	14.0		1310	Lake	0.073*		Yes	3.40		minimum estimate	Håkan Wickström
pre-1980	Sweden	Roxen	58.5	15.7		9500	Lake	0.031*		Yes	0.70		minimum estimate	Håkan Wickström
pre-1980	Sweden	Sommen	58.2	15.0		13035	Lake	0.011*		Yes	0.10		minimum estimate	Håkan Wickström
pre-1980	Sweden	Fardumeträsk	57.8	18.9		340	Lake	0.042*		Yes	1.20		minimum estimate	Håkan Wickström
1988	Denmark	Bjørnsholm å	56.9	9.2			River	Meso/Eutrophic	Sand/gravel	no		19-36 (range)	Mark recapture	Bisgaard and Pedersen, 1990
pre-1980	Sweden	Åsnen	56.6	14.7		14753	Lake	0.022*		Yes	0.61		minimum estimate	Håkan Wickström
pre-1980	Sweden	Ellestadsjön	55.5	13.7		264	Lake	0.061*		Yes	6.34		minimum estimate	Håkan Wickström
pre-1980	Sweden	Krageholmssjön	55.5	13.7		205	Lake	0.114*		Yes	11.65		minimum estimate	Håkan Wickström
1965-1979	UK Northern ireland	Bann	55.1	-6.5	494277	40,000	lake with minor river	Eutrophic	Siliceous	Yes	5.8	17.4	Fishery Yield plus mark -recapture	Derek Evans/ Robert Rosell
1981	Denmark	Brede aa	55.0	8.5	42500	65	River	Meso - Eutrophic	Sandy/muddy	No	19.7	49.0	Mark recapture	Nielsen 1982
1965-1979	Ireland	Erne	54.5	-8.3	437500	33 000	Lake/river	Eutrophic	Calcareous	no	0.2	1.3	fishery yield plus mark-recapture	Derek Evans/ Robert Rosell
1942-1944	England	Leven	54.2	-3.1	25400	1546	Lake/river	Oligotrpohic	Siliceous	No		0.3	Large scale experimental trapping (minimum estimate)	Lowe (1952)
pre-1980	Germany	Elbe	53.9	8.8	14826800	239130	River			Yes		5.1	Model estimate	Uwe Brämick
1971-1979	Ireland	Burrishoole	53.9	-9.6	8400	474	Lake/river	Oligotrphic	Siliceous	No		0.9	Direct count	Russell Poole
Pristine	Netherlands	Ijsselmeer	52.8	5.4		175000	Lake	0.1*	Mud and sand	No	0.2	40.0	Cohort model	Dekker pers. comm
1950	Netherlands	Polders	52	5			Polder		Mud/sand	No	14.1		minimum estimate	VanDrimmelen 1953
1950	Netherlands	Lakes	52	5			Lake		Mud/sand	No	21.2		minimum estimate	VanDrimmelen 1954
1905-1941	France	Certes Marshes	44.7	-1.0	150		marshes				43.7		minimum estimate	Aubrun 1987
pre-1979	Italy	Comacchio	44.6	12.2	10000		Lagoon					20.0	Total count	Rossi 1979

Table 4.1b: Estimated silver eel yield and production (in kg/ha wetted area), post-1980.

Years	Country	River	Latt.	Long.	Catchment surface area	wetted area available to eel	Waterbody type	Trophic status (*mg P per l)	Catchment geology	Stocked	Silver eel yield (kg/ha)	Potential spawner escapement (kg/ha)	Method of calculation of potential spawner escapement	Reference or contact
post-1980	Sweden	Vigdansystemet	63.5	16.8	-	58	Lake	0.009*		Yes	0.60		minimum estimate	Håkan Wickström
post-1980	Sweden	Storsjön	63.1	14.4	-	147	Lake	0.034*		Yes	0.64		minimum estimate	Håkan Wickström
post-1980	Sweden	Mälaren	59.5	17.0		87200	Lake	0.026*		Yes	0.41		minimum estimate	Håkan Wickström
post-1980	Sweden	Hjälmaren	59.2	15.8		47691	Lake	0.026*		Yes	0.42		minimum estimate	Håkan Wickström
post-1980	Sweden	Öljaren	59.1	16.0		1791	Lake	0.051*		Yes	0.04		minimum estimate	Håkan Wickström
post-1980	Sweden	Hasselforssjöarna	59.1	14.7		1884	Lake	0.012*		Yes	0.18		minimum estimate	Håkan Wickström
post-1980	Sweden	Sottern	59.0	15.4		2780	Lake	0.018*		Yes	0.36		minimum estimate	Håkan Wickström
post-1980	Sweden	Tisnaren	58.9	16.0		3785	Lake	0.017*		Yes	0.16		minimum estimate	Håkan Wickström
1983-2007	Norway	Imsa	58.9	6.0	12800	1160	River	Meso/oligotrophic	Siliceous	No		1	Direct count	Maria Korta
post-1980	Sweden	Ringsjön	58.9	17.4		3918	Lake	0.06*		Yes	2.49		minimum estimate	Håkan Wickström
post-1980	Sweden	Vänern	58.9	13.3		269100	Lake	0.008*		Yes	0.08		minimum estimate	Håkan Wickström
post-1980	Sweden	Bondsjön	58.8	16.0		33	Lake	0.024*		Yes	0.60		minimum estimate	Håkan Wickström
post-1980	Sweden	Ången	58.8	17.2		242	Lake	0.092*		Yes	0.25		minimum estimate	Håkan Wickström
post-1980	Sweden	Glan	58.7	16.0		7390	Lake	0.033*		Yes	0.33		minimum estimate	Håkan Wickström
post-1980	Sweden	Ymsen	58.7	14.0		1310	Lake	0.073*		Yes	2.50		minimum estimate	Håkan Wickström
post-1980	Sweden	Roxen	58.5	15.7		9500	Lake	0.031*		Yes	0.13		minimum estimate	Håkan Wickström
post-1980	Sweden	Vättern	58.3	14.7		56600	Lake	0.005*		Yes	0.00		minimum estimate	Håkan Wickström
post-1980	Sweden	Sommen	58.2	15.0		13035	Lake	0.011*		Yes	0.04		minimum estimate	Håkan Wickström
post-1980	Sweden	Fardumeträsk	57.8	18.9		340	Lake	0.042*		Yes	1.23		minimum estimate	Håkan Wickström
post-1980	Sweden	Högvadsån (Nydala K	57.3	12.9		2338	Lake	0.017*		Yes	0.06		minimum estimate	Håkan Wickström
post-1980	Sweden	Rusken	57.3	14.3		3396	Lake	0.02*		Yes	0.20		minimum estimate	Håkan Wickström
post-1980	Sweden	Tjärnesjön	57.2	12.9		318	Lake	0.017*		Yes	0.20		minimum estimate	Håkan Wickström
1980- 2007	Latvia	Daugava	57.0	24.2		3871	Lake/river	Eutrophic	Calcereous	No	0.03*		minimum estimate (brown & silver)	Janis Birzaks
post-1980	Sweden	Bolmen	56.9	13.7		17319	Lake	0.015*		Yes	0.38		minimum estimate	Håkan Wickström
post-1980	Sweden	Unnen	56.9	13.5		1686	Lake	0.015*		Yes	0.24		minimum estimate	Håkan Wickström
post-1980	Sweden	Åsnen	56.6	14.7		14753	Lake	0.022*		Yes	0.03		minimum estimate	Håkan Wickström
1980- 2007	Latvia	Barta	56.5	21.1		3797	Lake/river	Eutrophic	Calcereous	No	0.1*		minimum estimate (brown & silver)	Janis Birzaks
post-1980	Sweden	Ivösjön	56.1	14.4		5017	Lake	0.01*		Yes	0.12		minimum estimate	Håkan Wickström
post-1980	Sweden	Råbelövsjön	56.1	14.2		630	Lake	0.031*		Yes	0.48		minimum estimate	Håkan Wickström
post-1980	Sweden	Vombsjön	55.7	13.6		1197	Lake	0.082*		Yes	2.85		minimum estimate	Håkan Wickström
post-1980	Sweden	Snogeholmssjön	55.6	13.7		247	Lake	0.061*		Yes	2.16		minimum estimate	Håkan Wickström
post-1980	Sweden	Sövdesjön	55.6	13.7		272	Lake	0.061*		Yes	0.92		minimum estimate	Håkan Wickström
post-1980	Sweden	Ellestadsjön	55.5	13.7		264	Lake	0.061*		Yes	3.90		minimum estimate	Håkan Wickström
post-1980	Sweden	Börringesjön	55.5	13.3		277	Lake	0.109*		Yes	2.25		minimum estimate	Håkan Wickström
post-1980	Sweden	Fjällfotasjön	55.5	13.3		173	Lake	0.109*		Yes	3.33		minimum estimate	Håkan Wickström
post-1980	Sweden	Krageholmssjön	55.5	13.7		205	Lake	0.114*		Yes	3.87		minimum estimate	Håkan Wickström
2003-2007	UK Northern ire	Bann	55.1	-6.5	494277	40000	lake with minor river	Eutrophic	Siliceous	Yes	3.2	6.4	Fishery Yield plus mark -recapture	Derek Evans/ Robert Rossell
1989-1999	Ireland	Erne	54.5	-8.3	437500	33 000	Lake/river	Eutrophic	Calcareous	no	0.3		fishery yield plus mark-recapture	Derek Evans/ Robert Rosell
1994-1995	England	Leven	54.2	-3.1	25400	1546	Lake/river	Oligotrpohic	Siliceous	No		0.3	Resistivity fish counter	Knights et al., 2001
2000-2007	England	Leven	54.2	-3.1	25400	1546	Lake/river	Oligotrpohic	Siliceous	No		0.2	Resistivity fish counter	Miran Aprahamian
2005-2007	Germany	Elbe	53.9	8.8	14826800	239130	River			Yes		2.7	Model estimate	Uwe Brämick
1996-2006	Ireland	Burrishoole	53.9	-9.6	8400	474	Lake/river	Oligotrphic	Siliceous	No		1.3	Direct count	Russell Poole
2001-2007	Ireland	Corrib	53.5	-9.3		28869	Lake/river		Calcareous	No	0.5	1.7	Catch plus escapement plus estimated unreported catch	Lughaidh Ó Néill/ Russell Poole
2001-2007	Ireland	Ennell	53.5	-7.4		1433	Lake	Mesotrophic	Calcareous	Upstream transfer		2.7	Catch plus escapement	Kieran McCarthy
1992-1994	Ireland	Shannon Lakes	53.0	-8.3		42465	Lake/river			Upstream transfer		4.2	Catch plus escapement	McCarthy et al. 1994
2001-2007	Ireland	Shannon	53.0	-8.3		42465	Lake/river		Calcereous	Upstream transfer		2	Catch plus escapement plus estimated unreported catch	Lughaidh Ó Néill/ Russell Poole
2000	Netherlands	Ijsselmeer	52.8	5.4	175000		Lake					4.4	Length structured cohort analysis	Dekker 2000
2000-2002	France	Oir	48.6	-1.3	8700	22.9	river	meso		no		6.3	Direct count	Eric Feunteun
2000-2003	France	Frémur	48.6	-2.1	6000	59.9	Lake/river	eutro		No		1.9	Direct count	Eric Feunteun
2001-2005	France	Loire	47.2	-2.3	16600		River	Eutrophic		No		16.4	mark recapture	Eric Feunteun
1989-1990	Italy	Commacchio lagoon	44.6	12.2	10000		Lagoon					6.2	Total count	De Leo and Gatto 1995
2007	France	Camargue	43.5	4.4	11000		Lagoon					25.0	Direct count and validated model	Bevaqua et al. in prep
2007	France	Bages Sigean Lagoor	43.0	3.1			Lagoon		Calcereous	No	6.0	30.0	mark recapture	Elsa Amilhat
pre-1984	Sardinia, Italy	Porto Pino Lagoon	39.0	8.6	10000		Lagoon					19.0	Total count	Rossi and Cannas 1984

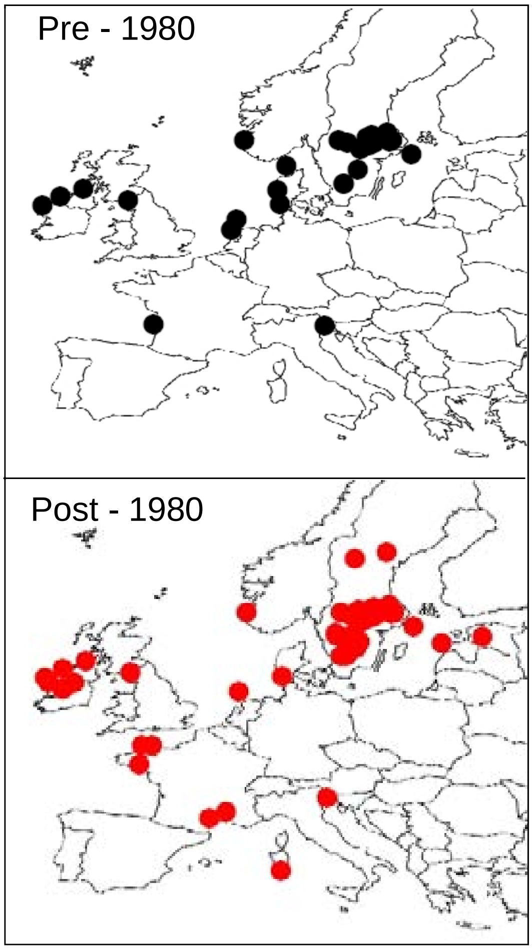

Figure 4.3: The location of the catchments for which historical (pre-1980 black) and recent silver eel production estimates (post-1980 red) are presented in the Tables above.

4.3.2 Modelling approaches

A number of modelling approaches have been made to estimate escapement or a reference condition to assess compliance with the EU escapement target.

The models are:

- Reference Condition Model (RCM)
- Eel Length Structure Analysis (ELSA)
- Scenario-based Model for Eel Populations (SMEP)
- Global Anguille (GLOBANG)
- Length-based Virtual Population Analysis (LVPA)
- Swedish Analytical Models (SWAM)
- Demographic Model of the Camargue (DEMCAM)
- Glass eel model to assess compliance (GEMAC)

These models and their potential to support the EMPs have been described by EIFAC/ICES WGEEL and Dekker *et al.*, 2006. In addition during the meeting a number of other approaches have been presented to the WGEEL as non peer-reviewed worked examples.

4.3.2.1 Elbe population dynamic model (Oeberst *et al.*, submitted)

An age based model has been developed by Oeberst *et al.*, submitted to examine the population dynamics of eel in the River Elbe (Germany) and estimate the number of eel emigrating from the catchment. The model inputs are quantity of immigrating young eel, number (and weight) of eel stocked, natural mortality and mortality caused by commercial and recreational fishing, cormorants, and hydropower plants. The structure of the model allows the sensitivity of the parameters to the overall estimate to be examined. The model may be used to develop management strategies and to assess the effectiveness of different management options to meet the EU target. It has the advantage of simple adjustment by being modular constructed and can be further developed using MS-EXCEL.

The model assumes that eel remain in fresh water for a maximum of 20 years. The available data for describing the different factors which influence the stock dynamics have different quality. Total catch (kg) per year is estimated for the commercial fishers and angler. The mean weight of the catch (g) and age–length based samples are only available from some areas of the Elbe and short periods. Length based estimates exist for the transformation of yellow eel to silver eel and for the eel which are taken by cormorants based on stomach samples. To combine the different data types a procedure is necessary for transferring length based data into age based data.

For the model it was assumed that eel age >8 were fully recruited to the fishery, this is based on a minimum size limit of 45 cm for commercial and recreational fishers. Recruitment is composed of natural immigration of glass / yellow eel based on monitoring estimates and stocked eel from published reports. Natural mortality is assumed to be constant at 13% (M=0.14) per year (Dekker, 2000). For recreational anglers the total weight of eel caught was the product of the total number of anglers and the mean weight of the catch. The amount of eel consumed by the cormorant population was estimated based on the number of cormorants, their residency time, the daily food intake and the average proportion of eel in their diet (Brämick and Fladung, 2006). The total catch of the commercial and recreational fishers and the consumption of eel by cormorants were converted from a weight based estimate to a number per age using weight to length conversions and a von Bertalanffy growth model. A length based logit-function was used to estimate the proportion of silver eel in the catch of eel by fishers and in the eel consumed by cormorants.

In addition, some general assumptions were used for estimating the catch in number by age group and year because appropriate data are lacking: The age frequency of the catches by fishers and anglers is similar to the age frequency of the stock combined with the requirement that eel younger than eight years are not landed; silver eel are not landed by fishers or the landings can be neglected.

Even though the model is adjusted to the conditions in the river system and to the availability of data, it also includes several assumptions and uncertainties. Therefore, the results of the model will have to be validated by monitoring the stock, especially by silver eel monitoring.

4.3.2.2 Irish model to estimate silver eel escapement (Ó'Néill and Poole, in prep.)

Catch based estimates of historic/pristine escapement

The calculation of pristine productivity for exploited catchments requires estimates of silver eel escapement along with historic silver and brown eel catches (Figure 4.4). Historical catch records for silver eel fisheries were available for the five catchments of the Corrib, Moy, Garavogue and Erne. The efficiencies of the fisheries had been previously estimated for the Shannon, Corrib and Erne silver eel fisheries. Where fishery efficiency was not measured an approximately average value of 33% was used to calculate escapement. In addition to the catch at the recording station and escapement past the recording station the brown eel and silver eel catches made upstream were included to estimate pristine productivity. In the absence of historical data for these latter parameters (brown and silver eel catches upstream of the recording station) it was assumed that the yields were equal to those currently observed (2001–2007).

Brown eel yield was assumed to be equivalent to the same weight of potential silver eel. This assumption was based on the logic that in a system subject only to natural mortality, migration would only be delayed such that fecundity (related to weight) would be maximized. Consequently, it is unlikely that there would be a net loss of weight in subsequent years from a cohort. Finally, the productivity estimates were corrected by the level of unreported and illegal fishing. Unreported yield was derived as the ratio of unreported licences to licences issued within the relevant River Basin District between the years 2001–2007. The proportion of the fishery yield taken illegally was assumed to be equal to that estimated for the Shannon by the DEMCAM (SLIME) model (Dekker *et. al.*, 2006). For those catchments with hydropower, an estimate of the impact was derived by imposing a 28.5% mortality per turbine passage (WGEEL, 2002). Therefore, the probability of surviving passage through 'n' number of hydropower installations is $(0.715)^n$.

The estimated pristine spawner escapement ranged from 0.9–5.4 kg/ha with a mean of 3.9 kg/ha (Table 4.2).

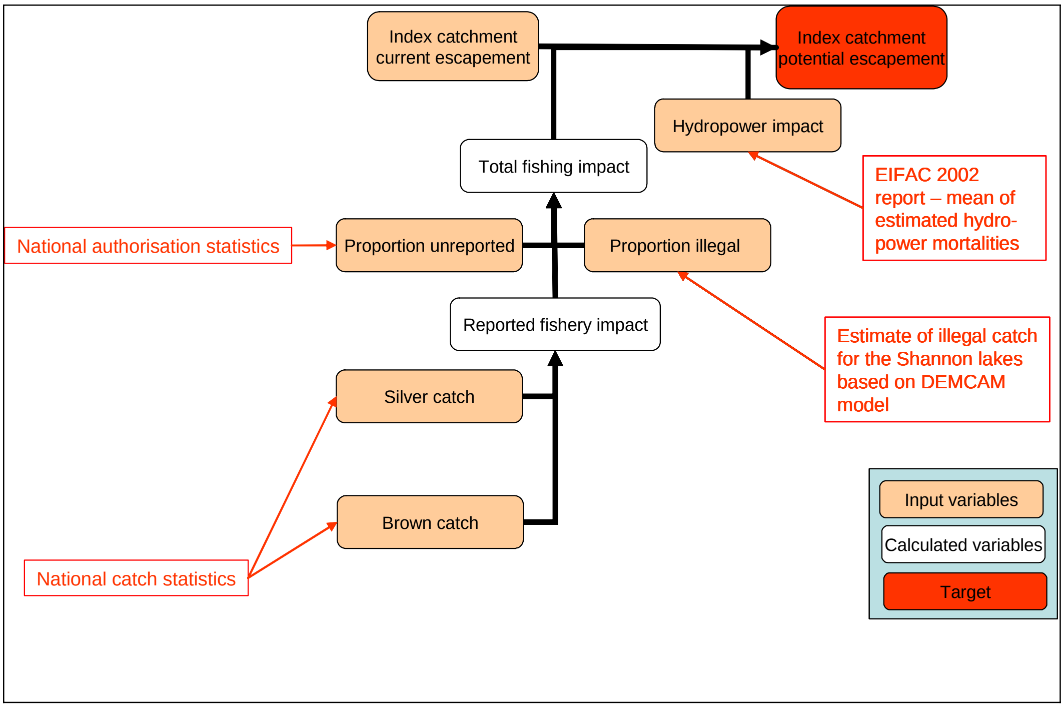

Figure 4.4: Description of how potential production (escapement) was derived from the current escapement of catchments where estimates of silver eel escapement, fishery yield and the impact of hydropower are available.

Table 4.2: Estimated pristine spawner productivity from five Irish catchments based on either direct measurement and/or catch data.

		MOY	GARAVOGUE	ERNE	CORRIB	BURRISHOOLE
		1942–1952	1962–1975	1955–1982	1976–1982	1971–1980
Silver eel catch at recording station (t)		3.4	0.9	9.2	19.4	0.0
Escapement past recording station (t)		6.8	4.4	51.3	38.8	427.5
Brown eel yield upstream (t)	Reported	4.0	1.7	13.4	9.0	0.0
Brown eel yield upstream (t)	Unreported	3.0	1.2	23.4	6.5	0.0
Silver eel yield upstream (t)	Reported		0.0		18.6	0.0
Silver eel yield upstream	Unreported	29.1	1.2	9.2	13.4	0.0
Hydropower impact (t)		0.0	0.0	25.4*	0.0	0.0
Wetted area (ha)		8418.0	1783.0	25.9	28869.0	475.0
Productivity (kg/ha)		5.3	5.4	4.5	3.4	0.9

***occurs following recording station.**

Potential production based on habitats of similar characteristics

The method involved determining the relationship between productivity and the geological characteristics of the catchment.

Growth rate of eel were available for 17 catchments (Moriarty, 1988, Central Fisheries Board). The wetted area within each catchment was quantified using a geographical information system and classified according to the proportion of the catchment area comprising non-calcareous geology. For 17 catchments growth rate was found to be closely negatively related to the proportion of the catchments comprising non-calcareous geology (Figure 4.5) (r^2=0.67; p<0.0001).

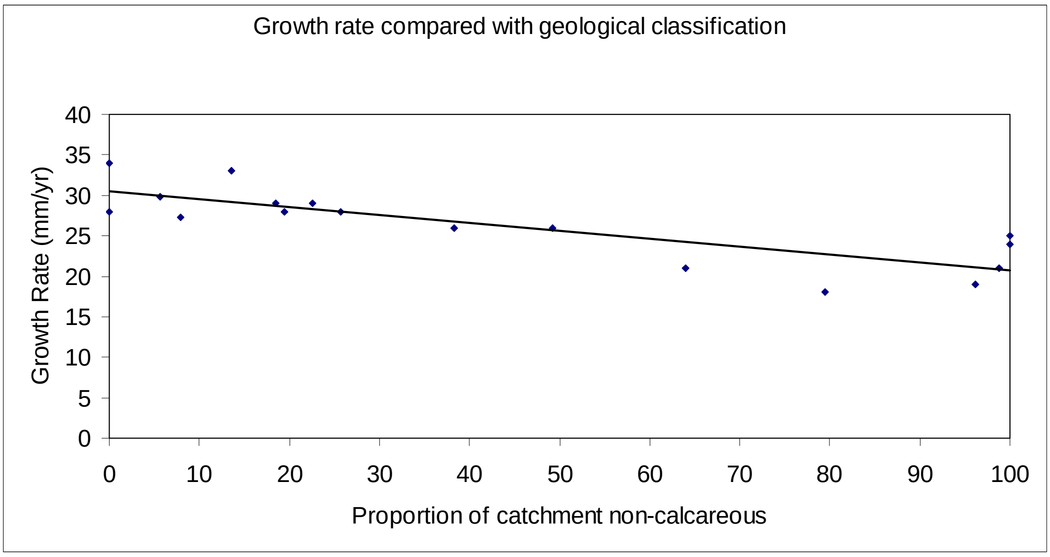

Figure 4.5: The relationship between growth rate and the proportion of the catchment comprising non-calcareous geology.

The four catch-based production estimates along with the direct estimate for the Burrishoole (Table 4.2) were plotted against the proportion of non-calcareous geology within the catchment (Figure 4.6). These historic estimates suggest that in exclusively non-calcareous catchments silver eel productivity was approximately 0.9kg/ha whereas in predominantly calcareous catchments silver eel productivity averaged about 4.5kg/ha.

An obvious weakness in the relationship presented in Figure 4.6 is the distribution of the data, with very few data for intermediate or non-calcareous catchments. To increase the robustness of the model the 5 available productivity estimates were used to convert the growth-rate estimates for 17 catchments into pristine production estimates.

Potential silver eel productivity was regarded as a product of recruitment, natural survival and average silver eel weight. Natural mortality was imposed at a constant rate of 14% per annum. This rate was chosen because the average age of Irish silver eels is approximately 18 years and the cumulative natural mortality over the continental life stages is approximately 2.5 (Dekker, 2004). The residence time was the time required for glass eels (70 mm) to grow to the Irish average silver eel length of 480 mm (sexes combined).

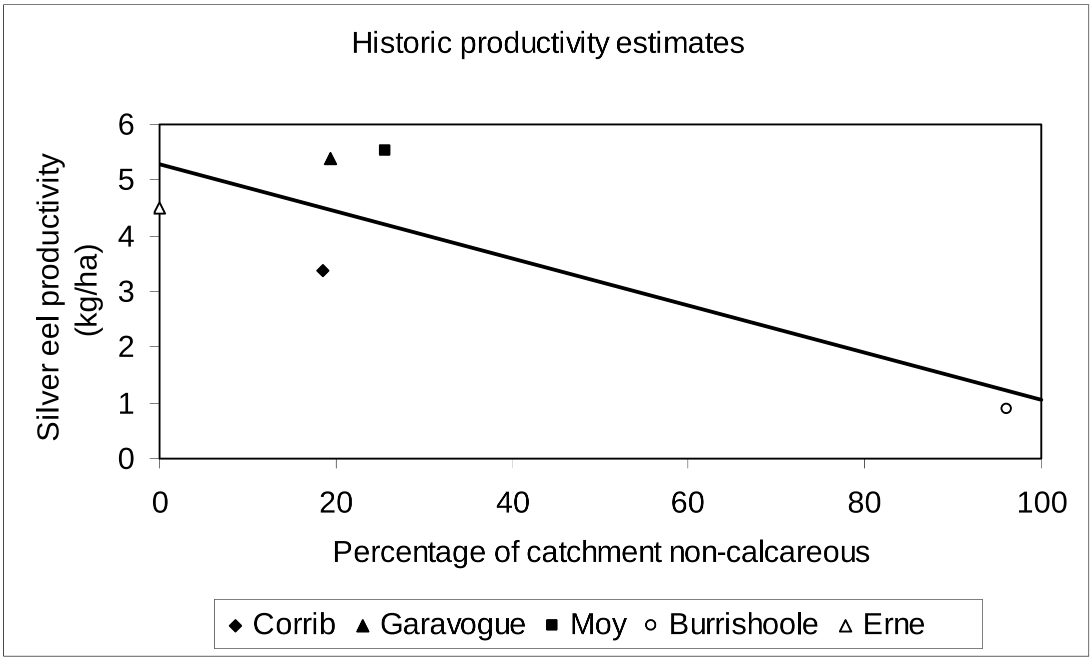

Figure 4.6: Catch based productivity estimates plotted against the percentage of catchment with siliceous (non-calcareous) geology.

For each of the 17 catchments the proportion of fish surviving (S) was thus estimated as follows:

$S = (1\text{-}0.14)^{((480\text{-}70)/G)}$

Where G = growth rate (mm/yr)

For those five catchments data on silver eel production was also available (Table 4.2) and these where used as index catchments to estimate potential spawner escapement as follows:

Spawner production$_x$ = (Survival$_x$/Survival$_i$) * Spawner productivity$_i$

Where i= "index" river; x = river where no estimate of spawner production is available.

This calculation was repeated using the survival and spawner productivity for each of the five "index" catchments and the mean computed. The relationship between the estimated productivity and geology for the 17 catchments is shown in Figure 4.7 together with the estimate for those five catchments where productivity had been measured either from catches of by direct measurement.

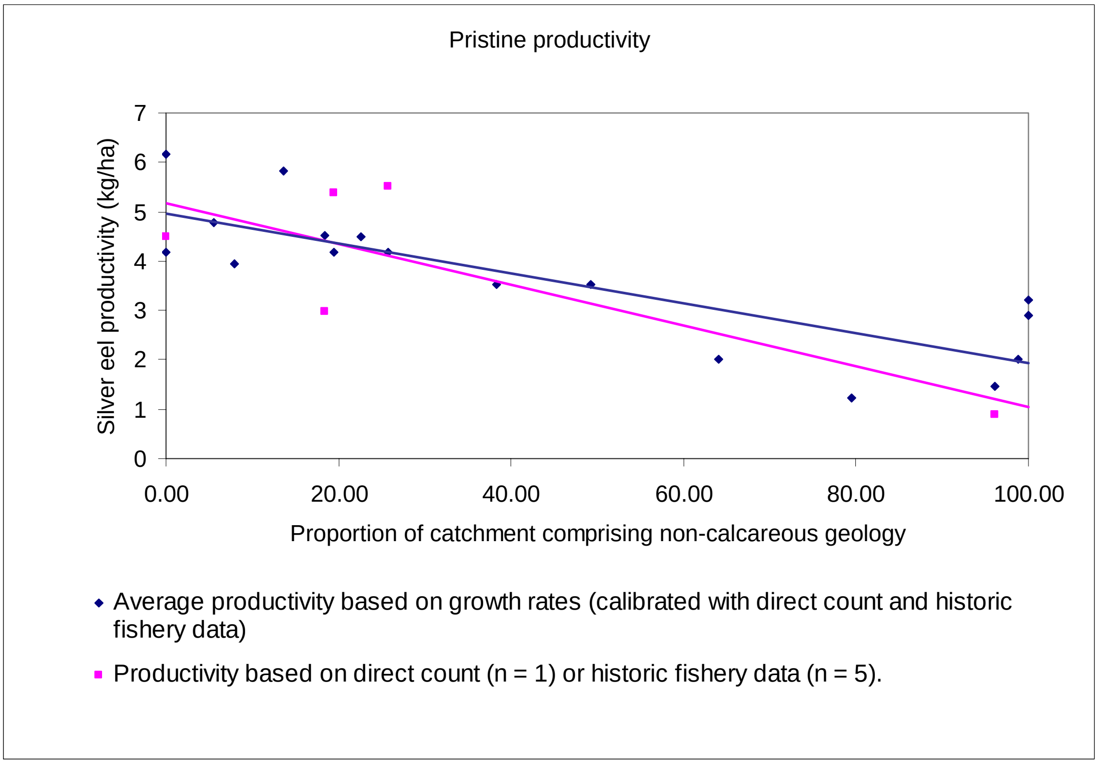

Figure 4.7: Relationship between silver eel productivity (kg/ha) and percentage of catchment with siliceous (non-calcareous) geology. The pink points are based on catch based or direct estimates of productivity. The blue points are based on the relative productivity of the catch based estimates but these are not included in the regression.

These data now allow for calculation of pristine productivity (kg/ha) based on either:

1) The relationship between silver eel productivity (based on four historic catch records and one historic total count) and the proportion of non-calcareous geology in the catchment using the regression equation:

Productivity (kg/ha) = -0.041*(percentage of catchment non-calcareous) + 5.18

2) The relationship between silver eel productivity (based on 17 growth rates calibrated with four historic catch records and one historic total count) and the proportion of non-calcareous geology in the catchment using the regression equation:

Productivity (kg/ha) = -0.030*(percentage of catchment non-calcareous) + 4.97

For Ireland pristine spawner production is estimated at 641 928 kg (4.17 kg/ha) using the regression based on historical catch or total count data and 651 092 kg (4.23 kg/ha) using the regression based on growth rates calibrated with historical catch or total count data.

As reliable data becomes available this approach will be taken to extrapolate from data rich to data poor situations where applicable. This approach is well established for salmon management in Ireland. The regression approach, as described, allows the transfer of data from index catchments with production estimates to catchments where little or no data exists on the basis of geological proxy for production.

4.3.2.3 French methodology to estimate silver eel production (Hoffman, unpublished)

The evaluation of the biomass of silver eel produced in continental waters at the French scale is based on modelling the yellow eel abundance. 20 000 electrofishing operations were used to fit the model. They corresponded to 9000 stations and cover the period 1980–2005. The model describes presence absence and abundance of total densities and densities per class size of 15 cm.

Four categories of variables were used: environment (distance to the sea, temperatures, altitude, geographical area), temporal (month, year), variables linked with anthropogenic pressure (habitat quality, obstacles, glass eel and yellow eel fisheries) and variables associated with electrofishing (fishing method).

The work is based on a GIS database of the French river network, which has been analysed to extract some environmental parameters (distance to the sea, cumulated river length upstream, river width, Strahler rank). Environmental parameters are extracted and densities are predicted in all points of the network. Setting anthropogenic parameters to zero, it is possible to predict the actual pristine productions. Temporal variables allow the prediction of past densities. The combination of both provides a figure of past pristine productions. Densities are converted into numbers by multiplying by the water surfaces.

The aim is to compare the estimated "pristine" 1989 densities with those determined during the 1960s and 1970s and if the latter are higher adjust the pristine 1989 estimate by a factor. This density would then be compared with current estimates (Figure 4.8).

The yellow standing stock will then be compared with actual estimates of silver eel production.

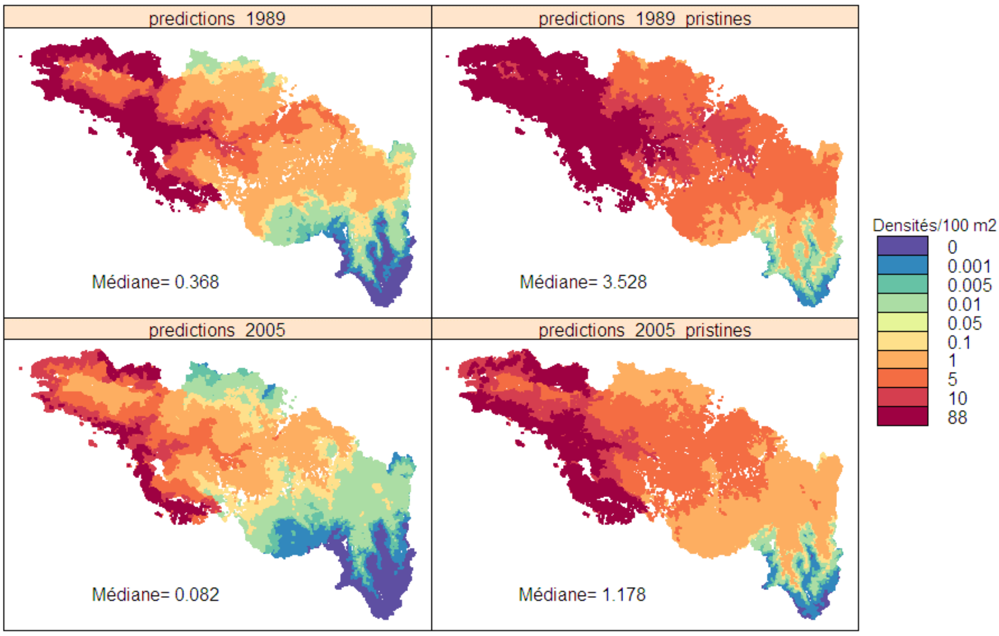

Figure 4.8: Model prediction in Loire Bretagne of the spatial variation in yellow eel densities (nb/100 m²). Surfaces are not yet calculated so the median of eel densities is shown on each graph. Pristine correspond to predictions without dam and with no glass eel fishery.

The predicted temporal trend in yellow eel densities estimated at the mouth of the river in the absence of dams for the period 1982–2005 is shown in Figure 4.9. After 1989 there is a steady decline in density. It should be noted that prior to 1989 the method of data collection differed, and the difference may reflect the lower density estimates.

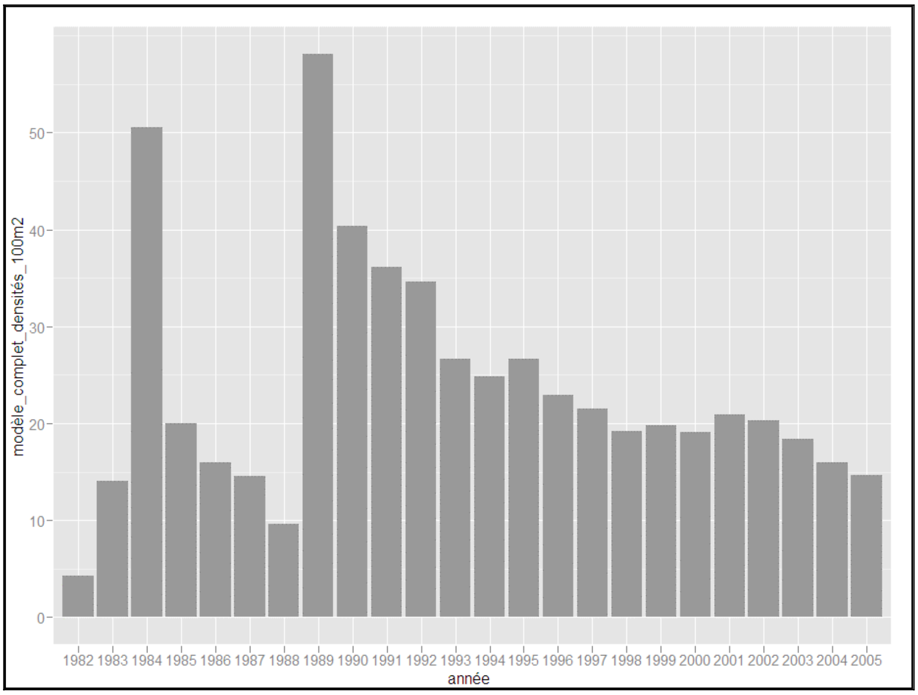

Figure 4.9: Model prediction of the temporal trend in yellow eel densities (nb/100 m²) in Loire Bretagne. The year effect was classified as category in both presence-absence and abundance when present models, the densities are those predicted at the mouth of the river, in the absence of anthropogenic impact.

For each obstacle the severity of the obstruction was estimated on a scale of 0–5 and for obstacles in series the impact was estimated to be cumulative. Obstacles have the effect of reducing the density of eel upstream (Figure 4.10). There is a rapid decline in density with an increase in the number and severity of the obstruction falling to approximately a third at a cumulative obstruction score of 50.

The model also predicted that eel density declines with distance from the sea (Figure 4.11).

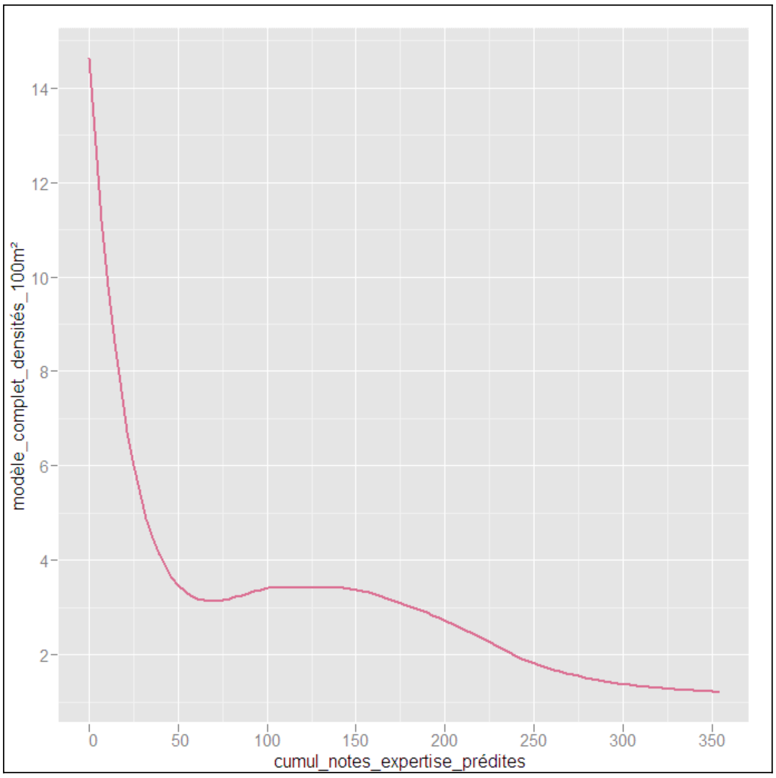

Figure 4.10: Model prediction in Loire Bretagne of the cumulated effect of obstacles. The effect of obstacles is expressed as a scoring (from 0 to 5 impassable). Densities (nb/100 m²) are predicted at the sea, in 1995, in the Loire, without anthropogenic impact.

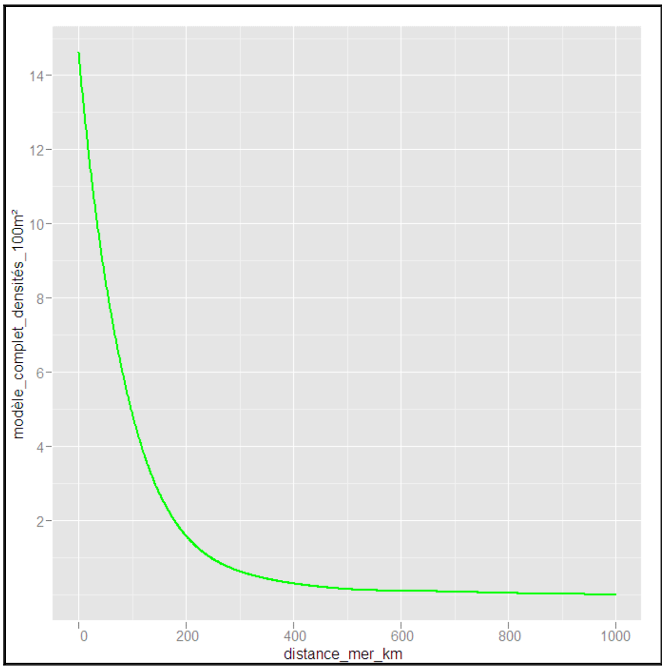

Figure 4.11: Model prediction in Loire Bretagne of the effect of the distance to the sea. Densities (nb/100 m²) are predicted in 1995, in the Loire, without anthropogenic impact.

4.3.2.4 Silver eel production in Danish streams (Pedersen, pers.comm.)

Silver eel production in Koge Lellinge stream was estimated to be 105 kg/ha river (wetted area) (Rasmussen and Therkildsen, 1979). The estimate was based on the density of resident yellow eels, observed growth (derived from age reading) and mortality with data collected during the period 1965–1968. The estimate is therefore based on glass eel recruitment during the period the late 1950s and early to mid-1960s. The population consisted mostly of males with mean weight of 100 gramme. The experiment was undertaken in the lowest part of the stream and downstream of a weir, the estimate therefore can not be taken as representative of silver eel escapement for the catchment as a whole but only the lower part of the river.

Silver eel production in River Brede was estimated to be 49 kg/ha river (wetted area) (Nielsen, 1982). The silver eel were caught in autumn 1981 using fykenets with the escapement estimated using mark-recapture and is thus based on the recruitment of glass eel during the period 1965–1975. The population of silver eel was 82% males and 18% females. Average weight was 120 grammes.

Silver eel production in the River Bjornsholm was estimated in 1988 to be in the range 9–39 kg/ha river (wetted area) (Bisgaard and Pedersen, 1990). Densities of resident yellow eel, observed growth rate (derived from age reading) and mortality produced an estimate of 39 kg/ha river (wetted area). This compares with an estimate of 9 kg/ha river (wetted area) from mark-recapture on silver eel carried out in August and September and therefore should be considered a minimum estimate of escapement. Sex ratios of silver eel were 40% males and 60% females with an average weight of 280 grammes.

In Denmark, it is proposed that 50 kg/ha (wetted area) represents "pristine" escapement for the fresh-water environment. This translates into the EU escapement target of 20 kg/ha (wetted area).

4.3.2.5 Quebec approach (Verreault and Lambert, pers. comm.)

A Canada-France-Québec research project was set up to evaluate impacts of barriers opening in terms of escapement and net productivity gain in the fresh-water habitats of the St. Lawrence watershed. This GIS decision tool will be based on eel habitat surface and eel distribution in a watershed. More precisely, the model is based on the exponential decrease of potential yellow eel abundance with distance from marine waters. Then the potential yellow eel density for every river stretch is modulated by the cumulative mortality and passiblity of downstream barriers then converted in absolute abundance of silver eel escaping the system. The model final output will be an estimate of potential production of oocytes by using a size-fecundity relationship.

4.4 Future methods for silver eel escapement (yellow eel proxies)

It is essential to adopt standardized methods to estimate escapement, potential biomass (*e.g.* biomass available in the river system) and also effective biomass (that will escape and that has reasonable probability to reproduce) derived from silver eel quality and mortality within the river catchment. Possible methodologies are outlined below and in the INDICANG methodological guide (Adam *et al.*, in press) not yet seen by the WGEEL.

Silver eels biomass production is a primary management target to be urgently achieved for starting the restoration of the European eel (*Anguilla anguilla*) population. An assessment of the proportion of individuals actually escaping from catchments-and able to reproduce-compared to a theoretical pristine production under no human intervention, is of critical importance for preserving this resource, and the EU obliges Member States to implement measures. However, there is currently very little information on silver eel escapement and even less information on silver eel quality (e.g. defined by parasite burdens, metallic and organic contamination of tissues, fat content). In order to estimate effective breeding biomass in data-poor catchments, research is required to develop and implement methods and protocols describing reliable proxies. Such research has recently started during the EU programme INDICANG that proposes to clarify some of the basic concepts needed to implement assessment tools for a characterization of the production of spawning biomass in a catchment. These concepts rely mostly on the influence of the catchment context (conditions for the eel growth) on the silver eel population characteristics (biomass and numbers, sex ratio, size and age structure, condition indices) before migration. The effective breeding biomass (escapement of high quality future spawners) is then estimated by attributing anthropogenic mortality rates (fisheries, hydroelectric turbines, dams and reservoirs). Risk analysis is also needed to define the proportion of eels that are healthy enough (low parasite burdens, high condition and fat content as well as low chemical contamination levels) for successful migration and to contribute to the gene pool. As a first step, this effective breeding potential should be estimated at the catchment area level from the sources to the sea. Then, regional approaches need to be developed and implemented to model relations between catchment characteristics and silver eel population characteristics (Acou *et al.*, in press).

Here we review different approaches which have been implemented or proposed to estimate silver eel escapement. The methods will soon be available and translated in four languages (French, English, Castillano, Portuguese) in Chapters 8 and 9 of a "Guide book for European eel monitoring" produced from INDICANG project (website references). Parts of the results are also presented in Robinet *et al.*, 2008. In addition to being able to quantify the status of the stock information is also needed on processes, particularly growth and mortality, as such there is a requirement to ensure standardization of the method(s) used to estimate age.

4.4.1 At the catchment level

4.4.1.1 Estimating silver eel biomass escapement

Direct estimates intercepting silver eel runs

a. Commercial silver eel fisheries can, depending on their location and scale, provide good opportunities for direct estimation of the numbers and biomass of silver eels escaping from hydrosystems, by analyses of annual variation in either yield or cpue provided that it is possible to determine the efficiency (proportion of run captured) of the eel capture systems involved. Examples of such investigations, of population dynamics and seasonal patterns of seaward migrating eels, include those undertaken on the River Loire, River Shannon and Corrib, River Bann (Lough Neagh outlet), the River Imsa, the Baltic basin and the St Lawrence. Difficulties can occur when the fishing season does not cover the full migration period or when there is significant eel production downstream of the fishery area. Use of mark/ recapture methods for estimation of fishery capture efficiency allows for estimation of the numbers and biomass of migrating eels at the fishing sites. This can involve use of a variety of tags and marks (see Concerted Action for Tagging of Fish: www.hafro.is/catag). Experimental fisheries could be established in data poor areas and used to improve fishery monitoring methodologies. (Vollestad and Jonsson, 1988; Caron *et al*., 2000; Feunteun *et al*., 2000; Feunteun *et al*., in press; Allen *et al*., 2006; WGEEL Baltic sea; and McCarthy *et al*., 2008).

b. Wolf traps, or related systems, or use of winged nets deployed for research purposes can provide precise estimates of migrating eel population dynamics and under some circumstances all silver eels can be counted and weighed. However, this is usually only possible in smaller river systems where discharge patterns allow for silver eel trapping throughout the migration season. Examples of this type of silver eel escapement estimation include the studies undertaken on the Norwegian River Imsa (Vollestad and Jonsson, 1988), the French Rivers Frémur (Feunteun *et al*., 2000) and Oir (Acou *et al*., in press), the Burrishoole (Poole *et al*., 1990; 1994) and the outlet of Lough Ennel in the River Shannon, Ireland (McCarthy, unpublished data).

c. Counters and various acoustic technologies can allow for the estimation of silver eel escapement in locations where eel capture is not possible. For example, hydroacoustic methods, such as were used by McCarthy *et al*., 2008 to investigate variations in numbers of silver eels migrating downstream in the headrace canal of the Ardnacrusha hydropower plant in the River Shannon, and resistivity counters and Didson acoustic cameras trialled for counting emigrating silver eel in the UK (M.A. Aprahamian, pers. comm.). Such eel counts, and linked data on size frequencies of the migrating eels, are only possible in locations where other fish species (with target strengths in the same range as the silver eels) are not also migrating downstream at the same time as eels. Work is in progress in Ireland, UK, Poland and other European countries that should lead to improved sampling protocols and to more widespread use of this method for estimation of eel escapement rates.

Indirect estimates using yellow eel proxies

In many water basins, lack of data concerning silver eel estimates, requires the use of alternative approaches to meet the demands of Council Regulation 1100/2007 for estimating silver eel escapement. The use of proxy indicators from sedentary eels and habitat population models seem to be the most promising approaches (Feunteun *et al*., 2000; Aprahamian *et al*., 2007; Lobon-Cervia and Iglesias, 2008; Feunteun *et al*., in press,). These procedures should nevertheless be standardized so that methodologies used can provide representative estimates of silver eel production, e.g. sampling at the beginning of the migratory season (late summer in southern latitudes and middle summer in northern latitudes).

Mark-recapture or other more locally adequate methods could be used to estimate density of yellow and silver eels. Several habitat types representative of each catchment should be evaluated in order to be able to extrapolate for the whole catchment and include it in habitat population models.

Eel mortality rates need to be determined throughout the river basin including the estuary as well as fresh-water habitat (see also Chapter 3).

In some countries, lack of data on both yellow and silver eels requires a different approach in which, habitat data collected within the WFD should be used in conjunction with eel population data from similar regional areas. However, EMPs based on this provisional approach should also include details of sampling programmes to provide a basis for future determination of spawner escapement.

Estimating effective silver eel biomass escapement

Effective silver eel biomass {proportion of the potential silver eel biomass * mortality (Fishery, Hydropower, Natural) * quality} estimation is essential if the actual contribution made by particular rivers, river basin districts or larger scale European regions is to be evaluated now and during post evaluation of EMPs. This integration of data on population dynamics and eel quality has not been subject to the detailed level of discussion to which other elements of the EU eel recovery plan have been subjected. However, a more standardized approach to this topic is required if results of ongoing studies on contaminants, parasites and diseases of silver eels are to be integrated at a European level.

4.4.1.2 Quality

Monitoring quality of silver eels should aim to establish the proportion of migrating eels that have sufficient quality to reach the spawning grounds, breed and produce adequate numbers of viable larvae. In analyses of silver eel populations the extent of quality monitoring will be more limited for eels released following capture and measurement. For released eels, the life-history stage determination, and the usual length and weight measurements, must be recorded for representative subsamples.

Observations of significant decreases in fat levels in yellow eels over 15 years in Belgium and the Netherlands raises serious concerns about their reproductive potential (Belpaire *et al.*, in press), and warrant the inclusion of eel quality estimates within the quantitative targets for escapement.

Considerably more parameters should be requested on a subsample of silver eels. These can involve data on contamination levels of metals and organic (for methods refer to quality section), fat content and condition factor, otolith age reading, *A. crassus* and EVEX and other viral diseases. Information on life-history traits and population characteristics should also be provided for sampled silver eel populations and this can involve sex ratio estimated from size frequencies (with calibration using sacrificed eels). There is a need to establish a size-age relationship and also an index relating eel quality to breeding success.

4.4.2 At the regional level

It is anticipated that the EMPs are developed under the River Basin District (RBD) level. The success of EMPs depends on a good coordination and consistency between measures taken under Regulation 1100/2007 and European Directives having impact in the river basin. Therefore, to make EMPs more effective, it is desirable that catchment based models are also developed at a regional level (involving each RBD), aiming at predicting silver eel escapement.

4.5 Methods for evaluation of management measures

A close link between both management and eel sub-target will be established in the following sections with regard to selected management measures (Table 4.3). The relationship between management and eel sub-targets will allow for a direct feedback to management if measures are not achieved and/or the locally targeted eel population responded, or failed to respond, in the predicted manner (e.g. an increase in yellow eel density). The methods to evaluate management measures and the response of the targeted eel life stages should be applied locally and therefore give a feedback to the authorities in the eel management units. By this feedback loop local managers will be able to adapt their management approach without regard to the delayed response of the whole eel stock (e.g. changes in recruitment). However the proposed management- and eel-targets are not intended to be an exhaustive list of all possible management measures. It should be taken as a first step in filling the gap between local management and the long-term recovery.

It is also recognized that methods for evaluating the outcome of management measures on the population level (eel sub-targets) are not always fully available and need further research. The same holds true for the definition of different quantitative levels of eel sub-target. The levels have to be related to the actual status of the eel population with respect to the global objective of full recovery (e.g. 40% of spawner escapement without anthropogenic impact). The level of the management action finally depends on how far a certain management unit is away from the objective (refer to Figure 4.2).

4.5.1 Management measures and methods for evaluation

4.5.1.1 Commercial fishery

EMP´s will involve fisheries regulation measures throughout the distributional area and across all continental life stages. A range of different measures can be identified and applied to the different life stages. Evaluating the effects may require different approaches and time frames.

Management sub-target 1.1: Effort restrictions. For all life stages, the regulation and limitation of the access to the fishery is a common measure that can be applied.

4.5.1.2 Glass eel fishery

Quotas and partial or total closure of fishing activities are the most plausible methods in managing a glass eel fishery.

Management sub-target 1.1; Achievement of Quota. A defined proportion of the recruits to a management unit is excluded from the local fishery. Evaluation should be based on knowledge of variation in abundance/catchability over time in the season and monitoring of landed quantities.

Management sub-target 1.2; Total or part time closure. A given degree of closure results in a predetermined reduction of fishery mortality. This target must be based on the knowledge of glass eel abundance over time in the fishing area and may be monitored by field control of fishing activities.

4.5.1.3 Yellow eel fishery

Quota, total or part time closure, size limits and closed areas are measures applicable in regulating most fisheries, including fishing for yellow eel. Technical regulations of the fishery for yellow eel may have different effects depending on where they are imposed in a catchment. If they are imposed downstream, in an estuary or near the area of primary recruitment, they may have an effect on density-dependent migration and thus proliferate upstream in the river basin. On the other hand, if they are introduced upstream in a system, where the subpopulation has a higher degree of residence, the expected effect will primarily concern demography and mortality. The statements above suggest different designs of monitoring and short-term evaluation.

Management sub-target 1.3; Quota. A defined proportion of the yellow eel stock in a management unit is excluded from the local fishery. Evaluation should be based on knowledge of the local production in the area and effects of a regulation can be monitored in landed quantities.

Management sub-target 1.4; Total or part time closure. A given degree of closure results in a predetermined reduction of fishing mortality. Evaluation of this target needs stock assessment models, which are often dependent of an existing fishery. A total closure thus is easier to evaluate.

Management sub-target 1.5; Size limits. Imposing size limits is targeting reduction of fishing mortality. Evaluation of this target needs stock assessment models, which are often dependent of an existing fishery.

Management sub-target 1.6; Protected areas. A management target for protected areas could be evaluated as the proportion of the available habitat or productive potential that is taken out of fishery. In this case, as in most other cases, the proper management target is a certain reduction of fishing mortality in the management unit.

4.5.1.4 Silver eel fishery

The most plausible tools to manage a silver eel fishery are total or part time closure and size limits. Protected areas may also be considered.

Management sub-target 1.7; Total or partial closure should fulfil the target to reduce mortality by a predetermined value. Evaluation must be based on a good estimate of the number of eel that would be caught if fishing was open and the total catch in the open season. This target may be monitored using landings and historical information on distribution of catches over the entire season.

Management sub-target 1.8; Legal size limits may include exclusion of the smallest as well as the biggest individuals from the landed part of the catch. This target should be set bearing in mind the total effect on effective SSB. Egg production may not be/is not linearly related to body weight (Verreault, 2002). Compliance with the target must rely on sampling of the size distribution in the total catch, discards included.

Management sub-target 1.9.; Protected areas. The effect of protected areas should target a certain proportion of the silver eel production in a management unit and should be restricted/closed for all types of fishing activity, i.e. F=0 for x% of the potential production.

4.5.1.5 Recreational fishing

In parts of Europe recreational fishery generates a major part of the fishing mortality. This kind of fishing is to a great extent focusing on the yellow eel stage but capturing silver eel may also occur (Staas, 2006). The measures available for managing this sector of fishery are primarily the same as those for the commercial fishery. Thus the biological targets are similar to those presented above under yellow eel fishery. All management actions described in the same section could be applied to recreational fishery. The presence of poaching though, may introduce the need for official control.

Management target 1.10.; Control of effort. This target should be the control of effort taken in a management unit or in predefined parts of a management unit.

4.5.1.6 Actions to make rivers passable and enhance habitat quality

Upstream migration

Management sub-target 2.1; number of dams where eel ladders will be installed, especially in and near the zone of active colonization:

Management sub-target 2.2; surface area of river channels and lakes in a catchment or a percentage of lost habitats that could become recolonized by eels.

Evaluation of management sub-target 2.1 and 2.2 could be achieved annually by listing of the recently equipped dams combined with GIS techniques of upstream surface measurement.

The conversion of the management targets into an eel sub-target assume that all habitats within a river system are equally productive per unit surface area and eels were totally excluded upstream of man-made obstacles (Verreault *et al.*, 2004; ICES 2007).

Management sub-target 2.3; number of fish passing over the obstacles. To determine these numbers an eel ladder should be equipped with a fish counting device (trap, video camera etc.). However, passage of fish may fluctuate a lot with several peaks during the migration period. For example, in the River Couesnon, 75% of the fish trapped occurred within four weeks whereas 17 weeks contributed to less than 10% of the total catch (Legault, 1994). The target in absolute numbers could be difficult to achieve in the short term especially when a decreasing recruitment trend is observed. It is probably better to define a relative target i.e. percentage of fish that succeed to migrate upstream. Briand *et al.*, 2005a undertook a survey of arrival near the obstacle by using a mark and recapture technique but this kind of application is difficult to execute and repeat for a long period.

Downstream migration

Current practice of stocking and the (recent) construction of fish passes have led to the establishment or maintenance of yellow eel population in habitats situated upstream of hydropower plants. In many cases these areas will be included into the natural eel habitat. But when reaching the silver eel stage a fairly large proportion of these eel are lost as a consequence of turbines passages and or impingement. Possible mitigation measures consists of installing bypass systems, switching off hydropower turbines temporarily and capturing downstream migrating silver eels (and incidentally yellow eels) before entering hydropower turbines.

Management sub-target 2.4; number of obstacles where appropriate bypass systems will be installed, or where hydroelectric power turbines should be switched off temporarily, or where trap-and-transport measures will be carried out.

Evaluation of this management target could be achieved annually by listing the recently equipped dams.

4.5.1.7 Reduction of environmental contamination

Management sub-target 2.5; reduction of pollutant discharge until total prohibition of use for the most dangerous contaminants.

The direct evaluation of such target is not simple because it is difficult to estimate the quantity of pollutants being input to the river, especially when sources of pollutant are diffuse.

4.5.1.8 Increase of habitat quality

Management sub-target 2.6; Wetted surface area of river where eel habitat quality is improved.

As with contaminants the direct evaluation of such a target is not simple because it is difficult to estimate the habitat quality and the relationship with the quantity of eel.

4.5.1.9 Stocking of glass eel or pre-grown (farmed) yellow eels

If stocking is to be used as a management measure according to the EU-Regulation, it has to be assumed that stocking is performed at the actual state-of-the-art (decision tree and stocking protocols are available; see Chapter 5) with respect to carrying capacity and sufficient quality of the chosen habitats (see relevant data collected under the WFD). The health status of material used for stocking with special regard to parasites, viruses and other pathogens has to be checked. Additionally silver eels produced from such stockings should be able to escape from the habitats without major losses as a consequence of pumping stations or hydropower turbines.

Management sub-target 3.1 Defined proportion of habitat with low recruitment in the management unit for supplementation of eels and number of eels stocked per surface unit (ha) according to available eel surplus for stocking.

Management sub-target 3.2 Defined proportion of natural eel habitats without recruitment and number of eels stocked per surface unit (ha) according to available eel surplus for stocking.

Stocking activities will in future rely on the assumption that a surplus of glass eel from at least some European estuaries is still available. In view of high prices for glass eel the locally available budget may limit stockings more than biological or logistical aspects.

4.5.1.10 Measures related to aquaculture for stocking

A great proportion of glass eel captured in Europe is currently used for eel production in aquaculture. This proportion is assumed to diminish in the next years as according to the EU-Regulation up to 60% of all eel below 12 cm should be reserved for stocking. On the other hand stocking, as a conservation measure, can include eels up to 20 cm in length. This is in accordance with current stocking practice using pre-grown eels from aquaculture for release in natural eel habitats. As prices of glass eel tended to be high in recent years and glass eel are assumed to face a high natural mortality in the first years this practice will probably continue in coming years. As a consequence of rearing conditions there is a concern about the quality of such eel released after a time in conventional eel aquaculture with regard to health status and genetic diversity (see Chapter 5.4.2.3).

Management sub-target 4.1 Ensure the production of sufficient numbers of eels (for stocking) with a good health status with respect to parasites (*Ang. crassus*), viruses (HVA, Eve, EVEX) and other pathogens.

Management sub-target 4.2 Ensure the production of eels from aquaculture with a minimum genetic selection and avoid stocking of slow growing individuals sorted out from aquaculture.

4.5.2 Eel sub-target

4.5.2.1 Glass eel sub-target

Eel sub-target 1.1; Density target for wild (and stocked) 0+ in predefined sections of a catchment.

This can be monitored in ladders and/or by electro-fishing and to be evaluated against historical data. A short-term response is expected (few months).

Time frame for revision management action: 1 year.

Indicators; n/ha, absence/presence, front of colonization.

4.5.2.2 Yellow eel sub-target

Eel sub-target: Profile of eel occurrence according to longitudinal position in the catchment. More precisely, this target can be expressed in distance from the sea where the probability of eel presence is 50%.

No information on time-scale of response, probably few years depending on latitude.

Example of application

This methodology is based on an analysis electro-fishing data with logistic regressions. Lasne and Laffaille, 2007 estimated that study of temporal trends of "eels' logistic profiles along the longitudinal gradient" allow the assessment of the improvement of colonization after mitigation of local impacts.

Eel sub-target: Density of yellow eel in the upstream reaches.

A short-term target could be set as a specific increase in density on a certain level in a river system after a certain period of time. Compliance can be monitored by mark-recapture, counting in ladders, by electrofishing, with fykenets or other kinds of fishery-independent methods (ICES 2007) and can be evaluated referring to historical data or expected densities from models.

No information on time-scale of response, probably few years depending on latitude.

Indicators

Numbers passing, n/ha, cpue.

Example of application

An illustrative example is given by the reopening of the Vilaine watershed (Briand *et al.*, 2005b). The construction of the eel ladder resulted in high densities (>1 eels/m^{-2}) in the downstream and middle stream areas after two or three years after. These changes remain clear and the examination of five years of data has changed little of the conclusions expressed after only two years. Number of glass eels climbing the fish ladder led to the colonization of the entire basin and a possible saturation in the downstream and middle stream areas. But decrease of glass eel arrival and density-dependant mortality could complicate the interpretation of the results, by inducing a decrease in density in some parts of the catchments (Briand *et al.*, 2005b). A similar approach was performed on the Fremur River and stressed again the importance of maintaining longitudinal connectivity in rivers.

Eel sub-target; Degree of habitat saturation of yellow eel.

Response in distribution/habitat saturation level in the entire catchment can vary in time frames according to latitude, altitude, climate, etc. A reasonable estimate is that a sub-target like this could be set to 3–5 years in the central area of distribution. The target fulfilment can be evaluated against historical data or densities from models.

Indicators

Ratio between saturated and unsaturated surface, ration between actual density and carrying capacity.

Eel sub-target: Sex distribution.

An increase in density induced by a reduced fishing mortality may result in a density-dependent change in sex ratios. Evaluation of the appropriate target level will be difficult, but may be based on historical data.

Example of application

The Baltic eel stock declined sharply in the 1960s and the 1970s following a preceding decline in recruitment of young yellow eel into the Baltic Sea. The hypothesis was raised that the reduced recruitment was due density-dependent processes in the areas of primary recruitment, i.e. the Kattegatt and the Danish straits (Svärdson, 1976).

Following this male eel almost completely disappeared in SW Sweden. An effect of density on sex ratio was also observed in Lough Neagh in Northern Ireland (Rosell *et al.*, 2005).

The time frame for a response in density-dependent sex differentiation is uncertain, as there is a period of time between recruitment and sexual differentiation.

Indicator

Proportion of sexes per size group.

Eel sub-target: Short term response in mortality rate.

Local estimate of global mortality (fishing mortality, other source of anthropogenic mortality) rate can inform on pressure on the stock.

Example of application

The LVPA assessment models quantify the population state and the impact of fishing, for the data years Dekker, 1996 #865}. A minimum of assumptions and a maximum of data ensure a close tracking of the true population state in recent years; in particular, estimates of both the population number and the fishing mortality by length class are updated annually. The Beverton and Holt methodology easily allows for simulation of alternative fishing regimes, and derivation of reference points. Application on the yellow eel fisheries in Lake Ijsselmeer demonstrated that this fishery overexploit the local stock of eel. Current fisheries reduce male spawner escapement to one in seven parts and reduce female spawner escapement to one in seven hundred parts of the unexploited situation (Dekker, 2000).

ELSA is a modelling approach based on eel length taken into account relative change in recruitment, sex ratio, growth, natural and fishing mortality and rate of silvering. It is useful to estimate total mortality rate from a simple length structure above 30 cm (Lambert *et al.*, 2006). The information about eel stock status provided by an application on the Gironde estuary present analysis urges to implement management actions in fresh-water part of the estuary.

Time frame for revision management action

Two to five years (should be revised).

4.5.2.3 Silver eel sub-target

Eel target: level of mortality rate for each obstacle, maximum delay for migration. For global river management, cumulative mortality and delay can be targeted.

An approximate estimate of turbine mortality can be obtained using empirical formula from literature (Larinier and Travade, 1999). More accurate estimations of eel mortality rates can be obtained by telemetry procedure although they are difficult to obtain as a consequence of the uncertain behaviour of eels during their downstream migration (ICES 2007).

Evaluation of such target should take into account the variability induced by environmental fluctuations and therefore a multi-annual survey is advised.

Time frame for revision management action

Two or three years.

Eel target: Number of silver eels escaping

This can be monitored by catch statistics, direct counting methods, or mark–recapture experiments (ICES 2007).

The potential production of silver eels can be deduced by converting the re-established yellow eel population or production (data from electro-fishing) into silver eel using simple population models. Where downstream dams are present, escapement estimates should be adjusted to account for cumulative mortality from dam passage.

Time frame for revision management action

One to five years.

4.5.2.4 All life stage sub-targets

Eel sub-target 4.1: Level of contaminant load in eel. Measurements in fish are possible for many contaminants, especially for lipophilic ones since eels are particularly sensitive to bioaccumulation of such contaminants. Eel measures give better responses (% of detection) than measurements in water or in sediment (Belpaire and Goemans, 2007a) and an adaptation of the Flemish survey (Belpaire and Goemans, 2007a) to the relevant scale of the studied source of pollution should be advised.

The time response of these management actions depends mainly on the persistence of the contaminant in the field. For example, in Flanders lindane load decreased rapidly after its ban in 2002, whereas DDT continues to slowly decrease 30 years after prohibition (Maes *et al.*, 2008).

Eel sub-target 4.2; Level of quality index. An index of (yellow or silver) eel quality is important for evaluating the net effect of silver eel escapement on reproduction.

Fat content could also be good proxy indicator of the contamination level and a subsequent decrease in yellow eel fat content has been tentatively linked to the capability of silver eels to perform the migration to the Sargasso (Belpaire *et al.*, 2008). Health status of eels used for stocking especially with regard to *A. crassus* and viruses such as HVA, EVE and EVEX can complete this index.

Table 4.3: Linking management sub-target and eel sub-target. Relation in a short term between management sub-targets (level or magnitude of action in local management) and eel sub-targets (response of the eel population to management) (GE: glass eel YE: yellow eel; SE silver eel).

			Eel sub-target									
			GE	YE					SE			
			1.1; Den sity	2.1 Occur-rence	2.2 : Density	2.3.; Habitat saturation	2.4. Sex Distri-bution.	2.5 Mortality rate	3.1; Obstacle mortality	3.2 Escapee number	4.1 Conta-minant load	4.2; Quality index
Management sub-target	Fishery	1.1 ; GE Quota	✓	✓								
		1.2; GE time closure	✓	✓								
		1.3; YE Quota		✓	✓	✓	✓	✓				
		1.4; YE time closure			✓	✓	✓	✓				
		1.5; YE Size limits			✓	✓	✓	✓				
		1.6; YE Protected areas		✓	✓	✓	✓					
		1.7; SE time closure								✓		
		1.8; SE size limits								✓		
		1.9. SE protected areas								✓		
		1.10. Control effort						✓				

Table 4.3: continued.

			Eel sub-target									
			GE	YE					SE			
			1.1; Den sity	2.1 Occur-rence	2.2 : Density	2.3.; Habitat saturation	2.4. Sex Distri-bution.	2.5 Mortality rate	3.1; Obstacle mortality	3.2 Escapee number	4.1 Conta-minant load	4.2; Quality index
	Upstream migration	2.1; Equipped dam number		✓	✓	✓	✓					
		2.2; Opened surface area		✓	✓	✓	✓					
		2.3; Fish passing number		✓	✓	✓	✓					
	Down-stream mig.	2.4 N°. of obstacles							✓	✓		
	Pollution	2.5; Pollutant reduction								✓	✓	
		2.6; Improved habitat surface			✓	✓						
	Stocking	3.1 Surface of habitat with low recr. and N°. of stocked		✓	✓	✓	✓					
		3.2 Surface of habitat without recr. and N°. of stocked		✓	✓	✓	✓					
	Aquaculture	4.1 N°. of produced eels with a good health status						✓				✓
		4.2 N°. of produced eels with minimum genetic selection						✓				✓

4.6 Conclusions and recommendations for Chapter 4: Assessing stocks and management actions

4.6.1 Conclusions

It is suggested that managers define interim targets for the management measures in order to integrate local action efficiently to the aim of long-term recovery of the European eel stock. For this purpose management sub-targets defining the magnitude of actions (e.g. number of dams removed) will be linked with eel sub-targets reflecting the expected short-term response of the local eel population. Eel sub-targets should therefore allow a fairly rapid evaluation of the management measures taken but sensitivity and time response of some of the proposed eel sub-targets would need further investigation before their application would be operational.

Eel sub-targets should finally be integrated into the evaluation of the status of the whole eel stock. However it has to be recognized that adequate methods or modelling approaches for doing this exercise are still lacking.

Implementation of EMPs requires the development of methodologies to obtain those data. They can include either direct (*e.g.* mark-recapture) or indirect measures (yellow eel proxies to determine silver eel production and eel habitat modelling production). It is important to ensure standardization and quality control of the method(s) used to estimate age.

Use of direct methods, though preferable in many respects, will be severely restricted by: uneven distribution of silver eel fisheries within and between regions; limited fishery monitoring resources; and in extreme fluctuations in large river flows. However, where possible, use of direct methods should be prioritized.

A variety of indirect methods, mostly dependant on yellow eel proxies and modelling, are available for areas where direct measurements of silver eel escapement are not possible and should be extensively used to estimate regional and national silver eel escapement. Selection of models should take account of SLIME conclusions and advice given elsewhere in this report (Dekker *et al.*, 2006). Validation of indirect methodologies should be undertaken on an ongoing basis for a network of river systems where reliable direct estimation of silver eel escapement biomass is possible.

Estimation of effective spawner biomass should be undertaken in all EMPs (*i.e.* at local, regional and national levels) and this will require quantification of adverse effects of contaminants, low fat levels, non-lethal turbine damage, viral diseases, along the lines previously proposed for *A. crassus* as well as other anthropogenic mortality rates along the river catchment. Local management decisions should then be made by reference to effective silver eel escapement rather than total spawner biomass estimates.

There are very few quantitative estimates of pristine (pre-1980) and current silver eel production to allow comparisons to be made between systems and there is very few data on the importance of estuarine and coastal populations to overall production. Modelling will be needed to transfer estimates from data rich to data poor systems. Some approaches have been outlined by this Working Group which complements those from presented in previous working Group reports and in Dekker *et al.*, 2006.

4.6.2 Recommendations

- well defined sub targets for short-term, local management efforts should be used, and that data should be collected so that they can be post-evaluated both regarding the fulfilment of the management efforts and the anticipated effects on eel;
- population model(s) should be used to assess the status of stock, compliance with (sub) target(s), to evaluate management actions and to evaluate the influence of biotic and abiotic factors on the stock at a range of geographical scales;
- adaptive feedback links are established between post-evaluation results and resulting changes in management efforts;
- care should be taken so that locally established (short-term) sub targets ensure long-term recovery, eventually leading to the restoration of the spawning stock so that the eel reach full recruitment capacity.;
- since short time evaluation of management actions urges for a list of monitoring activities, fishery dependent as well as fishery-independent, methods for monitoring in connection to the sub targets presented by the WGEEL in this report and in the report of 2007 should be implemented ASAP within the DCR and elsewhere and that where possible these activities should be coordinated nationally with related monitoring activities, i.e. regarding biodiversity within the WFD;
- the concept of effective spawner biomass escapement should be adopted for all EMPs and comprehensive protocols for integration of standardized eel quality data should be developed for application of this concept;
- standardized terminology, and identification criteria be adopted, for use in all European eel programmes;

5 Stocking and aquaculture

5.1 Introduction

Stocking and transfers of juvenile eel have been discussed at length by the Working Group (most recently ICES, 2006 and 2007). These discussions have covered the principles and extent of stocking, stock transfer practices and their contributions to fisheries. Their effect on escapement has been discussed mainly in conceptual and theoretical frameworks as a consequence of a lack of hard data. The WG 2007 recommended that “guidelines, or best practice manuals, should be established for methodologies for ……. stocking of eel”.

ToR b) develop methodologies for the assessment of the status of the eel stock, the impact of fisheries and other anthropogenic impacts and of implemented management measures; this might include, for example, support for EMPs on the determination of "pristine" spawner production levels and **relative contribution of stocking.**

Extract from 2006 WGEEL report-the changing scientific advice regarding stocking.

"Scientific advice on re-stocking has changed over the years, from clearly in favour (Moriarty and Dekker, 1997), to against on precautionary grounds (ICES, 2000). In our previous report (ICES, 2005b), the risks involved were discussed, balancing potential genetic effects against the risk that the current stock might suffer from depensatory effects in the reproductive phase, for which re-stocking might be one solution.

Clearly, arguments both pro and contra re-stocking remain valid, and no final and scientific advice can be derived. However, the previous advice was based on the potential for depensation occurring in the reproductive phase. All arguments pro and con being as they are a more practical and nearby argument has come to the fore in this report: that seed stock areas might progressively become depleted as a consequence of a continued decline in glass eel immigration. Options for potentially successful restoration of the stock by glass eel restocking are fading. Re-stocking of glass eel, either in southern areas rapidly contributing to silver eel production, or in northern areas with a long postponed and long lasting contribution to silver eel production, therefore needs urgent consideration."

The Working Group revisited this topic in 2008 in order to provide updates on stocking figures and practical information to support stocking best practice and will provide support to EMP’s and the EU Commission.

5.2 Methods to assess the relative contribution of stocking to the regeneration of the European stock, and for EMPs

5.2.1 Source of glass eel

Advice from ICES to the EU commission (ICES, 2005a) was that the recent glass eel catch (ca. 100 tonnes) is less than that required (150 to 1000 tonnes) to supply the total potential productive habitat (about 40 000 km2), and ACFM further concluded that full-scale restocking alone is unlikely to achieve the EU objectives in the medium term (ICES, 2006).

Therefore, the advice remains that there are likely to be insufficient glass eel available from the fishery to meet the demands for stocking at the European level. However, the Regulation EU: 1100/2007, requires that fisheries make at least 35% of eel <12 cm available for stocking in 2009, rising to 60% by 2013. The implementation of EMPs in 2009 may effect the reduction in some glass eel fishing effort, either as part of local

Management Plans or as a consequence of the 50% cut required where plans are not submitted and approved. This outcome will not be known until the EMPs are published. Here, we consider the potential effect (benefit) of this stocking material.

5.2.2 Yield potential

The yield potential can be calculated from Yield/Recruit (Y/R) estimates. Most of the data on Y/R available are obtained from stockings in lakes and an Italian lagoon. The data for lakes range from 5–72 g.stocked eel^{-1}, but most are in the range 20–50 g.stocked eel^{-1}. The yield-per-recruit in the Italian lagoon appears to be more than twice as high. If the total catch of glass eels in Europe is in the region of 100 tonne (ICES, 2005) of glass eels, with 3000 glass eels per kilo, and 35% (minimum requested by the Eel Regulation) provided in 2009 for stocking, this would have a production potential for approximately 2000–5000 tons of silver eel after one eel generation time. When 60% of the catch becomes available in 2013, it will have a lifetime potential for 3500–8500 tons of silver eels given no anthropogenic mortality. ICES 2006 produced comparable results (10 000 tons of silver eels when stocking 100 tons of glass eels) when using population dynamic calculations and data from Moriarty and Dekker, 1997. The above estimates are maximum estimates, based on the assumption that the catch of glass eel will be in the region of 100 tons. There is of course the possibility that there may be no surplus of glass eels in the near future (ICES, 2007).

Glass eel are caught using moving and stationary fishing gears. There is evidence that handling mortality of some of these gears, e.g. trawls may be up to 40%. Reduction of these mortalities would lead to the more efficient use of the limited and declining resource of glass eels.

5.3 Review of stocking activity across Europe

Before the WG meeting, a simple questionnaire was sent to the WG members in order to obtain additional information. The responses to this questionnaire are briefly described in the following section. Information from 17 countries is included. For this purpose, UK and Northern Ireland were considered as two countries, since there is a considerable transfer of glass eels from the "UK" to Northern Ireland.

A. Does your country buy eels for stocking?

Yes: 11 (DE, PL, N.Irl, SE, NL, BE, FI, EE, LT, LV, DK)

No: 6 (FR, ES, PT, UK, IE, NO)

A clear geographical pattern can be seen. Countries at the Atlantic coast do not buy eels whereas countries further east of the Atlantic, and in particular around the Baltic Sea, usually purchase eels for stocking.

It has to be noted that this is a dynamic picture, which may change from year to year depending on several factors (availability and price of glass eels, situation of the fishery in the respective country, political and administrative decisions).

B. If so which life stage, glass or yellow eels? (only countries with "Yes" under question 1)

Glass eels: 6 (DK, LT, EE, FI, SE, N.Irl)

Yellow eels (elvers, pre-grown eels): 1 (LV)

Both: 4 (BE, NL, PL, DE)

Clear changes in the stocking strategies have occurred in the past and will probably re-occur in the future depending on several factors, in particular the availability and price of glass eels *vs.* pre-grown eels from farms. New scientific results may also influence the decision for one of the stocking types (e. g. survival and growth rates of glass eels vs. pre-grown eels, gender selection based on farm densities and risk of infection with diseases from the farms). There are risks and benefits for each type, which are considered in another section of this report, and which should be considered in the stocking strategy.

C. How much stock was purchased in 2008?

The data for 2008 were not complete and did not allow a useful analysis. Therefore, the data for **2007** were considered here.

Total glass eels 2007: 5.7 Million individuals

Total yellow eels 2007: 5.6 Million individuals

There are uncertainties in these numbers and the data are not complete for all countries (but all 11 countries which answered "yes" under question A, are included). Therefore, these numbers must be considered as minimum values. The calculation is difficult, since some countries buy glass eels and rear them in farms for a while before stocking. In some of these cases, the original numbers of imported glass eels are not available (just the numbers of young yellow eels stocked).

A rough estimate was made about the total amount of glass eels finally used for stocking. For that purpose, yellow eel numbers were translated into glass eel numbers (glass eel equivalents) by correction factors usually used in Denmark (1 farmed eel equals 1385 glass eels; M. I. Pedersen, pers. comm..) and Germany (1 farmed eel equals 3 glass eels; e. g. Knösche *et al.*, 2004).

Based on these factors, the total numbers of glass eel (equivalents) used for stocking ranged from 13.5 Millions to 22.5 Millions. If a mean weight of 0.3 g for glass eels is assumed, these numbers translate into biomasses of 4.5 t to 7.5 t. Even though these are rough estimates, they may indicate the order of magnitude of glass eels used for stocking of natural waters in Europe. If this is compared to the total glass eel catch in Europe, which was between 50–60 tons in 2007, a proportion of 7.5–15% of the total glass eel catch was used for stocking. This is in the same order of magnitude as previous estimates. These figures may be influenced by incomplete recordings of stocking as well as of glass eel catches.

D. From where or whom?

It does not appear possible to provide very clear analyses about the trade paths of glass eels since the situation is very dynamic or poorly reported (Figure 5.1). Glass eels are mainly purchased from France or from the UK. However, even glass eels bought from the UK, may previously have been imported from France. When pre-grown eels from farms are used for stocking, they are either imported as glass eels and reared in farms within their own country (e. g. DK, NL, partly DE, LT) or directly imported as young yellow eels (mainly from NL, DE, but possibly also DK and in smaller amounts from other countries). The information is probably incomplete.

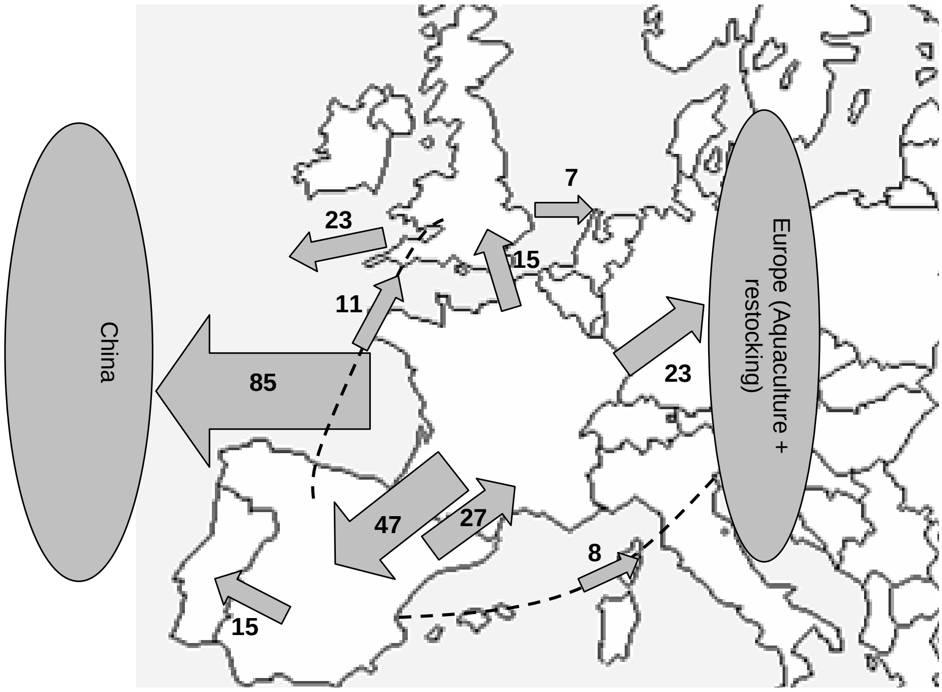

Figure 5.1: Mean trade volumes of glass eel (T) 1996–2006 in Europe analysed from EUROSTAT database.

The analysis of the questionnaire demonstrated that at present it is not possible to trace the origin and trade paths of glass eels and young yellow eels. However, as a consequence of the obligations in 2009 from CITES and from the EU Council Regulation (1100/2007-the "Eel Regulation"), Member States have to develop systems for the traceability of traded eels. Consequently, the availability of information on numbers/biomasses of eel traded and their trade paths are expected to improve in the future.

E. Does your country have a protocol in place by which it stocks its waters?

Yes:	6 (DE, ES, SE, UK, EE, DK)
No:	7 (PT, PL, LT, LV, IE, NO)
Will be developed:	1 (BE, NL)
No info/unclear status:	3 (FR, FI, N.Irl)

The information shown here contains some uncertainties. The type of protocol may be very different between countries. It may contain just rules on were to place the eels and at what density whereas in other cases a screening for diseases or parasites may be included. Other countries are at the stage of developing protocols at present. The situation may even differ within one country if regional authorities or government are responsible for fisheries issues as is the case in Germany. A considerable number of countries do not have protocols in place suggesting room for further improvement in this area.

F. Does your country intend using stocking as a tool in its eel management plans?

Yes:	12
No:	1 (NO)

Still in discussion:	2 (IE, FR)
Unclear/no information:	2 (PT, FI)

The majority of countries intend to use stocking as an option in the Eel Management Plans. This raises the question if, given the possibility of a further decline in glass eel catches and the obligation to achieve the management targets also in the donor catchments, sufficient numbers of glass eel will be available to reach the stocking targets. However, the decision whether the export of glass eel from those catchments (mainly in France and the UK) to other countries for stocking will be permitted, includes an economic and political dimension, which is difficult to assess.

5.4 Decision framework

The WG has presented and made use of various decision frameworks in our earlier reports (ICES 2006 and 2007; Williams and Aprahamian, 2004; Symonds, 2006; Montreal report (Williams and Threader, 2007)).

5.4.1 Management policies

5.4.1.1 Objectives

"Whenever stocking of fish is to be considered, the aims and specific objectives of the exercise must be clearly defined and adhered to" (Cowx, 1999).

Only more recently has stocking been done to mainly enhance local stocks in order to improve or provide the basis for a profitable fishery. In some circumstances stocking was done to mitigate or compensate for depleted stocks, as a result of upstream dams related to hydropower. Such stocks may be depleted as a consequence of dams as migration obstacles for young ascending eels and as turbine-induced mortalities in silver eels.

Concurrently with the awareness of the serious decline in the European eel stock and in connection with the preparation of eel management plans, stocking has become one measure to improve the stock. This time stocking is done with the main purpose of increasing the production of silver eels leaving the managed unit and contributing to the spawning biomass, i.e. not to support a fishery.

COM has proposed stocking in waters with free access to the sea as one measure among others to enhance local stocks with the ultimate goal aim to increase the biomass of spawners to produce a sufficient number of recruiting glass eels (COM 1100/2007).

Stocking as part of management plans may also occur in new water bodies, or areas where eel are absent, in order to produce additional potential spawners where access to the sea is open.

Another objective might be to restore local stocks in order to improve or preserve biodiversity (Verreault, pers. comm.) and this also might be beneficial if there is an olfactory cue to upstream migration. Alternative strategies to stocking have to be considered and analysed. Improving the possibilities for eels to migrate upstream might be a sufficient measure where dams are obstructing upstream migration, given that the emigration route is secured. Improved environmental conditions in eel growing waters, thus increasing survival and growth, may also be an alternative or addition to stocking.

As there is a general lack of stocking material (glass eels) there is no room for a misuse of this restricted resource. Therefore stocking should only be done as part of a management plan ensuring a significant escape of silver eels. The potential availability of central funding through the European Fisheries Fund (EFF) to support stocking for enhancement purposes, may ensure parity with other competitors for seed stock (e.g. aquaculture, fisheries enhancements).

5.4.2 Ecological considerations

5.4.2.1 What size of eel should be stocked?

There are three main options; stocking of glass eel, young yellow eels and ongrown eel from aquaculture. Apart from that there is the option of moving eels "over the dam" in cases of migration obstructions (assisted migration). The latter option is not dealt with here.

The risks concerned with diseases, parasites, biased sex-ratios and genetic selection may best be avoided by stocking with eels that are as young as possible from a natural state. Stocking with yellow eel caught in the wild poses the additional risk of their being contaminated. If ongrown eels from aquaculture are considered for stocking, there are risks of disease spread, reduced genetic fitness (Section 5.4.2.3) and skewed sex ratios. When purposely infected with herpes virus in aquaculture, as seems to be widely practised, when these eels are stocked the spread of disease is a certainty, not a risk. However, stocking of healthy ongrown eels will result in comparable growth rates and mortalities compared to the stocking of glass eels (ICES, 2007).

Another risk associated with using ongrown eels, is the stocking of *Anguilla rostrata.* Stocking of *A. rostrata* seems to have occurred in the past (German Country Report, 2008; Ubl and Frankowski, 2008), *A. rostrata* is grown in European aquaculture and discrimination between *A. rostrata* and *A. Anguilla*, when grown up, is not possible in practice.

5.4.2.2 Contaminants

One of the potential ecological and environmental risks which stocking programmes should consider is contamination as a potential risk to produce (in stocked systems) reproducers not able to reach spawning grounds at the Sargasso Sea and/or produce enough gametes of high quality.

Consideration should be given to pollution with PCBs, flame retardants, pesticides and heavy metals. Priority should be given to those sites where such contaminants are absent or at permissible levels (information available through the European Eel Quality Database Chapter 6).

Detrimental effects of pollution on fitness and fecundity have been suggested earlier on (Larsson *et al.*, 1990), but recently, there are indications that poor quality of the spawners, namely the silver eels migrating to the oceanic spawning grounds, might be a key factor in the decline, e.g. decrease of body fat content. Palstra *et al.*, 2006 argued that gonadal levels of dioxin-like contaminants, including PCBs, in eels from most European locations impair embryonic development. Pollution might also impact reproductive success through effects on genotype: a significant negative correlation between heavy metal pollution and eel genetic variability was reported by Maes *et al.*, 2005. Insufficient condition and energy resources (Svedäng and Wickström, 1997), high bioaccumulation of persistent organic pollutants (especially polychlorinated biphenyls-PCBs) (Larsson *et al.*, 1990; Robinet and Feunteun, 2002; Palstra *et al.*, 2006) and pathological agents (Palstra *et al.*, 2007) have been reported as potential restrictive factors, disabling long distance migration and successful reproduction with prime quality gametes.

Where spawner quality is poor and lipid content low, silver eels may not contribute to the overall spawning and recruitment of the European stock. Accumulation of energy through lipid storage may be affected by different environmental factors such as disease agents, changes in food availability, other global changes in the environment, changes in (density-dependent) sex ratios even life-history characteristics, i.e. restocking itself and pollution pressure as a consequence of disruption of the endocrine processes.

5.4.2.3 Genetics, diseases and health issues

Genetics

The importance of maintaining genetic diversity can be divided into a short-term impact (in the order of few generations), by avoiding inbreeding and fitness decrease (population survival) and a long-term impact (over decades or even centuries), and by conferring the possibility to adapt to changing conditions (species survival). Genetic data may help to assess species integrity within the North Atlantic, evaluate the genetic stock structure of the European eel, clarify the spatio-temporal stability of the genetic structure, define the influences of oceanic conditions on genetic variability, monitor and guide the stocking policy in Europe, and evaluate the effect of population decline and habitat degradation on genetic variability and the overall fitness of eels (see also **Annex 4** for a more detailed review).

Genetic consequences of stocking practices

Below are listed some important points to consider in regards to genetics when planning stocking measures and provide some advice for sustainable stocking.

1) Deciding on mass stocking practices to supplement populations can lead to the rapid introduction of non-native genetic material from non-indigenous eel species. Monitoring the correct species identity (tracing) is therefore crucial to preserve genetic integrity of the European eel. Examples of this phenomenon have already been observed, mainly in Germany (Trautner *et al.*, 2006), where *A. rostrata* were found, prompting for up to date molecular identification methods for species discrimination (Maes *et al.*, 2006a). The European eel has been listed under CITES, potentially leading to increased importations of other eel species. Such exotic eel introductions have been a major problem in Asia, where European eels were introduced to supplement Japanese eel stocks (Okamura *et al.*, 2002; 2004).

2) Aquaculture grown glass eels (grown from glass eels to 10 cms) are often used for stocking purposes. Although at first sight no significant problem is expected from the genetic diversity point of view (glass eels are natural recruits), potential consequences could be other than expected. Indeed, keeping glass eels too long in such facilities will adapt them to aquaculture conditions (such as artificial food and temperature regimes), and will lower their competitiveness in the natural environment. Currently juvenile eels are deliberately exposed to water contaminated with the highly virulent Herpes virus *anguillarum* (HVA) in order to induce a limited infection which, although causing some mortality, will autovaccinate the fish prior to them meeting the infection at the most vulnerable fast growing stage. This process causes a significant drop in food intake and growth rate but is considered the lesser evil by the industry at present in the absence of an approved commercial vaccine. As such, ongrown eels used for stocking which have been reared under such practices pose an epidemiological

threat given that they can infect natural populations. Additionally, such practices create a high selective pressure on glass eels, reducing total genetic diversity and directionally selecting at the functional level for specific disease resistance genes (such as MHC). This has been revealed to have a very detrimental effect in salmonids when such individuals are released in the wild, as a consequence of a lower fitness for natural pathogens. Timing of stocking should be carefully considered in order to optimize survival. Stocking material should not be composed of the slow growers of aquaculture, which have been revealed to exhibit a lower functional genetic diversity and could demonstrate lower survival rates and skewed sex ratios.

3) At the population level, stocking practices can have major consequences on intraspecific biodiversity, as a consequence of the mixing of genetically differentiated populations. No stable geographical differentiation has been detected to date (Wirth and Bernatchez, 2001; Dannewitz *et al.*, 2005; Maes *et al.*, 2006). However, given long-term stocking practices since the 1950s, it is possible that these might contribute to a homogenization of populations as a consequence of massive translocations. Indeed, the presence of only a small level of geographical genetic differentiation at neutral genetic markers may lead to seriously underestimating of quantitative and adaptive differentiation between populations. From recent studies on marine fish populations we know that adaptive differences might be present but not detectable with the current molecular markers. Indeed, apart from analysing neutral genetic variation to assess the demographic independence and stability of fisheries stocks, knowledge of geographic and temporal scales of adaptive genetic variation is crucial to species conservation (Conover *et al.*, 2006; Maes and Volckaert, 2007). If distinct populations exist, the introduction of genetically different glass eels can potentially break up any existing adaptation in local stocks and have major fitness consequences on life-history traits, such as migration duration and timing, temperature resistance and size at maturation sizes. The homogenization of these traits can lead to a decrease in diversity and the loss of important traits for survival. However, given these concerns and the absence of data the following advice for different levels of natural recruitment is therefore precautionary.

Regions with no recruitment: stock with glass eels in high quality habitats originating in if possible the same main hydrographical region (Northern Europe, West Atlantic, Southern Europe, Mediterranean).

Regions with low recruitment: Preserve natural recruits, while preferably stocking glass eels from estuaries or neighbouring river basins in high quality upstream habitats.

Regions with high recruitment: care should be taken not to overfish glass eels for stocking purposes, as this will weaken the donor region and deplete the rivers from escapees.

If neither neutral nor adaptive differences can be detected in the European eel, stocking practices may have a beneficial effect. However, the question remains, whether stocked individuals will find their way to the Sargasso Sea and ultimately contribute to the spawning stock. The most important issue is then to preserve the total genetic diversity to allow adaptation to a changing environment. Keeping the highest level of biodiversity in phenotypic (quantitative) and genetic traits is crucial to the survival of the entire species.

Pathogens and parasites

The occurrence of diseases and parasites in eels has been recorded for some time. Up to now, consequences on the ability of eels to carry out their long-distance migration and reproduction were unknown, although these have been suggested as potential causes for the decline in eel populations. Available information on the introduction and spread of *A. crassus* in Europe illustrates how through live-transport of eels, within and between countries, and through stocking programmes the parasite has been rapidly dispersed to all major spawner producing areas.

In the proceedings of a recent workshop held in Montreal (Canada) in 2007, the risk of disease transfer when stocking eel was specifically addressed (Williams and Threader, 2007) because eel transfers increase the risk of pathogen introduction. In her review, Symonds, 2007 described several parasites, viruses, bacteria and fungi that have been found in eel communities in North America. In Europe, many studies on eel parasites and diseases indicate that stocking and transfers have been responsible for rapid spreading of their fellow travellers (Szekely, 1994; Van Ginneken *et al.*, 2004; EELREP 2005). The rapid spread of *A. crassus* throughout Europe indicates that eel transfer or stocking done without screening is a practice that can be detrimental for the population and aquatic community.

In Canada eel stocking and transfers must be done under "The National Code on Introductions and Transfers of Aquatic Organisms" to avoid risks to aquatic animal health from the potential introduction and spread of pathogens and parasites that might accompany eels being moved. Screenings are routinely done for elvers before their stocking in fresh-waters locations. Screenings for viruses (IHNV, ISAV, IPNV and EVH) and *A. crassus* in individuals prior to stocking were negative since the initiation of the stocking programmes, four years ago.

In spite of warnings concerning viruses and diseases issued from WGEEL in 2006, there is still no common protocol for parasite and disease screening prior to stocking. Each country applies its own regulation and screening procedure for stocking. For example, Sweden practises quarantine for imported glass eel prior their stocking in brackish and fresh-water areas whereas no specific procedures are in place for other countries. Table 5.1 shows what is done for each European country prior to glass eel and/or elver stocking to prevent the introduction of parasites, viruses and pathogens.

It appears that few countries have put in place procedures to prevent the introduction and spreading of parasites and diseases when stocking young eels. This could be very detrimental for the future of eel populations since stocking will presumably be part of many national Management Plans. A robust protocol for screening stocked stocks should be put in place as soon as possible.

Table 5.1: Current procedures for stocking glass eel/young eel to European countries.

Country	Stocking	Screening for parasites, viruses and pathogens	Quarantine
Belgium	Yes	No	N0
Denmark	Yes	Yes	Yes
Estonia	Yes	Yes	No
Finland	Yes	Yes/No	Yes
Poland	Yes	No	
France	Yes	No	No
Germany	Yes	Yes/No	No

Country	Stocking	Screening for parasites, viruses and pathogens	Quarantine
Ireland	Yes1	No	No
Italy	No	-	-
Latvia	Yes	No	No
Lithuania	Yes	No	No
Netherlands	Yes	No	No
Norway	No	-	-
Portugal	No	-	-
Spain	Yes	Yes	-
Sweden	Yes	Yes	Yes
UK	Yes	Yes*/No	No

[1]Stocking restricted within the same water catchment.

*** For England and Wales only.**

5.4.3 Fisheries considerations and considerations for other users

Generation times of eels decrease with temperature and increase with latitude and may be 2–3 times lower in the most Southern parts of the distribution range as compared to the Northern parts of Scandinavia. Growth of eels varies between 14–62 $mm.year^{-1}$ within its distribution range (ICES, 2006) and this means that for male silver eels of 37 cm it will take then 5–21 years to reach that size. For female eels of 67 cm it will take twice as long, while for longer females it will take even longer. If the glass eels were stocked in 2009, the effects on silver eel escapement could be expected from 2014 (at the earliest) to approximately 2050, depending partly on stocking location and partly on sexual differentiation and eel growth. Therefore this is a measure that might be valuable over a longer time-scale. If the stocked eels are not hampered by anthropogenic factors, they could contribute significantly to silver eel escapement after 10 years or more. Eels stocked in suitable habitats may well grow faster than if left *in situ* and, therefore, mature earlier (Aprahamian, 1988).

5.4.3.1 Effects on recipient eel populations

The surface area of available habitats in Europe is estimated at $5–10*10^6$ ha (ICES, 2005). A possible stocking of 60 tonne (at most) when well spread over the available habitat, will have no significant negative effect on the growth of the existing eel populations. However, if high stocking rates are applied locally, this will be different because of density-dependent growth rates (reviewed by ICES, 2007).

Effects on existing populations may occur when stocked eels are diseased. Change in sex ratios (as demonstrated on Lough Neagh under differing recruitment and stocking patterns (Rosell *et al.*, 2005)), in favour of males, potentially affecting the yearly production of the non-stocked eels. Effects on the whole stock may occur if the genetic fitness of the stocked eels is further reduced. The latter might occur when stocking eels from aquaculture without additional care for reducing possible genetic effects.

5.4.3.2 Effects on the remainder of the exploited fishery

The effects on the fishery depend largely on the total quantity of eels to be stocked. If the aforementioned 35–60 tons would be stocked, it has a yield potential in the same order of magnitude as the eel aquaculture production in Europe or the current eel landings in Europe. This potential would be fully realized after one generation time. If not fished at all, this would increase the production of silver eels (ICES, 2006). The quantity of 35–60 tons of glass eels is more or less equal to, or more than the historical maximum of stocking rates (40 tons).

5.4.3.3 Effects in mixed-stock fisheries

There are no additional effects expected in mixed-stock fisheries.

5.4.4 Implementation constraints

5.4.4.1 Introduction

Cowx, 1999 recognized a number of potential constraints associated with any stocking programme, and posed these as a series of checks for managers, regarding the availability of:

- sufficient quantity and quality of fish;
- suitable methods of the transportation and expertise;
- sufficient funds; and,
- have the access rights been defined.

The issues of funding for stocking programmes, and access to donor and recipient waters are political rather than scientific issues, and so we will not consider them here. The first two bullet points have been considered previously by ICES (2006, 2007) and others (Williams and Aprahamian, unpublished; Symonds, 2007; Montreal, 2008). Here, we summarize the outcomes and update supporting materials where they have become available since the 2007 report was compiled.

5.4.4.2 Are sufficient quantities of eel available for stocking, at the local level?

At the local or catchment level, there may be a surplus stock of glass eel, arising as a result of density-dependent mortality being higher in the absence of fishing (ICES, 2006). The prime assumption for a local surplus of eel is that removing the eel has no impact on the donor population (on silver eel output). That is, reductions in density-dependent mortality (or other limiting effects such as growth rates and gender determination) result in enhanced production of silver eel in the stocked population exceeding the putative loss (from fishing elvers) in production from the donor population.

Lobón-Cerviá and Iglesias, 2008 studied long-term variations in the density of eels in the Rio Esva (northwestern Spain) at an estuary site and at nine sites distributed among three tributaries (1986–2006). Mortality rates calculated for age cohorts revealed a consistent positive trend, with 53.3% of the variation in cohort mortality rate explained by variation in glass eel abundance. Note, however, that this population is characterized by fast growing and early maturing eels, almost all of which become male.

Although the Regulation (1100/2007) does not specifically require that eel for stocking are sourced only from catchments where such a surplus exists, it is prudent to focus collection on such catchments. However, previous ICES reports and other reviews have provided little guidance on how managers could assess whether a surplus exists, and thereafter, quantification of this surplus.

The direct means for this assessment is to quantify the size of the donor population, typically glass eel, and compare this with estimates of the amount of settled elver required to produce the target silver eel output. The EU InterReg programme, Indicang, considered methods for the absolute quantification of glass eel in estuaries, recommending flux quantification (filtration) or mark recapture exercises, but noting that these methods are difficult in large and stratified estuaries (Feunteun, pers. comm.). Alternatively, an indirect assessment can be made based on studying the associated yellow eel population under conditions of varying glass eel exploitation to establish lack of impact of said fishery. For example, a glass eel fishery in the Severn estuary, England, does not yet seem to have had any measurable negative impact on upstream stocks of eel (See UK country report 2006).

ICES, 2006 discussed the concept of the carrying capacity of eel in relation to deciding whether to stock eel in a water body, but it should be considered also in deciding whether a potential donor water body can sustain the loss of eels to be stocked elsewhere.

There are two considerations; immediate effects of loss to the estuary, and subsequent effects to the yellow eel population and silver eel output from the river basin.

A method of calculating carrying capacity of a river or lake for eel has not been identified; in part as a consequence of the difficulty in assessing density and/or biomass of eel accurately in a given body of water (Williams and Aprahamian, 2004). Whether a site is at carrying capacity is linked to ease of access for colonization and the productivity of the water.

In tributaries of the lower Severn, Aprahamian, 2000 found eel density ranged from 0.12-1.14 m^{-2} and biomass from 2.56–25.24 gm^{-2}. The absence of any relationship between growth and either density or biomass, suggests that the sites were limited by their productivity and may indicate that they were close to or at their carrying capacity, defined as the maximum density or biomass that the habitat can sustain under average conditions.

In the southern part of their range the carrying capacity is likely to be higher as a consequence of higher temperatures and productivity resulting in a shorter generation time, even if extremely variable among sites. No recent evaluations are available, but given the potential for spawner production of those environments, the enhancement of evaluation studies on this aspect is recommended. Greater importance should be given to biomass when trying to assess whether a site is or is not at carrying capacity. This is because there is a smaller variation in biomass when compared to density both within and among river systems (Aprahamian, 1986) and it is more related to carrying capacity (Knights *et al.*, 2001).

The analysis of eel fishery 'outputs' from L. Neagh in relation to glass eel stocked (ICES 2007) suggests a density-dependent relationship with a negative exponential between input stock and eventual output. That is, outputs are maximal for inputs in the range of 150 to 200 glass eel per hectare.

Similarly, Knösche *et al.*, 2004 give a formula, how to estimate the recapture rate in the fishery after stocking for a range of common stocking densities for German waters (50–00 glass eel equivalents per hectare).

Recapture rate (%) = 611 * stocking density $^{-0.81}$

Thus, at a stocking density of 50 glass eels/ha, this would result in a recapture rate of 26%, whereas at 500 glass eels/ha it would decrease to 4%.

However, the general lack of information on carrying capacity in eel populations noted by ICES 2006 continues to this day.

A method of calculating carrying capacity of a river or lake for eel has not been identified, in part as a consequence of the difficulty in assessing density and/or biomass of eel accurately in a given body of water (Williams and Aprahamian, 2004). Whether a site is at carrying capacity is linked to ease of access for colonization and the productivity of the water and recruitment. However, the general lack of information on carrying capacity in eel populations noted by ICES 2006 continues to this day. The most likely sources of eel for stocking (and seeding ongrowing facilities) are glass eel fisheries in estuaries, and traps where upstream migrating eel are concentrated, such as eel passes on weirs and dams. In considering the effects of removing glass eel from estuaries and lower reaches of rivers, the carrying capacity of the estuary may be important. There is, however, no information currently on this, and it is an area that should be addressed. A study group to address this area has been proposed to the Diadromous Fish Committee 2008.

5.4.4.3 Potential indirect impacts on donor stock

ICES, 2006 noted that under the current situation of critically low stock levels, removal of glass eel from any site to stock another should only be done with a full assessment of the effect on recruitment into the growing areas dependent on that donor site. In addition to the direct effects on the size of the local population, there are two other potential risks with removing glass eel from the donor site, a reduction of dispersal of juvenile eel to upstream habitats, and possible alterations to sex ratio of silver eel.

Upstream migration may be driven by intraspecific competition and higher densities downstream. For example, the construction of an estuarine dam on the Vilaine prevented recruitment of eels for 25 years, but the installation of an eel pass resulted in a density-dependent migration behaviour; 1+ groups being forced into the periphery of the high-density area (about 0.8 eels m^{-2}), which extended further upstream in successive years (Feunteun, 2002). Note, however that this “wave” type migration, is in contrast to that reported by Ibbotson *et al.*, 2002 for eels colonizing the River Severn where upstream migration was mainly through diffusion. Removal of stock from downstream areas may reduce the propensity for colonization of upstream areas.

Although the physiological mechanisms for gender differentiation in eel (reviewed by Davey and Jellyman, 2005) are still unclear, evidence supports the concept that it is density driven. There is a risk that removing glass eel from estuaries will affect subsequent gender differentiation and sex ratio of yellow eel (and hence silver eel). Transporting undifferentiated eels from high to relatively low density habitats may well influence ultimate sex ratio of the silver eel output, and by association, the weight of output and distribution across time.

5.4.4.4 Issues of ownership

In considering where to stock, managers must evaluate the subsequent potential exploitation and other mortalities of the eel, e.g. fisheries, turbines, etc. There may be a number of users who potentially benefit from the stocking, and therefore, they should all contribute to funding of the stocking.

5.5 Artificial reproduction of eel

5.5.1 Introduction

Summary of the main findings relevant to WGEEL from the *European Aquaculture Society Thematic Group Workshop on European Eel Reproduction* (October 24th, 2007, Istanbul).

Given the complex nature of the eel life cycle and that maturation occurs during the oceanic phase there is very little information on natural maturation and reproduction.

Consequently much of this work is derived from laboratory studies which examine the environmental effects, endocrine control and artificial reproductive techniques on the production of larval European eel. Details of abstracts on this work can be found at http://www.easonline.org.

The onset of sexual differentiation in eels:

Studies from Israel into the hormonal development in young farmed eels <25 cms found a difference in the hormones released from the pituitary gland depending upon the density of eels held in tanks. Those with fewer eels in them, developed into female eels associated with the hormone release of the female hormone estradiol, while those in higher densities became male associated with the release of the male hormone 12 Keto-testosterone.

5.5.2 Silver eels

Several studies presented evidence that silver eels leaving continental Europe should be considered as being in a pre-pubertal state given that swimming appears to be a strong natural trigger for the development of advanced maturation. During the swimming phase lipid stores in the eel are utilized for the production of energy to fuel their migration and to produce gametes through a variety of hormonally induced metabolic pathways. Research into the thermodynamic influence of hydrostatic pressure on swimming ability found that the metabolism of the eel's fat stores was much more efficient at depth thus optimizing their energy expenditure during migration. Once they have arrived at the spawning grounds several studies into the olfactory capabilities of silver eels and their reactions to specific eel odours suggested that olfaction maybe crucial to synchronizing final maturation in both sexes.

5.5.3 Embryo and larval development

The natural development of embryos appears to be influenced by hydrostatic effects (that had not been used previously during artificial attempts at fertilization) which induce a slower egg cleavage rate and thus embryo development period. It's likely that this may be caused by the pressure influence on thermodynamics and or mechanical stress on egg membranes and water transfer through them at these depths.

Despite many previous attempts to artificially breed European eel the hatching of larvae has only been achieved on a few occasions with a maximal larval life of 3.5 days. The main obstruction has been the intricate hormonal control mechanisms that inhibit gonadal maturation at the onset of puberty. Repeated hormonal treatments to produce gametes have been successfully applied to produce viable eggs and larvae of the Japanese eel. Similar methods have been applied to the European eel, but deficiencies in genitor quality causing fertilization failure had hampered the ability to produce larvae in the past. Investigations into the failure found that an essential fatty acid was missing from the feed given to the broodstock which when included produced fertile eggs. Mass hatchings from these eggs have been achieved and the larvae were fully developed and ready to feed 12 days post-hatching. However further development of the larvae past this stage failed as a suitable feed has yet to be found/developed.

5.5.4 Artificial reproduction techniques

The hormonal induction of maturation is a fundamental requirement for artificial reproduction but this presents difficulties in terms of synchronizing the development of males and females. To aid this cryopreservation techniques have now been developed for eel sperm which yielded viable eel sperm several months after deep freeze storage. Prior to storage the hormonal induction of the males yielded sperm after four weeks the quality and quantity of which increased up to eight weeks after induction. Developments in the maturation of females have found that low initial temperatures increase the sensitivity of the female and that temperatures <17°C during gonadal maturation produced better results.

5.5.5 The Japanese Experience

Japanese glass eel were successfully produced in captivity in 2005 (Kagawa *et al.*, 2005), and since then this work has progressed to produce hybrid larvae of European (male) and Japanese eel (female). The success of this work has relied heavily upon the production of a suitable feed for the larval stage, details of which are currently contained in a Japanese Government registered patent.

5.6 Conclusions for Chapter 5: Stocking and aquaculture

5.6.1 Potential benefit of stocking to regenerate the stock

At present, it is estimated that around 7.5 to 15% of the glass eel catch is used for stocking, either directly or as on-grown eels. Estimates suggest an insufficient supply of glass eel from the total fishery for stocking to full capacity at the European level. Nevertheless, the Regulation 1100/2007 requires that 35%, rising to 60%, of glass eel catches are made available for stocking to enhance the stock. If these percentages were applied to recent annual catches of glass eel, the potential lifetime effect of this increased level of stocking, in the absence of anthropogenic mortalities, could be in the same order of magnitude as current fisheries or eel culture. However, there is a continuing and urgent requirement for robust evidence of the extent to which stocking and transfers on local, national and international scales can increase silver eel escapement and spawner biomass.

The general lack of information on carrying capacity in eel populations noted by ICES 2006 is still an issue hampering management of eel.

5.6.2 Identifying local surplus

It is anticipated that assessments conducted for EMPs will decide whether or not there is a local supply of eel sufficient to meet demands for stocking (either within catchment, RBD, nation or elsewhere in Europe). However, there is a limited understanding on methods by which to make assessments of a local surplus on a quantitative, biological basis.

5.6.3 Post-evaluation of the net benefit of stocking

The assessment post-evaluation of the contribution of stocking to silver eel production is still hindered by the limited quantitative information available on survival/mortality rates (stage specific and glass eel to silver eel), both for stocked eel and wild/natural eel for comparative purposes, for habitats representing the variety available across Europe, and especially for stocking in rivers.

5.6.4 Risks of stocking

It appears that few countries operate procedures to prevent the introduction and spreading of parasites and diseases when stocking young eels and this could be detrimental for the future of eel populations since stocking will presumably be part of many national Management Plans. The risks remain of disease and parasite transfer via stocked material, potentially both from the 'wild' and on-grown in aquaculture. For example, the practice of aquaculture in terms of viral inoculations needs to be addressed. A robust protocol for screening stocked stocks should be put in place as soon as possible.

New techniques are currently used for genetic analyses of the eel stock and results are expected in a few years. These results may prompt a re-assessment of the potential risks associated with stocking.

There is a clear need for assurance that donor populations are not impaired by the removal of glass eel. Notwithstanding the potential risks to the donor population, it is anticipated that assessments conducted for EMPs will determine whether or not there is a local supply of eel sufficient to meet demands for stocking (either within catchment, RBD, nation or elsewhere in Europe).

5.6.5 Aquaculture/on-growing to support stocking for enhancement

Spawner quality in terms of levels and composition of lipids and contaminants appears to be a key issue for the success of both natural and artificial reproduction. Given the future requirements for stocking glass eel or deciding to stock on-grown eel, the implications of the findings on hormonal release and subsequent gender development depending upon stocking densities must be considered.

Spawner quality in terms of lipid levels and contaminants appears to be a key issue for the success of both natural and artificial reproduction.

5.7 Recommendations

5.7.1 Methods to support the basis of stocking for enhancement purposes

The WG recommends that developing methods to make assessments of local surplus of stocking material on a quantitative, biological basis is a priority for research in the near future. Data to post-evaluate the relative contribution of stocking to silver eel production can only be supplied by experimental studies, and although acknowledging that some studies are ongoing, we recommend concerted action to address this area, especially with regard to stocking in rivers, and the relative performance and yield-per-recruit of stocked cultured eels compared with glass eels.

A study group to address eels in saline habitats has been proposed to the Diadromous Fish Committee.

5.7.2 Risks associated with stocking

The eel should be included in the European fish disease prevention policy in order to minimize the risks of transfer of diseases associated with stocking.

A robust protocol for screening stocked stocks should be put in place as soon as possible.

Purposely infected eels in aquaculture with pathogens (viruses, etc.) should not be used for stocking purposes.

The culture of *A. rostrata* in European aquaculture will make it impossible to discriminate between stockings of *A. anguilla* and *A. rostrata* and should be avoided; the same applies to possible growing of other eel species in the future. The improved systems to trace glass eel trade, for CITES and the Regulation (EU 1100/2007), should facilitate this, and the WG strongly support these developments also to address the risks highlighted here. Besides the Eel Regulation and CITES, the following EU Council Regulation (EC) N° 708/2007 concerning the use of alien and locally absent species in aquaculture is also likely to allow better control of farmed alien species like *A. rostrata.*

Despite limited evidence and a complicated variety of possible impacts of environmental factors, such as contaminants, on silver eel quality, conservative advice remains that stocking for stock enhancement purposes should not be conducted in waters heavily polluted with substances that might pose risks for spawner quality.

6 Eel quality

6.1 Introduction

In recent years (e.g. ICES, 2006) the Working Group has described the risks of deteriorated biological quality of eels. In 2005 the EU-EELREP programme (Estimation of the reproduction capacity of European eel) concluded that contamination with PCBs impaired fertility while infections with pathogens and parasites were devastating for swimming eels.

The recommendations of the WG EEL 2006 highlighted the need to monitor and to collect information on (1) **pollution and disease** to be able to designate areas producing high quality spawners (e.g. with **low contaminant and parasite burdens** in order to maximize protection for these areas; and (2) the **chemical status** of eel under the implementation of the WFD.

An increasing level of evidence on the detrimental impact of contamination and diseases on the eel has been made available.

ICES 2007 reported on the advances made in the collection of data on contaminants, parasites and fat levels in eel, and reported that many Member States started the monitoring of eel quality. In 2007, the WGEEL initiated the set-up and development of a European Eel Quality Database (EEQD), allowing the compilation of a comprehensive overview on the contaminant load in eel over its distribution area. Results from the EEQD demonstrated that considerable variation in contaminant load exists within river basin districts, according to local anthropogenic pollution, linked with land use. There is evidence that, on a pan-European scale, large differences in eel quality occurs between catchments. Furthermore, 'black spots' with low quality eels were detected. Lipid content, which is believed to be an important index of fitness, was highly variable between sites. New evidence (Geeraerts, *et al.*, 2007) was presented on the negative impact of certain contaminants on the fitness of eel.

The recommendations of the Working Group 2007 (ICES 2007) proposed that:

1) MS should further develop and maintain the European Eel Quality Database.

2) MS should initiate harmonized monitoring strategies to develop a European Eel Quality Monitoring Network, to collect the relevant data to be fed into the EEQD. National eel management plans, should take account of these data for evaluation of the quality of spawners.

3) Under the implementation of the WFD eel specific extensions should be included, using the eel as an indicator of river connectivity and ecological and chemical status, and making cost-effective use of collected data, also for the benefit of the EU Eel Regulation and recovery of the eel stock.

During the WGEEL 2008 session, new scientific evidence of eel quality as an important factor in the decline of the species has been presented and discussed. The WGEEL 2008 also updated the EEQD. In the light of the introduction of the EU Regulation in 2007, the WGEEL proposed recommendations and discussed urgent research needs/demonstrated gaps in eel quality knowledge.

6.2 Contaminants

6.2.1 Introduction

Due to specific ecological and physiological traits, eels are particularly sensitive to bioaccumulation of lipophilic contaminants. From recent scientific evidence (Belpaire, 2008) there is reason for serious concern as the level of measured concentrations of some contaminants has been demonstrated to have adverse effects on the reproduction success of the silver eel.

Current gonadal levels of dioxin-like contaminants, including PCBs, in eels from most European locations impair normal embryonic development and that PCBs and other contaminants may have contributed to the decline of eel recruitment observed since 1980 (van den Thillart *et al.*, 2005; Palstra *et al.*, 2006), a conclusion consistent with the fact that the emission of PCBs in the environment (van Leeuwen and Hermens, 1995) preceded the decline of European eel.

An extensive dataset of contaminants has been analysed by statistical modelling, to demonstrate relationships between fitness (lipid content and eel condition) and various environmental variables and PCBs (especially the higher chlorinated ones) and DDTs were revealed to have a negative impact on the lipid content of the eel. (Geeraerts *et al.*, 2007).

Extensive information has already been provided in the WGEEL 2006, and 2007 reports (ICES 2006; 2007). Recently, Belpaire, 2008 compiled an overview of research on contaminants in Flanders (Belgium). The status and trends of eel quality factors and the potential role of contamination in the collapse of the stock are presented and discussed here.

6.2.2 The eel and the Water Framework Directive

The EU Water Framework Directive requires monitoring of a selection of priority substances in the aquatic phase, including lipophilic substances. However, there are strong arguments for measuring the latter in biota (Belpaire and Goemans, 2007a, b). Yellow eel is a good candidate because it is widespread, sedentary and accumulates many lipophilic substances in its muscle tissue. Several authors have described the indicative value of measured concentrations, yet few studies have investigated the extent to which the spectrum of contaminants present characterizes the local environmental pollution pressure. To evaluate the value of the pollution profile of an eel as a fingerprint of the chemical status of the local environment, two datasets were selected from the Flemish Eel Pollutant Network database. One set from a small catchment area to investigate site-specific profiles, and one from seven large Flemish rivers to investigate river-specific profiles. The pollution profiles of persistent organic pollutants in individual eels along a river (even at distances <5 km) proved to be significantly different (Figure 6.1). Analysis of pooled contaminant data from multiple sites and sampling years within rivers allows characterization of river-specific chemical pressures. The results highlight the usefulness of eel as a bio-indicator for monitoring pollution with lipophilic chemicals like polychlorinated biphenyls and organochlorine pesticides in rivers (Belpaire *et al.*, 2008). It was concluded that, as such, eel may be used effectively within the monitoring programme for a selection of priority substances referred to in the Water Framework Directive (Table 6.1). Some countries reported planning reporting eel quality data within the WFD chemical status report.

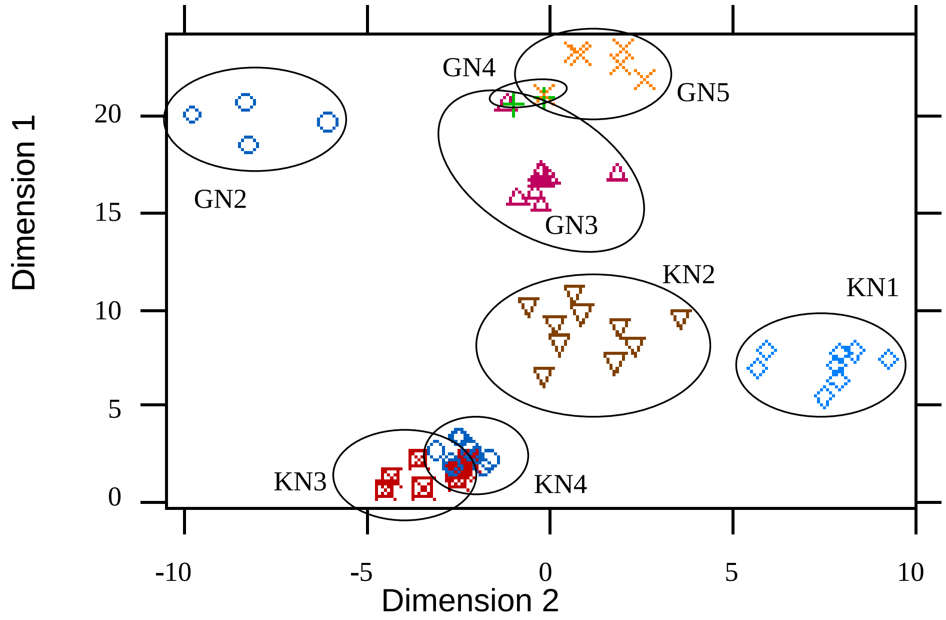

Figure 6.1: Canonical discriminant analysis of eels collected at eight sites in the Grote Nete and Kleine Nete on the basis of their PCB and OCP concentrations (N= 61). Distance between locations varied between 4 and 20 km.

Table 6.1: WFD substances mentioned under CEC (2007), and available data from measurements of Flemish eels. All data are expressed in ng g⁻¹ wet weight. DL, detection limit (from Belpaire and Goemans, 2007).

Substance	Note	Range Min – Max (Mean)	%<DL	No. of sites	Years	Source
Benzene	a	1.2–18.9 (5.7)	0	20	1996–1998	j
Brominated diphenylethers	a	6.9–5 284.4 (369.1)c	0	18	2001	l
Cadmium and its compounds	a	D.L.-151.4 (11.7)d	19	357	1994–2005	k
1,2-Dichloroethane	a	D.L.-4.9 (1,2)	55	20	1996–1998	j
Hexachlorobenzene	a	D.L.-61.6 (5.7)	<1	357	1994–2005	k
Hexachlorobutadiene	a	D.L.-12.2 (1.8)	50	20	1996–1998	j
Alfa-Hexachlorocyclohexane	a	D.L.-13.7 (0.8)e	13	357	1994–2005	k
(gamma-isomer, Lindane)	a	0.1–2 076.4 (46.9)	0	357	1994–2005	k
Lead and its compounds	a	D.L.-1 744.2 (56.6)f	3	357	1994–2005	k
Mercury and its compounds	a	10–535.4 (113.5)g	0	355	1994–2005	k
Naphthalene	a	1.5–63 (5.8)	20	20	1996–1998	j
Nickel and its compounds	a	D.L.-2 944.7 (186.2)h	16	297	1994–2005	k
(1,2,4-Trichlorobenzene)	a	D.L.-30.9 (6.0)	15	20	1996–1998	j
Trichloromethane (chloroform)	a	D.L.-96.0 (13.4)	25	20	1996–1998	j
DDT total	b	6.6–1 102.7 (90.2)i	0	357	1994–2005	k
p,p′-DDT	b	D.L.-62.6 (2.9)	38	357	1994–2005	k
Aldrin	b	D.L.-11.4 (1.3)	33	96	1994–2005	k

Substance	Note	Range Min – Max (Mean)	%<DL	No. of sites	Years	Source
Dieldrin	b	D.L.-237.6 (19.1)	15	357	1994–2005	k
Endrin	b	D.L.-29.1 (1.1)	80	346	1994–2005	k
Tetrachloroethylene	b	D.L.-88.9 (13.4)	50	20	1996–1998	j
Trichloroethylene	b	D.L.-30.3 (2.0)	95	20	1996–1998	j

[a] Priority substances.

[b] Other pollutants, which fall under the scope of Directive 86/280/EEC and which are included in List I of the Annex to Directive 76/464/EEC, are not in the priority substances list. Environmental quality standards for these substances are included in the Commission's proposal to maintain the regulation of the substances at Community level.

[c] The data present the Sum of 10 BDEs.

[d] Cd.

[e] alpha-hexachlorocyclohexane.

[f] Pb.

[g] Hg.

[h] Ni.

[i] Sum of p,p'-DDD, p,p'-DDT, and p,p'-DDE.

[j] Data from Roose *et al*. (2003).

[k] INBO Eel Pollutant Monitoring Database.

[l] Data from de Boer *et al*. (2002) and Belpaire *et al*., 2003.

6.2.3 Eel pollution monitoring networks-status and trends

Most of the countries submitted data on contaminants to the EEQD (see Annex 5 for Country reviews). In many sampling sites, concentration of contaminants fell and this probably reflects decreasing contaminant exposure. However, the monitoring does not evaluate the presence of new contaminants not to mention the increasing number of non-native species. Nevertheless there are widespread industrialized regions where contaminant loads still exceed reference levels.

Some countries are operating Eel Pollution Monitoring Networks on a national scale. The networks allow the follow-up of contamination in eels and allow detailed analyses of the status and trends for a specific contaminant, or a group of contaminants. They also allow detailed analysis of status and trends of contamination on a certain spatial scale (site, river, catchment, town, province, region). In some countries (e.g. Belgium) these trends can be viewed in reports via predefined queries on a national database available on the Internet, and maps are available for contamination in eel for PCBs, pesticides and heavy metals (e.g. Goemans *et al.*, 2008). As an example the distribution of PCB 156 in eel from Flanders (Belgium) is represented in Figure 6.2. This allows the indication of good and bad quality eel areas.

Eels from different river basins differ in contamination. Belpaire *et al.*, 2008 presented PCB and OCP contamination profiles for some basins in Belgium. Eels from the river Yser are characterized by high OCPs, especially dieldrin and lindane (γ-HCH), and low PCB levels. In the River Maas, PCB concentrations are high, and are dominated by the higher chlorinated (and higher toxic) PCBs.

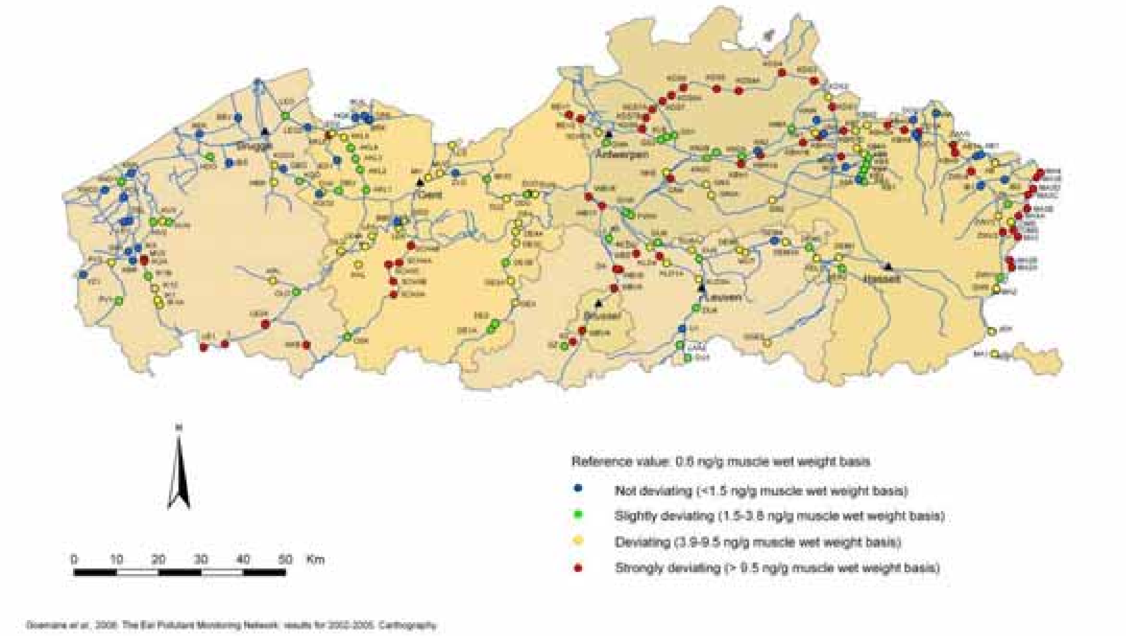

Figure 6.2: Distribution of PCB 156 in yellow eel in Flanders (2002–2005); means on muscle wet weight basis, classified following the deviation from the reference value (Goemans *et al.*, 2008).

High concentrations of some substances in eel tissue confirmed the previously known high pollution load of some specific areas, but in many cases however, eel analyses revealed unknown environmental problems. In a few cases analysis of eels from a specific location has demonstrated unsuspected high pollution levels of several contaminants. But several contaminants (e.g. BTEX (benzene, toluene, ethylbenzene and the xylenes) compounds, PCBs and some very persistent OCPs like DDTs) are widespread in certain countries. (Roose *et al*., 2003)

Results of measurements of dioxins on eight locations in Belgium (Flanders) indicate some reason for concern. Dioxin concentrations in eel vary considerably between sampling sites, suggesting that eel may be good indicators of local pollution levels. The European Commission has set maximum levels of 4 pg TEQ g^{-1} fresh weight for the sum of dioxins (WHO-PCDD/F TEQ) and 12 pg TEQ g^{-1} fresh weight for the total-TEQ i.e. the sum of dioxins and dioxin-like PCBs (WHO-PCDD/F-PCB TEQ) in muscle meat of eel and products thereof (Directive 2002/69/EC). Half of the sampling sites in Belgium demonstrate DL-PCB levels exceeding the European consumption level (with a factor three on average). The levels of PCDD/FS and DL-PCBS measured in some sites gave rise to serious concern about the reproduction potential of the eels from these sites. Human consumption of eels, especially in these highly contaminated sites, seems unwise (Geeraerts *et al*., in press).

Trend analysis in a Belgian study (Maes *et al*., 2008) over the period 1994–2005 indicated that there were significant decreases in the average wet weight concentration of all PCB congeners, nearly all pesticides and four metals. The observed decline of PCBs in eel tissue was in agreement with other studies reporting on time-series of contaminants in fish. PCBs were banned from the EU in 1985 and since then, several time-series have indicated decreasing levels of contamination. Also concentrations of most pesticides decreased significantly over time. This was especially evident for α-HCH and lindane, demonstrating that the ban of lindane in 2002 has positive effects on the accumulation in biota. Similar reductions were modelled for HCB, dieldrin and endrin; however these compounds were banned many years ago. Unexpectedly, concentrations of *p,p'*-DDT increased while at the same time, *p,p'*-DDD and *p,p'*-DDE demonstrated significant decreases.

The ratio of DDE over DDT was >1 in all eels analysed, normally suggesting that DDT had not been recently reapplied. At some locations in Flanders, however, the ratio of DDE over DDT rapidly decreased by an order of magnitude of three over a few years. Such a steep decrease, even if the ratio was higher than one, probably indicates recent application of DDT and demonstrates that not all stock was depleted. This urged regional policy-makers to make a serious attempt in order to collect the remaining stock of banned pesticides.

Some heavy metal concentrations decreased in the eel, in particular lead, arsenic, nickel and chromium were notably reduced. The concentration of lead in eel muscle tissue was consistently decreasing between 1994 and 2005, which possibly is related to the gradual changeover from leaded to unleaded fuels and a reduction of industrial emissions. For arsenic, nickel and chromium, the trend may be biased as data were available only since 2000. Cadmium and mercury, however, did not demonstrate decreasing trends and remain common environmental pollutants in the industrialized region of Flanders.

Following the very high levels of BFRs encountered in eels from Oudenaarde, new measurements were carried out in 2006 (Roosens *et al*., 2008). A descending trend in the contamination with BFRs was observed from 2000 to 2006 on this site. For PBDEs, levels have decreased by a factor 35 (26 500 to 780 ng g^{-1} LW), whereas for hexabromocyclododecane (HBCD), the decrease was less conspicuous, (35 000 to 10 000 ng g^{-1} LW). Based on these results we can conclude that in 2006, fish seem to be less exposed to PBDEs than 6 years earlier. This is probably as a consequence of the restriction regarding the use of the penta-BDE technical mixture (since 2004), a better environmental management and a raising awareness concerning PBDEs. However, since there are no restrictions regarding its usage, HBCD can still be detected in large quantities, especially in aquatic environmental samples taken next to industrialized areas, where it is used in specific applications. The textile industry is likely the cause of elevated BFR levels in fish on this part of the river Scheldt, but further studies should be set up to determine the exact origin and how far this contaminated area extends over the whole river.

It was concluded that Eel Pollution Monitoring Networks, such as the ones operated in Belgium and The Netherlands, allow getting a comprehensive overview of contaminants indicating environmental pressure, and they are able to document the temporal evolution of some of these pressures. These national monitoring networks should be upscaled at the European level. The intensity of pollution, at least at some sites, may well indicate potential negative effect on the health of these contaminated eels. These data underline the large variation in quality status of the eel over its distribution range. It is believed that this variation in quality is indicative with a variation in reproduction potential (Belpaire *et al.*, in press).

6.2.4 Contamination in eel and its role in the decline of the stock

We summarize the main findings of work in this field (see also Belpaire, 2008) in the following section and draw some conclusions related to the potential role of contamination in the collapse of the stock.

As a consequence of the increased international concern about the decline of the stocks, also research actions have paid increasing attention to analyse contaminants in the eel and to investigate the effects of these substances in the eel. As a result a large and growing quantity of information became available, and as suggested ICES 2007 a review on the effects of contaminants is underway. Many studies have examined the impact of a wide variety of xenobiotics on various aspects of fish biochemistry, physiology and population structure. In some cases of acute pollution, direct effects are clearly visible as fish may be moribund or dying. But contaminant exposure can lead to a decrease in growth or a lowered or deficient immunological system, causing an increased sensitivity to infectious diseases and parasites. But in most cases, these effects have been induced by effects on molecular and subcellular level. The last 20 years, an increasing number of reports deal with studying causality between pressure of xenobiotics and response at the subcellular level. In the eel, the impacts of contaminants on metabolic functions and on behaviour of the eel are widely divergent and act through various mechanisms. Figure 6.3 shows a simplified conceptual model of the effects of pollution exposure on the population structure of the European eel (after Geeraerts *et al.*, in prep, adapted from Lawrence and Elliott, 2003).

A significant negative correlation between heavy metal pollution load and condition was observed, suggesting an impact of pollution on the health of subadult eels (Maes *et al.*, 2005. In general, a reduced genetic variability was observed in strongly polluted eels, as well as a negative correlation between levels of bioaccumulation and allozymatic multi-locus heterozygosity (Maes *et al.*, 2005).

Van Campenhout *et al.*, 2008 studied the effect of metal exposure on the accumulation and cytosolic speciation of metals in livers of European eel by measuring metallothioneins (MT) induction. This research was carried out in four sampling sites in Flanders revealing different degrees of heavy metal contamination (Cd, Cu, Ni, Pb and Zn). It was concluded that the metals, rather than other stress factors, are the major factor determining MT induction. The effects of perfluorooctane sulfonic acids (PFOS) in Flemish eels were studied by Hoff *et al.*, 2005, indicating that PFOS induces liver damage.

In France, migrating silver eels *A. anguilla* were collected in a river system where algal blooms occurred yearly. Fifty per cent of eel livers were contaminated by microcystin-LR (the most common and toxigenic compounds associated with cyanobacterial blooms). Contaminated silver eels had lower fish condition compared to non-contaminated eels. Consequences of this impact for the breeding potential of these migrating eels are discussed, in particular the importance of lipids and energy reserve allocation. The consequences of contamination by microcystins on the breeding potential of silver eels should be further investigated (Acou *et al.*, 2008).

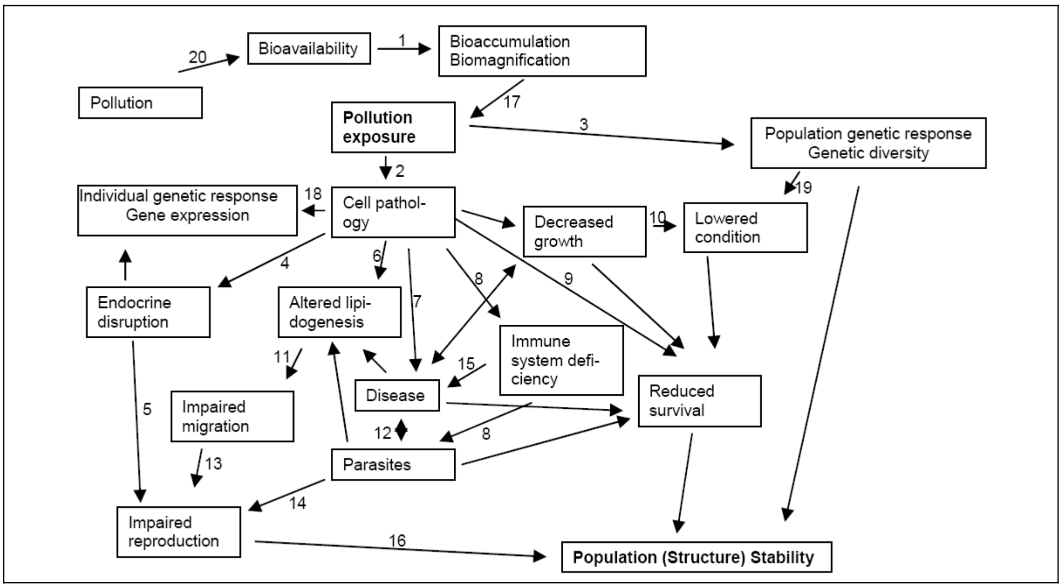

Figure 6.3: A simplified conceptual model of the effects of pollution exposure on the population structure of the European eel, *A. anguilla*. Adapted from Lawrence and Elliott, 2003. Numbers refer to references: (1) Vollestad, 1992; (2) Tuurula and Soivio, 1982; Svobodova *et al.*, 1994; Azzalis *et al.*, 1995; Stohs and Bagghi, 1995; Sancho *et al.*, 1997; Ibuki and Goto, 2002; Pacheco and Santos, 2002; (3) Nigro *et al.*, 2002; Jha, 2004; Maes *et al.*, 2005; Nogueira *et al.*, 2006; (4) McKinney and Waller, 1994; Versonnen *et al.*, 2004; (5) Jobling *et al.*, 2002; (6) Jimenez and Burtis, 1989; Sancho *et al.*, 1998; Fernandez-Vega *et al.*, 1999; Robinet and Feunteun, 2002; Hu *et al.*, 2003; Pierron *et al.*, 2007; (7) Roche *et al.*, 2002; (8) Sures and Knopf, 2004; Sures, 2006; (9) Sancho *et al.*, 1997; (10) Gony, 1987; (11) Ceron *et al.*, 2003; van den Thillart *et al.*, 2005; (12) Van Ginneken *et al.*, 2005; (13) Johnson *et al.*, 1998; Palstra *et al.*, 2007; (14) Sures, 2006; (15) Van Ginneken *et al.*, 2005; (16) Corsi *et al.*, 2003; (17) Van Campenhout *et al.*, 2008; (18) Ahmad *et al.*, 2006; Maria *et al.*, 2006; (19) Jha, 2004; Maes *et al.*, 2005; (20) Belpaire *et al.*, 2003 (after Geeraerts *et al.*, 2008, in prep).

Geeraerts *et al.*, 2007 analysed an extensive dataset of contaminants by statistical modelling and concluded that PCBs, especially the higher chlorinated ones, and DDTs, have a negative impact on lipid content of the eel. It was further demonstrated that fat stores and condition decreased significantly during the last 15 years in eels in Flanders and in The Netherlands (Belpaire *et al.*, 2008), jeopardizing a normal migration and successful reproduction. In Belgium and The Netherlands over the past 15 years, lipid contents dropped by about one-third (from ca. 20% to 13%) (Figure 6.4). Also the condition (Le Cren's relative condition factor) of the eels decreased. Lipid reserves are essential to cover energetic requirements for silver eel migration and reproduction. On the basis of the somatic energy reserves, reproductive potential of eels from various latitudes over Europe was estimated, assuming fat levels in yellow eel are indicative of those in silver eels. Only large individuals, females as well as males, with high lipid content seem to be able to contribute to the spawning stock (Belpaire *et al.*, 2008). Belpaire *et al.*, 2008 argue that the decrease in fat content in yellow eels may be a key element in the stock decline and raises serious concerns about the chances of the stock to recover (Figure 6.4).

It is therefore important to gain insight of the quality, lipid reserves and condition of the eels leaving continental waters and to include quality aspects in eel stock management. Both muscle lipid content and condition factor seem to be important integrative indicators in an overall estimate of the quality of the eels escaping to their spawning grounds.

Contaminant pressure is a plausible concern for the recovery of eel stocks and here we summarize arguments and hypotheses to underpin this:

1) Contamination has been demonstrated as the cause of population collapse of many other biota from the 1970s on (e.g. the collapse of several birds of prey in the 1960s as a consequence of DDT).
2) Many chemicals have been developed and put on the market, simultaneous with the intensification of agricultural and industrial activities during the 1970s. The timing of this increase in the production and release of chemicals may fit with the timing of the decrease in recruitment from 1980 on.
3) Eels bioaccumulate many chemicals to a high extent.
4) The more or less comparable decreases in recruitment in the Northern-hemisphere *Anguilla* species, like *A. rostrata* and *A. japonica*, during the last 30 years, might suggest that some new contaminants quickly spreading over the industrialized world, might have contributed to the decline.
5) Many reports have been dealing with direct adverse effects of contamination on individual, population and community level in fish. In eel, many detrimental effects of contaminants on the individual level have been demonstrated, including impact on cellular, tissue and organ level. Also genetic diversity seems to be lowered by pollution pressure.
6) Considering the high levels of contamination in eels from many areas, endocrine disruption in mature silver eels might be expected, jeopardizing normal reproduction. Dioxin-like contaminants have been reported to hamper normal larval development.
7) Lipid levels in eels have decreased considerably over the past 15 years. This decrease in lipid levels is mainly induced by contamination. Low lipid levels may have contributed to a reduction in migration and reproduction success.

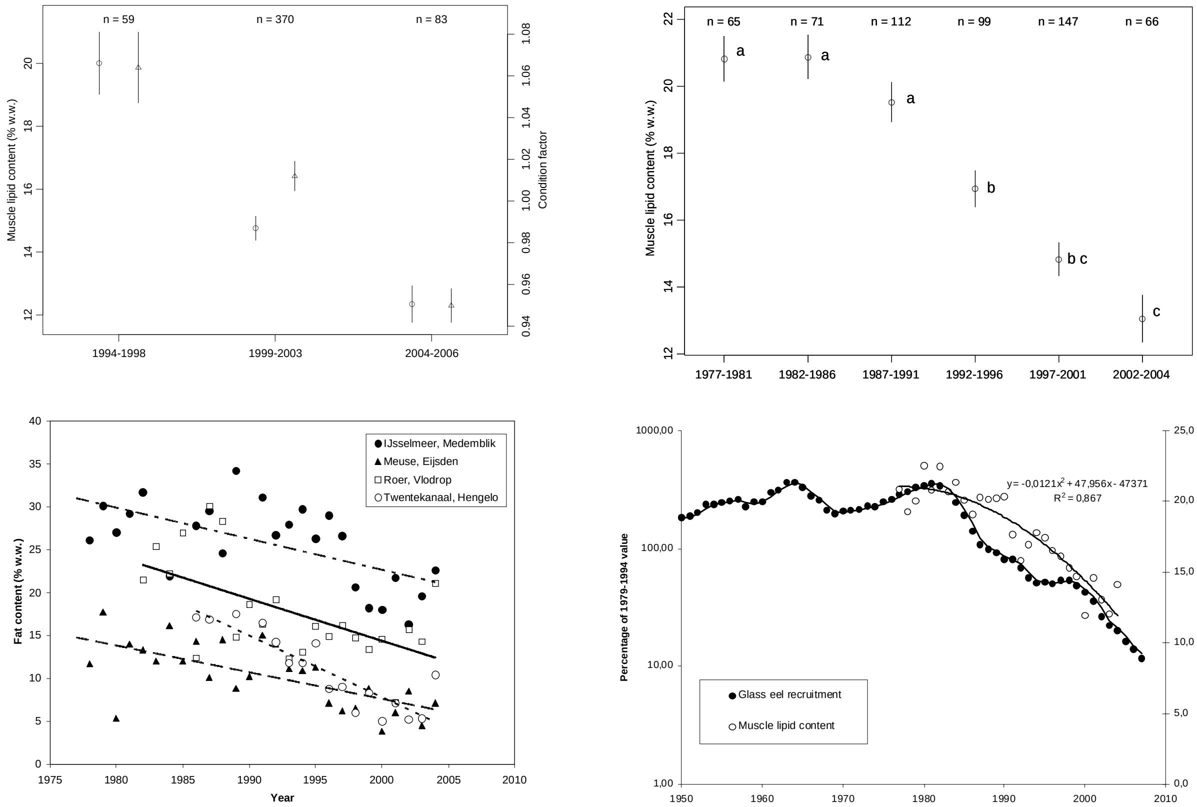

Figure 6.4: Temporal trend in fat contents (% of wet muscle weight) of yellow eels in Belgium (upper left panel) and The Netherlands (upper right panel) (means, bars indicating standard errors). The number of sites is indicated. Means of periods with the same letter are not significantly different from each other. For the Belgian eels also condition factor is presented. Lower left panel: Temporal trends in fat contents in yellow eels from four water bodies of different typology. Time trend of the fat content in muscle tissue (pooled samples) from yellow eels in a lake (IJsselmeer), a large river (Meuse), a small river (Roer) and a canal (Twentekanaal) in The Netherlands. Lower right panel: Time-series of glass eel recruitment in Europe (ICES 2007) and of muscle lipid contents in yellow eels from The Netherlands. Data of the time-series of glass eel recruitment are geometric means of monitoring data of recruiting biomasses in 21 European rivers, each series being scaled to its 1979–1994 average. Data of muscle lipid contents are means of pooled yellow eel samples from The Netherlands between 1977 and 2004 (Belpaire *et al.*, 2008).

Note: in the lower right panel: recruitment is on a log scale and muscle lipid is on a normal scale.

6.3 Parasites/pathogens

A. crassus can be considered widespread throughout Europe and there is a growing evidence that *A. crassus* is spreading further into new areas. New data in 2008 indicated the presence of the nematode in Canada (not included in the EEQD yet) for the first time. Further process research is required before the impact of contaminants and parasites can be included in the quantitative stock assessments.

6.4 Quality assessment of spawners using genomic tools

Eel decline might depend not only on the quantity of adult eels leaving the continent, but also upon their quality. Good quality spawners are those that succeed in crossing the Atlantic Ocean and reproduce. Parasites, such as the exotic swimbladder nematode *A. crassus* can impair eel viability by both increasing continental mortality and affecting the swimming ability of adult eels. Organic and inorganic pollutants may significantly reduce the quality and reproductive capacity of vertebrates. This is especially the case in fish, where pollutants may accumulate in the water and sediment and in the benthic biota (food). Additionally, infections and pollution have been revealed to impair strongly the survival and reproductive capacity of eels in experimental trials, resulting in an even stronger response to pollution and vice-versa (Palstra *et al.*, 2006; 2007). A thorough analysis of pollutants and pathogen stress levels and a better understanding of the biological response (besides measures of condition index) are missing. Pujolar *et al*., 2005 and Maes *et al*., 2005 assessed whether the genetic background of European eels could be linked to two fitness traits, early growth and pollutant bioaccumulation. Summarizing both studies here, there was strong evidence of a relation between genetic diversity and fitness measures (also called Heterozygosity-Fitness-Correlations or HFCs). It might be explained either by an effect of direct overdominance at functional markers. Recently, it became possible to reliably quantify the gene and protein expression levels during exposure to pollutants and parasites, allowing the early detection of decreased fitness and survival. Such knowledge would provide the chance for early warning systems, facilitating management actions before major mortality events in natural populations and provide a long-term assessment of success rates of conservation measures. Using sufficient background information on the identity and concentration of pollutant, this approach may yield better insights into the factors influencing the recently observed decrease in fat content, a potentially crucial measure for eel's ability to reach the Sargasso Sea. The ongoing analyses of northern (Belgium) and Southern (Italy) eel populations for their gene expression level and health status will allow adding a quality status tag on silver eels, while identifying good quality habitat for preservation.

6.5 The European Eel Quality Database

6.5.1 Introduction

In 2006 the EEL WG recommended that further sampling and ongoing monitoring into eel quality was urgently required. Member countries should set up a national programme on RBD scale to evaluate the quality of emigrating spawners. This should include at least body burden of PCBs, BFRs, infestation levels with *A. crassus*, and EVEX. It should be included in the national management plans while special emphasis should be given to standardization and harmonization of results (units and methods). To this effect the European Eel Quality Database was created in Belgium in 2007 and circulated among members of the EELWG requesting data on fat composition, contaminant analysis and infection parameters of *A. crassus.* During the intersession period and during the Working Group meeting 2008 eel quality data has been provided and included in the EEQD.

The database is coordinated by the Research Institute for Nature and Forest (Belgium) and includes data on eel quality elements, such as condition, contaminant concentrations and epidemiological parameters, in addition to the relevant descriptors of date and place of sampling and sample characteristics (eel life stage, number and morphometrics). The database was initially restricted to a limited number of quality elements (lipid content, ca. 30 chemicals and *A. crassus* infection parameters). During WGEEL 2007 some countries reported on some more elements, and the list of ICES7 (CB28, CB52, CB101, CB118, CB138, CB153 and CB180) congeners was extended with non-*ortho* and mono-*ortho* congeners, as they exhibit the highest dioxin-like toxicity and contribute most to the TEQ (toxic equivalency). Also one pesticide, several metals and some bacterial disease agents were added.

During the WGEEL, 2008 evidence has been presented that condition factors are important elements for estimating eel quality (Acou *et al.*, 2008; Belpaire *et al.*, 2008). It was recommended that condition should be included in the EEQD, this requires however a standardized methodology (Froese, 2006).

6.5.2 Analysis of the EEQD

During the Working Group session, new data were compiled and the EEQD now contains information from 14 countries reviewed in Table 6.2. Data from Norway, France and Estonia also are available and will be included in 2008. Data source is heterogeneous, data deriving most from national or local level surveys, but also from eco-toxicological studies. Belgium has presented the most exhaustive information, as a consequence of the availability of data from the Flemish eel pollution network, in place since 1994 (Belpaire and Goemans, 2007). Norway also provided a long time monitoring series in the Grenland fjords (S. Norway) following the discovery of PCDF/PCDDs in edible organisms after a 99% reduction in the load of waste components from the Hydro Porsgrunn magnesium factory (Knutzen *et al.*, 2001). However, the longest dataseries for bioaccumulation of contaminants is from the Netherlands, because in this country a monitoring network for PCBs, OCPS and mercury in eel is in place since the 1979s, linked to the safety for consumption norms. Germany and UK have provided data on concentration of pollutants and contaminants relative to some river basins, carried out within local monitoring programmes. Some countries (Italy, Portugal, Spain) did report data drawn from eco-toxicological studies carried out within specific researches. Some countries (e.g. France and the Netherlands) have published reports demonstrating that considerable information is available. At the present moment this information is not accessible for inclusion in the EEQD. On the whole, eel quality data were provided for approximately 600 different sites over Europe; at the present however, the database is overbalanced, most of the sites being situated in Belgium. Most information is available for heavy metals (771 records), PCBs (695 records) and organochlorine pesticides (OCPs) (656 records) while 566 observations on lipid content were also included. Apart from some observations on bacterial diseases available for three sites in Spain and one site in UK, disease agents included in the database are restricted to the swimbladder nematode *A. crassus*, with epidemiological data from 335 sites across Europe.

Given the importance of lipid levels as an energy resource utilized during the eels' migration and for the production of gametes, disturbing data are seen in Europe. Four out of twelve countries have a fat percentage above 20% (Figure 6.5, the minimal lipid storage needed for a successful reproduction (Boëtius and Boëtius, 1980; Van den Thillart *et al.*, 2004; 2005).

Research on the fat content in yellow eels has been done on two (independent) large datasets of lipid contents in yellow eels from Belgium and the Netherlands. A 7.7%

decrease in lipid content on wet weight basis over a 13 year period has been revealed in Belgium. Whereas in the Netherlands before 1990 the mean fat content was generally superior to 20%, a clear and significant decrease occurred after 1990. Notwithstanding the differences in both network concepts, and large variation in lipid contents of eels from various water bodies, similar trends were obvious in Belgium and the Netherlands: a drop in lipid contents over the past 15 years by about one-third (from ca. 20% to 13%) (Belpaire *et al.*, in press).

Table 6.2: Overview of the number of records of eel quality data compiled during the WGEEL 2008 and incorporated in the European Eel Quality Database.

Country	Fat	PCB	Pesticides	Heavy metals	A. crassus	BFR	Dioxin	PFOS
Belgium	409	408	373	373	140	24	8	
Denmark	7	6	6		3	4		12
Estonia								
Finland								
France		12		3				
Germany	14	12	23	23	26		2	
Ireland	13	9	7		6	7	7	
Italy	24	24	20	7	10			
Latvia								
Lithuania								
Northern Ireland	2				3			
Norway	8	8	8					
Poland	7	7	7	7	21		7	
Portugal	1	1		12	8			
Spain	18	60	73	52	52			
Sweden	25	10	1	179	51		7	
The Netherlands	37	99	99	76				
UK	1	39	39	39	16			
TOTAL	566	695	656	771	335	35	31	12

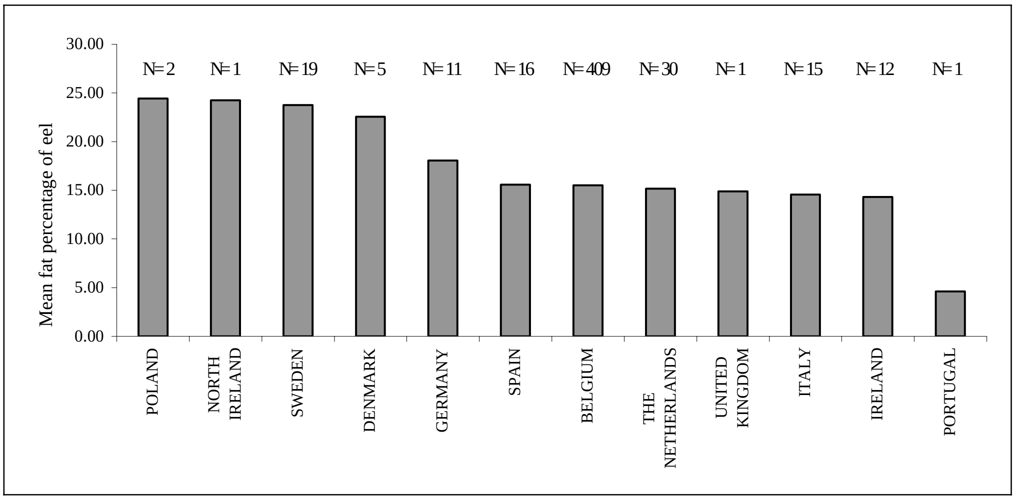

Figure 6.5: Variations in mean muscle lipid content (%) in yellow end silver eels in Europe. N indicates the number of sites on which the mean values are calculated.

6.5.3 Future development of the database

The development of a European Eel Quality Database in the WGEEL 2007 has been updated during the 2008 session and now forms the basis for compiling a comprehensive pan-European overview of eel quality data.

There is a wide range of information widely scattered over Europe by location and collecting agency. The collection and reporting of eel quality data are recommended within the international framework for the restoration of the species (Data Collection Regulation) as proposed by the Working Group on Eel (ICES, 2006) and the Scientific, Technical and Economic Committee for Fisheries of the EC (STECF, 2006). The collection of such data are now also included in the guidelines for the preparation of Eel Management Plans.

Some information is missing and the database has to be expanded and further updated in the future. For instance some countries (e.g. France and the Netherlands) have published reports that demonstrate considerable information is available but data were not presented for inclusion in the EEQD. It is also presumed that many unpublished results are available in some countries and should be utilized by inclusion in the database. Some were provided during the Working Group meeting, but could not be included in the database at the time.

Considering that eel quality could be a major element in the decline of the species, the database may become a useful tool for the (inter)national eel conservation measures. The database allows the identification and designation of good quality sites where special measures for maximum protection of stocks and emigrating spawners of good quality can be proposed (e.g. restriction of fisheries, priority places for restocking, priority for habitat restoration measures, etc). From preliminary analyses it was clear that many contaminants and lipid reserves varied a lot over the distribution area of the eel (ICES, 2007) and the presence of 'black spots' was identified. EEQD data on disease agents such as *A. crassus* demonstrated a widespread distribution over Europe. From an environmental point of view it is clear that the database will give information about specific environmental chemical pressures and will indicate pollution areas for specific contaminants. The database will allow an overview and in-depth analysis of eel quality on a Europe wide scale and follow-up of emerging problems of a chemical or epidemiological nature and could also be used as an early warning system for the spread of new eel diseases or contaminants. Yellow eels have been proposed as a sentinel organism for evaluating the chemical quality of priority hazardous substances in biota in accordance with the WFD. EEQD can integrate these data and make them available for eel stock management. The database will pinpoint sites where the quality of eels is below that deemed suitable for human consumption, so adequate fisheries management measures, like closing fisheries or preventing consumption of eels, can be taken in these areas.

6.6 Conclusions and recommendations for Chapter 6: Eel quality

6.6.1 Conclusions

Estimation of effective spawner biomass requires quantification of the adverse effects of contaminants, parasites, diseases, low fat levels, non-lethal turbine damage, along the lines previously proposed for *A. crassus*, as well as other mortality rates throughout the river basin. Present knowledge does not fully permit quantitative assessment of the effects of these factors on the overall stock.

The European Eel Quality Database (EEQD) has been updated with data on contaminants, parasites and fat levels in eel, allowing the compilation of a comprehensive overview of the contaminant load in eel over its distribution area. Results demonstrate highly variable data within river basin districts, according to local anthropogenic pollution, linked with land use. Persistently elevated contamination levels, above human consumption standards, are seen in many European countries. The most important reported impact is seen on the fat content of the yellow eels (i.e. in Belgium and the Netherlands) which has decreased over the last number years and which raises concern regarding the migratory and reproductory success of silver eels. There is growing evidence that *A. crassus* is spreading further into new areas and new data indicate the presence of the nematode in Canada (not included in the EEQD yet) for the first time.

Clear ecotoxicological effects of contaminants have been demonstrated. The most important impact is seen on the fat content of the eels which is decreasing over the last number of years and which may jeopardize migration and reproduction success.

The value of monitoring contaminants in eel for environmental issues has been demonstrated. But the eel as a bio-indicator is not recorded in the Water Framework Directive and the number of contaminants recorded is insufficient for safeguarding sufficient eel health.

6.6.2 Recommendations

The Working Group recommends the continuation on a local scale of the long-term monitoring of quality (contaminants, parasites and disease) in eel with an emphasis on standardizing the methodological approach, analysis of new compounds, an appropriate communication system and robust data management. The European Eel Quality Database should be developed and maintained. Member States should initiate harmonized monitoring strategies aimed toward the development of a European Eel Quality Monitoring Network, to collect the relevant data to be fed into the EEQD.

The Working Group recommends investigations into eel quality of the eels leaving continental waters so as to include quality aspects in eel stock management and evaluation of effective spawning escapement.

Carry out a Europe wide study to comprehend relationships between contamination and eel stock decline. An important focus should be to study the effects of contaminants on lipid metabolism and condition.

The Working Group repeats its recommendation that contaminant monitoring in eel should be included as a tool for measuring the chemical status of our water bodies as defined in the Water Framework Directive.

7 Oceans, climate and recruitment

7.1 Introduction

Term of Reference c. tasked the Working Group to, "review hypotheses and information on the possible relationships between the European (and American) eel stock(s), recruitment patterns and climatic and oceanic factors".

European *A. anguilla* and north American *A. rostrata* eel spawn in the Sargasso Sea. This part of the life cycle has not been witnessed or quantified and therefore the full stock–recruitment relationship circle cannot be closed at present. Oceanic factors, biological and physical, may influence the recruitment of eel through impacting on both the migrating silver eels and on the subsequent return of juvenile recruits. Overlaid on this, recruitment of European eel has decreased by approximately 95% since 1982 (Dekker, 2003) and is below 5% since 2000 (ICES, 2007).

In addressing this ToR, the WG in its pre-meeting undertook a literature review and invited submissions to this review. The WG would like to acknowledge inputs from Beaulaton, Bonhommeau, Cairns, Dekker, Friedland, Kettle, Knights, and Miller.

7.2 Review of ocean change/controlling mechanisms

Long-term climate variation in the North Atlantic has been revealed to correlate with observed trends in aquatic and terrestrial ecosystems throughout Europe (Ottersen *et al.*, 2001). SST (sea surface temperature) differences may be the main drivers of the North Atlantic Oscillation (NAO) and associated continental climate change. Cycles of change could result from slow transfers of warmer/colder water by the major thermohaline and wind-driven gyre currents (Hurrell, 1995). Changes in the NAO winter index (NAOI) since the 1820s appear to follow cycles with periods varying in the range 7 to 13 years. In addition to the NAO there are other natural longer period climate cycles i.e. the approximately 60 year Atlantic Multidecadal Oscillation (AMO, Sutton and Hodson, 2005) (Figure 7.1). Superposed on the natural climate oscillation is the steady anthropogenic increase of global temperature.

The widely used NAO index quantifies alterations in atmospheric pressure between the subtropical Atlantic (Azores) and the Arctic (Iceland). An increased Azores High indicates more and stronger winter storms crossing the Atlantic in a more northerly track, and shifts the Gulf Stream to a more northerly position. A number of alternative indices have been defined, varying in the months included, the analysis procedure and the exact locations measured (Dekker, 2004a). The NAO winter index is always used, because it provides the most pronounced signal. The North Atlantic SST demonstrates a long-time downward trend expressing the combined effects of NAO and AMO from the early 1940s until the early 1970s followed by a gradual increase until the mid 2000s, amplified by the anthropogenic warming. The most recent data indicate the beginning of a cooling period. The unusual warming of the North Atlantic is also indicated by the relationships to the Sargasso Sea Surface Temperature (SS-SST) (Figure 7.2). Other parameters have also been analysed by various authors and their putative effects are described in Table 7.1.

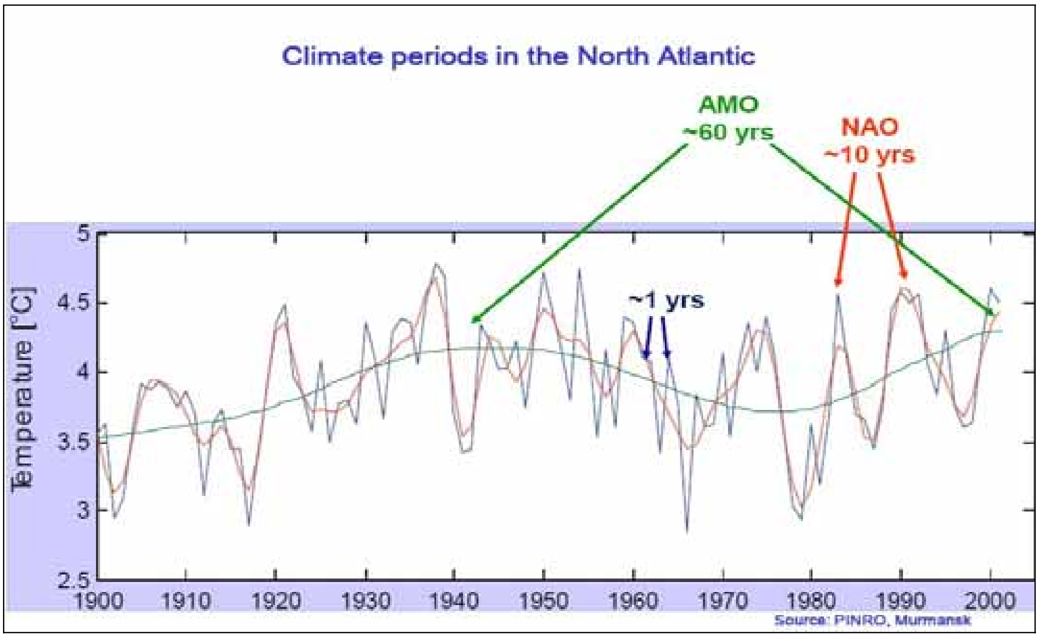

Figure 7.1: The effect of the natural climate oscillations over the North Atlantic area on the mean yearly sea temperature of the Kola section in the Barents Sea illustrating the interaction between decadal and multidecadal time-scales. From Svein Sundby presented at *Fisheries Management and Climate Change in the Northeast Atlantic Ocean and the Baltic Sea,* Bergen 17–18 April 2008.

7.3 Review of recruitment patterns in eels

Leptocephali larvae of European eel are transported along the Gulf Stream and North-Atlantic Drift for a journey taking somewhere between an estimated 8–9 months (Lecomte-Finiger, 1992) and 2–3 years (Tesch, 2003; Kettle and Haines, 2006; Bonhommeau *et al.*, 2008) to arrive back to the eastern Atlantic coast where they metamorphose to glass eels, ascend rivers and grow as yellow eels until reaching partial maturity (Tesch, 2003). American eel leptocephali must also reach the Florida Current or Gulf Stream, although they later have to leave that current system to recruit to the coast of North America. Leptocephali grow larger and have a longer larval duration than most fish species, taking up to a year or longer before they recruit to fresh-water habitats as glass eels or elvers. This long larval duration is thought to make leptocephali particularly susceptible to changes in ocean currents and food availability (Friedland *et al.*, 2007).

A fundamental question in resolving the role of ocean circulation in life cycle of the European eel is the duration of the larval migration. Schmidt, 1923 made a careful analysis of the age cohort size structure for leptocephali captures across the Atlantic Ocean and concluded that the passive transatlantic migration lasts two years with the metamorphosed glass eels entering fresh and brackish waters in spring at the end of their third year. Direct Lagrangian simulations (Harden Jones, 1968) indicated that the migration should take 2.5–3 years. A more recent Lagrangian study (Kettle and Haines, 2006) suggested that the duration of the larval eel migration was probably about two years. On the other hand, glass eel otolith ring counts have indicated an oceanic migration time of less than a year (Lecomte-Finiger, 1992), but there is debate about whether the growth rings are deposited daily. Knights, 2003 and Friedland *et al.*, 2007 suggest that there may only be a one year time delay oceanic perturbations represented by the NAO and the DenOever glass eel index, implying a one year migration period. The most recent study by Bonhommeau *et al.*, 2008 has indicated that there is a 2–3 year time-lag between perturbations of ocean temperature and primary productivity in the Sargasso Sea and glass eel recruitment indices in Atlantic France, and there is a convergence of opinion that the duration of the larval migration may be approximately two years.

Table 7.1. Oceanic parameters that have been analysed by various authors and their putative effects on eels.

Oceanic factor	Mechanism of influence	Author
North Atlantic oscillation NAO	NAO quantifies the alteration in atmospheric temperatures between the Azores and Iceland. It indicates a more northerly position of the Gulf Stream. Impacts larval migration	Dekker, 2004
Sargasso Sea Sea Surface Temperatures (SS-SST), average 0-100 m deep	The marine production increases with sea surface temperature in the cooler waters from the North Atlantic but decrease in warmer waters. This effect is as a consequence of a reduced vertical mixing and lower marine production thus impacting larval feeding	Bonhommeau *et al*., 2008
Sargasso Sea Winds	Surface current, caused by the combined effect of wind and Coriolis forces, have diminished, reducing the westward transport towards the Florida current into the Gulf Stream–could affect transport of leptocephali	Friedland *et al*., 2007
Mean Temperature of the northern hemisphere (NHT)	Would reflect climate change and its impact on primary production in the ocean and larval feeding.	Knights and Bonhommeau, unpublished
Gulf Stream Index (GSI)	Latitude of the Gulf Stream, from monthly charts of the north wall	Bonhommeau, 2008
Transport index (TI)	Strength of the Gulf Stream and North Atlantic current system (baroclinic gyre circulation in the North Atlantic) Calculated from potential energy anomalies (PEA) between Bermuda and Labrador basin – could affect transport of leptocephali	Bonhommeau, 2008
PP (Bermuda biological station, North of spawning area)	Primary production. Considered as a good proxy for leptocephali food.	Bonhommeau, 2008
Sea surface temperatures anomalies (SSTA)	Food availability for leptocephali would be expected to be reduced during warm high SSTA periods as a consequence of reduced spring mixing, nutrient recirculation and productivity	Knights, 2003
Surface expression of the 22.5°C isotherm	The 22.5 °C isotherm is a useful indicator of the northern limit of spawning by both species of eels in the Atlantic. Therefore, changes in the latitude or intensity of these fronts may affect both the spawning location and the subsequent transport of the leptocephali to continental habitats.	Friedland *et al*., 2007

A very short time-lag compared to the drift estimates seems unlikely considering the swimming ability of the leptocephalus larvae (Bonhommeau, 2008). To gain one year in the transatlantic migration the larvae has to sustain a continuous, directed swimming velocity of 15 to 20 cm/sec, or 3–5 body-lengths/sec. A typical anguilliform swimming speed is of the order 0.5 body-lengths/sec (Ellerby *et al.*, 2001).

Meta-analyses of many local dataseries have revealed common trends in the population. The breakpoint in the recruitment series in south and middle Europe from 1980 points to a shared process causing the decline thereafter. Recruitment series of young yellow eel in northern Europe deviates from this, with an earlier decline starting during the 1950s. This could be interpreted as a different climatic effect on the north- and south- going branches of the North Atlantic drift, which splits into the North East Atlantic and the Canary currents to the southwest of Ireland.

7.4 Review of hypotheses of causal linkages between oceanic factors and recruitment patterns

The mechanism or mechanisms behind the observed correlation between glass eel recruitment and climate oscillations are unknown. The migratory phase of adults and larvae, as well as the egg and larvae production might have been influenced by climate variation. Currently it is difficult to separate out the impact of ocean and climate on spawner migrations and on subsequent migrations of larvae and recruiting glass eels.

It has long been recognized that there may be a direct link between larval migration success and the density, or thermohaline circulation, of the ocean. The NAO might impact the larval migration by changing the ocean currents or by influencing ocean productivity and food availability for the migrating larvae (Knights, 2003). The long-term variations in glass eel recruitment indices may be modulated by characteristic time-scale of the NAO index, which varies in periodicity between 7 and 13 years. This had important implications in explaining the long-term decline in glass eel recruitment across Europe since the late 1970s as it has been recognized that the NAO index had been in a prolonged positive phase over this period (ICES, 2001; Friedland, 2007).

Focussing on the long term DenOever glass eel index, Friedland *et al.*, 2007 established the existence of significant correlations with environmental parameters in the North Atlantic during the spawning period between February and May: the surface expression of the 22.5°C isotherm, the eastward windspeeds, and the NAO. Explanations for the observed relationships focused on the possible influence of wind-induced geostrophic transport in advecting larvae into the Gulf Stream and on the impact of interannual variability of the mixed layer depth on nutrient supply and ocean productivity in providing food to the developing larvae.

A close negative relationship has been found over the last four decades between long-term fluctuations in recruitment and in sea temperature (Table 7.2). By contrast, variations in integrative indices measuring ocean circulation, i.e. latitude and strength of the Gulf Stream, did not seem to explain variations in glass eel recruitment (Bonhommeau *et al.*, 2008).

The impact of food availability in the Sargasso Sea on the success of the larval eel migration was suggested and rejected by Desaunay and Guerault, 1997. Using information about the length of the oceanic migration from otoliths the conclusion was that the number and physical condition of glass eels arriving on the coast of France was linked to chlorophyll concentration and food availability in the Sargasso Sea at the time of spawning. The largest glass eels near the spring arrival peak in coastal France were assumed to have started in the Sargasso Sea during the spring chlorophyll bloom of the previous year.

Bonhommeau *et al.*, 2008 used a short time-series to demonstrate a correlation between recruitment and primary production in the Sargasso Sea demonstrating a strong bottom–up control of leptocephali survival and growth. On a longer time-scale, SST is used as a proxy for primary production and related to recruitment indices. Sea warming in the eel spawning area since the early 1980s may have modified marine production and eventually affected the survival rate of European eels at early life stages (see Figure 7.2). Direct measurements of primary productivity in the northern Sargasso Sea were also found to be correlated with a three-year lag to the Loire River recruitment time-series in France, but not those at the other locations (Bonhommeau *et al.*, 2008). Changes in ocean productivity may also be associated with changes in the length and condition of glass eels recruiting to Europe (Desaunay and Guerault, 1997**;** Dekker 1998; 2004b).

Kettle *et al.*, 2008 have demonstrated that the NAO repeat cycle is present both in the glass eel catches and the FAO eel landing statistics. This means that there may be a resonant amplification between silver eel escapement and glass-eel recruitment. All stages of the life cycle appear to respond to interannual climate variability associated with the NAO, but it is not clear if the larval migration success is impacted directly by meteorological conditions over the Sargasso Sea or if it is modulated by the number of silver eels that are triggered to spawn by NAO-associated rainfall patterns in Europe.

Table 7.2: Correlations between various glass eel recruitment series and oceanic parameters.

Recruitment series	Oceanic parameter	Correlation	Time Lag (years)	Author
		Transport related parameter		
Series from Loire, L'Ems & Den Oever, 1950–2001	NAO (winter index)	-0.13	0 (max 1 and 6 years)	Dekker, 2004
DenOever 1938–2005	NAO (winter index)	-0.35	0 (max 0 and 8)	Friedland *et al.*, 2007
10 series	NAO (winter index)	GAM model significant effect but no linear trend		Beaulaton, 2008
26 series	NAO (winter index)	Anticorrelated-significant	1 to 4	Kettle *et al.*, 2008
Drakkar model, particles that succeeding in reaching the 20 W	NAO (winter index) GSI PEA	0.5 0.73 0.57	0	Bonhommeau, 2008
Mercator model, particles succeeding in reaching the 20 W	NAO (winter index) GSI TI	0.78 0.80 0.47	0	Bonhommeau, 2008
Drakkar model, minimum migration duration	NAO (winter index) GSI TI	-0.57 -0.75 -0.48	0	Bonhommeau, 2008
21 series 1935–2007	NAO	-0.28 -0.31 -0.35	2 3 7	Knights and Bonhommeau, unpublished
7 series	TI	NS	3	Bonhommeau *et al.*, 2008

Recruitment series	Oceanic parameter	Correlation	Time Lag (years)	Author
7 series	GSI	NS	3	Bonhommeau *et al.,* 2008
DenOever 1947–2004	Latitude of the surface expression of the 22.5°C isotherm in the Sargasso Sea	-0.15 to -0.39 according to month and longitude	1	Friedland *et al*., 2007
DenOever 1949–2003	Winds	-0.09 to -0.48	1 year	Friedland et al., 2007
		Production related parameters		
1955–2007	SS-SST	NS	1–6 years	Knights and Bonhommeau, unpublished
1935–2007	NHT	NS	2–3 years	Knights and Bonhommeau, unpublished
Loire series from trader 1994–2004	PP	0.74	2.5 years	Bonhommeau *et al*., 2008
Ems DenOever, Loire Nalon 1960–2005	SS-SST	-0.88	2.5-year	Bonhommeau, 2008
DenOever (3 year average) 1952–1995	SST anomaly at 100–250 m	-0.47 -0.30	0 year 1 year	Knight, 2003
DenOever (1960–1996)	Size of glass eels	0.7	0 year	(Dekker, 1998)

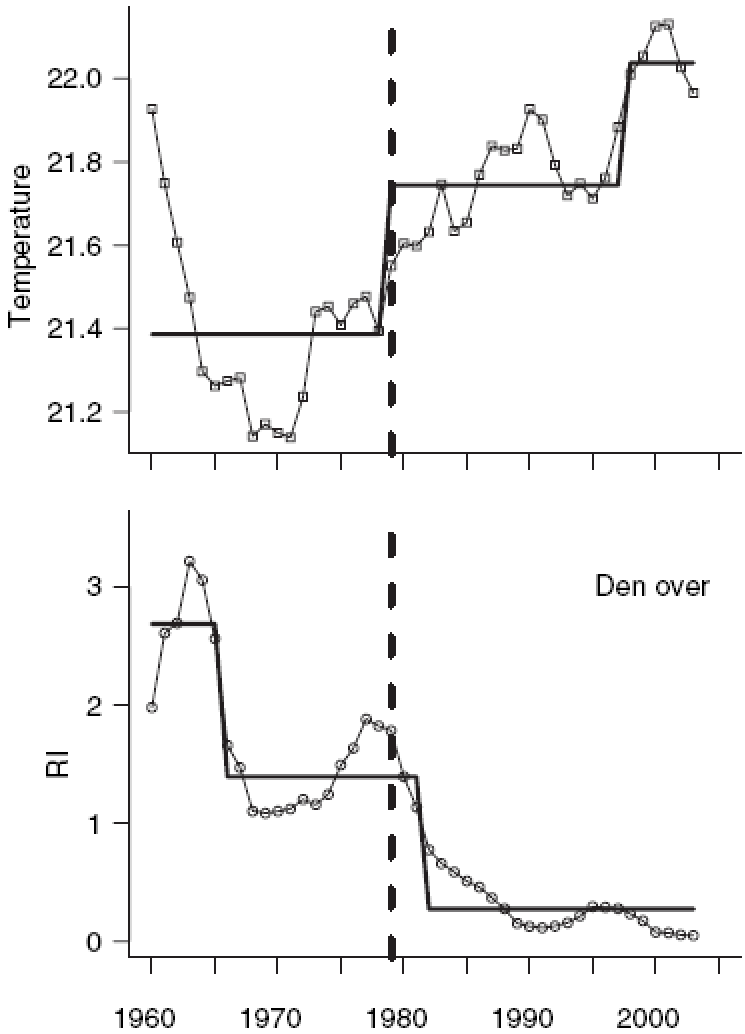

Figure 7.2: Time series of DenOever recruitment index (5-yr moving average; solid line with circles) and temperature (°C; 5-yr moving average; solid line with squares) in the Sargasso Sea from 1960 to 2003. Bold lines indicate regime shift detection (Rodionov and Overland, 2005) and vertical dashed line indicates the regime shift in temperature in 1979. (Reproduced from Bonhommeau *et al.*, 2008).

7.5 Ocean factors as reason (or contributory factor) for recruitment decline (1980s onwards)

The historic record shows strong evidence that the abundance and size of glass eels recruiting to the continent have the same periodicity as natural climate oscillations (Figure 7.3). Evidently NAO, and other climate cycles, are primarily meteorological indices that, at most, can be proxies to those ecological and hydrographic changes in the North Atlantic that could be the primary causes for variations of eel recruitment. Several parameters are possible candidates for the cause of the decline e.g. sea surface temperature anomalies and changes in productivity linked to temperature.

A shift in sea temperature in 1979 marked the beginning of changes in the Sargasso Sea environment and was followed by the large shift in eel recruitment detected in 1982 in most of the European rivers that have been analysed (Bonhommeau *et al.*, 2008). Correlation analysis of the glass eel catches revealed that almost all the monitoring indices across Europe vary in phase, providing support that they are modulated by a large-scale meteorological disturbance (i.e. as previously suggested by Knights 2003; Friedland *et al.*, 2007). However, measuring ascending young eels (young of the year, and older), the drop in recruitment in northern European rivers was observed considerably earlier. This leaves the possibility open that conditions closer to the European shelf may be important or that the decline in southern Europe started earlier also (see l'Adour and Gironde series, Chapter 2).

Temperature may be one of the main governing factors influencing eel larvae survival by decreasing food availability in the Sargasso Sea (Bonhommeau *et al.*, 2008). The size of glass eels is positively correlated with abundance and with the NAO-cycle. This also points to a role of ocean primary production on the feeding of glass eel and possible starvation of leptocephali. (Dekker, in prep, Figure 7.3).

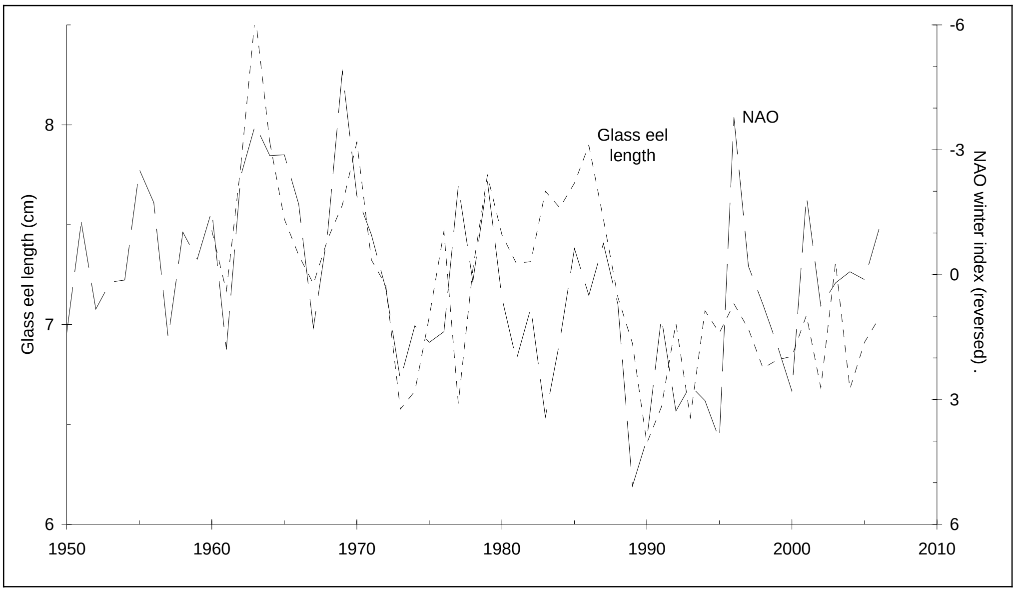

Figure 7.3: Trends in glass-eel length entering Lake IJsselmeer (short dash), and the NAO winter index (long dash). (Data from Dekker, 1998 and Hurrell, 1995). (From Dekker, in prep).

Changes in ocean currents, particularly in the Sargasso area, may have also affected glass eel recruitment. This assertion is supported by the correlation between recruitment series and NAO. It is also supported by results from modelling demonstrating the positive effect of transport indices on both success and time of migration. However, when looking at indices related to the strength of the Gulf Stream (TI and GSI), no significant correlation was found (Bonhommeau, 2008).

The steep decline in recruitment between 1980 and 1983 and the continued low and still declining recruitment since then cannot be easily explained by oceanic factors alone. The demonstration of a possible stock recruitment relationship (Dekker, 2003; 2004b; updated by WGEEL 2007) demonstrates strong evidence of a depensatory mechanism in the relationship. In this S/R relationship, landings have been used as a proxy for continental stock and it is assumed that continental stock varies in parallel with SSB. It is possible that this relationship between stock and SSB is not constant and that SSB has declined faster than the stock, possibly as a consequence of a breakdown in the migratory phase, the spawning process and/or the quality of the spawners, leading to a smaller number of recruits per spawner than observed prior to the 1980s. Isolation or fragmentation of spawning effort as a consequence of low SSB may have exacerbated this. The steep stock related decline in recruitment could be overlaid on the oceanic influences and might have drowned out the ocean signals in latter years.

A different view to this is proposed by Knights and Bonhommeau, unpublished. They found that combined and geographical-area stock trends are more meaningful than landings data for use in formulating stock–recruitment hypotheses and modelling and in developing management targets. Their results predict that glass eel recruitment would to be able to recover in less than 10 years from very low levels if ocean-climate conditions become more favourable. This conflicts with the life cycle modelling study of Astrom and Dekker, 2007 which concluded that stock recoveries could take >80 years. Also, Dekker *et al.*, 2003 and Dekker, 2004b assumed the general decline in combined landings was a proxy for stocks and hence spawning stock and that depensation could have led to the falls in recruitment 20 years later. The study by Knights and Bonhommeau, unpubl. however, suggests that fluctuations in environmental factors, both oceanic and near-continent, are the main determinants of recruitment over shorter periods and that classical stock–recruitment models cannot be applied to the European eel. It also debated the assumption that large female eels produced in the Baltic make a major contribution to overall production of the European eel (e.g. Tesch, 2003), as North Atlantic/North Sea glass eel recruitment was relatively very high around 1980, despite the major declines in Baltic stocks beginning in the 1950–1960s. In conclusion, Knights and Bonhommeau, unpubl. suggest that combined European landings data cannot be used as a simple direct proxy for stocks, certainly in different regions in NW Europe. The lack of any clear recovery in recruitment during the low NAO periods in the late 1990s led Dekker, 2004a to question the role of the NAO in affecting glass eel recruitment. However, the continual warming of the N Atlantic signalled by the rising SS-SST and NHT has probably overridden the effects of the NAO (Knights and Bonhommeau, unpubl.).

7.6 Conclusions and recommendations for Chapter 7: Oceans, climate and recruitment

7.6.1 Conclusions

- Sufficiently long time-series of glass eel recruitment, covering several periods of the natural climatic oscillation over the North Atlantic, reflect the same periodicity.
- The causal link between climate and recruitment strength, is unknown.
- It is unknown where and when during the oceanic life of the eel larvae the climate effect operates. It may be in the Sargasso Sea or closer to the European coastal area.
- The recent, prolonged strong decline in eel recruitment is out of phase with the dominating climate cycle, the North Atlantic Oscillation, although continual warming has probably overridden the effects of the NAO.

As long as the causal factors of oceanic influence are unknown, it is not safe to assume that the decline is explained by climate alone, especially while we know that the anthropogenic influences during the continental life stage of the eel are large and better understood. The fact that oceanic climate may contribute to recruitment variation is not grounds for abstaining from all possible measures to increase silver eel escapement to boost spawning-stock biomass. At some level the stock/recruitment relation will always be important-there is no recruitment without eggs. Ocean environmental factors can never justify a lack of conservation measures.

The options and expectations for management outcomes can be summarized in Table 7.3 that can be used in a risk analysis:

Table 7.3: Options and expectations for management outcomes.

	Hypothesis about cause of decline		
	Pure stock/recruitment	**Ocean environment**	
Action taken		**Improving**	**Deteriorating**
Reduce anthropogenic mortality	Recovery if measures are sufficient	Recovery faster than expected	No recovery or slower than expected
No action	No recovery	Possible recovery	Faster continued decline

7.6.2 Recommendations

To address the difficulties comparing ocean environmental cycles with biological cycles of eel it is necessary to improve our knowledge of the oceanic phases of the eel life cycle. This will allow us to better understand which oceanic factors are behind the climate effects. This in turn will allow for a more sophisticated analysis than mere correlations and the weighting of the role of climate effects on reproductive success, compared to continental factors. Some key questions are:

- The question of the interaction between leptocephali mortality and dispersion.
- The role of leptocephali in the ecosystem, including feeding and predation.

WGEEL proposes that an ICES Study Group is established to coordinate and plan research on the oceanic effects on leptocephali and metamorphosis to glass eel.

8 Research needs

8.1 Introduction

The Working Group on Eel identified a considerable need for new research on eel population dynamics and its influencing factors. Due to the current implementation of the EU eel recovery plan (EU Regulation 1100/2007), the primary focus of discussions on research requirements at WGEEL 2008 was on supporting the assessment of the stock and its recovery as sought by the implementation of this regulation. WGEEL 2008 did not, however, lose sight of the continuing lack of knowledge of the fundamental biology (i.e. carrying capacity and density-dependence) and of the European eel's ocean phase (including spawner quality and migrations). It is recognized that methods for evaluation of the outcome of management measures are not yet fully available either at the population (international target), or local (sub target) level.

8.2 Priority research needs

WGEEL believes that the best approach is a series of integrated and internationally coordinated projects and is set out in Figure 8.1. A programme of research is needed to address gaps in knowledge, gather data to evaluate the status of the stock, and further develop stock assessment methods to determine compliance with targets and the effectiveness of management actions at the international and local level.

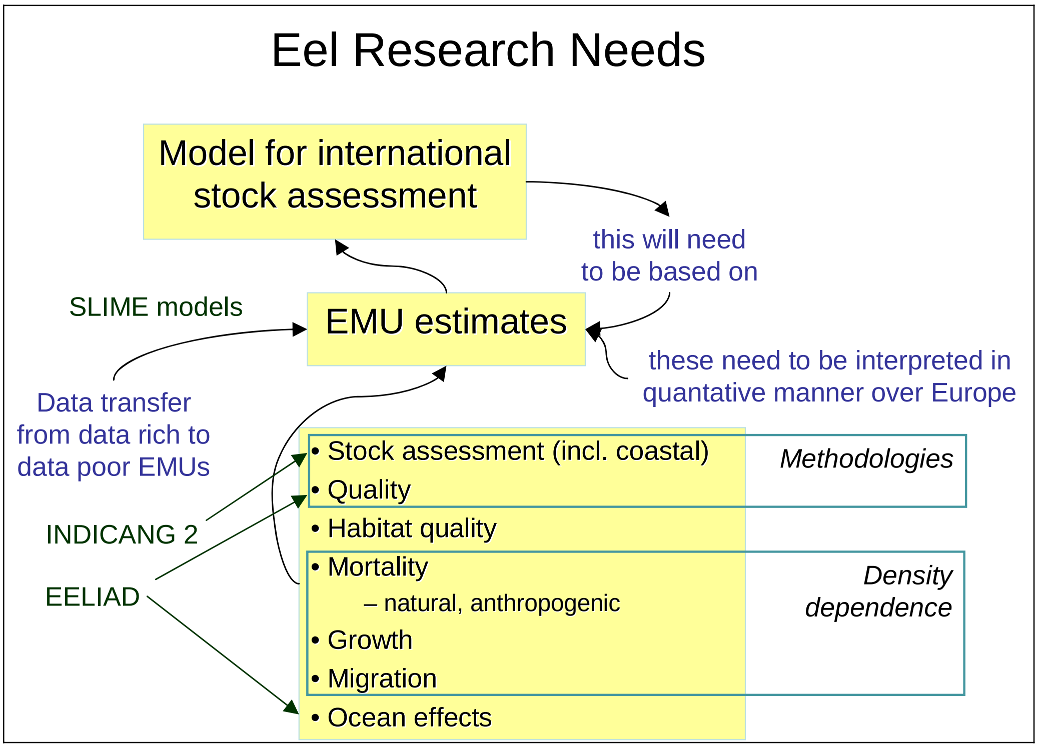

Figure 8.1: Flow diagram showing linkages between research needs.

The priorities for integrated research are as follows:

- International Stock Assessment and trend monitoring
- Local stock assessment and post-evaluation of management actions
- Process based research on biological parameters required for estimating escapement.

8.2.1 International stock assessment and trend monitoring

Improved annual trends on recruitment, stock and yield

Emigrating silver eel biomass, numbers and sex ratio

The aggregation of river basin specific data and assessments, into stock-wide assessments in support of stock to recruitment (S-R) and recruitment to spawner stock biomass (R-SSB) assessment and modelling (e.g.VPA).

The further development of models to assess compliance with the recovery target and evaluate management actions

The international assessment of recruitment and stock trends to assess the response of the stock to management actions under the Regulation, noting the WGEEL recommendation on accessibility to national eel management plans and supporting eel data.

8.2.2 Local stock assessment and post-evaluation of management actions

The development of local stock assessment procedures and estimates of silver eel escapement

The further development of models and methodologies to assess compliance at the local scale with the recovery target and evaluate management actions

The development and testing of methods to characterize and quantify eel stocks in deeper areas of rivers, lakes, estuaries and coastal waters

The testing of relationships between habitat characteristics, eel quality and eel production as indicators of the relative production potential for different habitats

To develop methods for quantitative assessment of the availability of local surplus for stocking, and for the contribution of stocking to escapement

Implementation of EMPs requires the development of methodologies to obtain estimates of escapement. These can be direct (*e.g.* mark-recapture or acoustic counting) or indirect methods (*e.g*. yellow eel proxies to determine silver eel production and eel habitat modelling production). Validation of indirect methodologies is required.

8.2.3 Process based research on biological parameters required for estimating escapement

Quantify the possible density-dependence effects in various processes including mortality, growth, movement, maturation and sex differentiation.

Quantify the impacts of pathogens, parasites, diseases, and low chemical quality on effective silver eel escapement and spawning success. This should include the relationship between eel quality and body fat content.

Quantify any impact of aquaculture, transport and stocking of eel in terms of reduced spawner production

Research is required on the relative importance of the habitat types used by eels and what demographic characteristics they exhibit in these habitats, such between fresh (rivers and lakes) and saline (brackish/salt) waters.

Recent research has suggested that processes in the oceanic phase (including spawner quality) may be important in determining recruitment levels. Improved knowledge of the oceanic phases of the eel is needed to further the initial search for correlations between eel recruitment and oceanic processes.

8.3 Other research needs

WGEEL 2008 focused heavily on the requirements of the EU Regulation and the need for international and national stock assessment. Additional research will be required in order to fill many gaps in the biology and management of eel.

Research on optimum collection and transport methods for glass eel to reduce mortality for stocking

Timing and frequency of stocking

Related eel health issues

Post-evaluation methods for the net benefit of stocking for conservation

Investigations examining the competitiveness, survival and reproductive capacity of stocked glass eels, compared with their naturally recruited counterparts by marking the stocked individuals and comparing their recapture at sexual maturity

Quantify the relation between fat content and eel quality, the effects of specific contaminants and parasites on fat metabolism and a possible relationship between eel fat content and environmental variables such as changing temperature, changing trophic status, and food availability

Predator prey relationships (e.g. cormorants).

8.4 Proposals for study groups

WGEEL proposes that an ICES Study Group is established to coordinate and plan research on the oceanic effects on leptocephali and metamorphosis to glass eel.

WGEEL notes and approves the proposal for an eel age calibration workshop.

WGEEL notes and approves the proposal to the DFC (2008) for a study group on anguillid eels in saline (brackish/salt) waters.

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Annex 2 – Agenda

Agenda for Joint EIFAC/ICES WGEEL 2008, Leuven

Wednesday 3rd September

9.00	Get organized
9.30–10.00	Welcome RP
	Welcome Dr Jurgen Tack, INBO
	Local Welcome and Information: Filip Volckaert/Greg Maes
10.00–10.30	Intro to Working Group, ToR, etc. RP
10.30	Coffee
10.45–11.15	EEQD and eel Quality, introduced by Belpaire
11.15–11.45	Aquaculture and Restocking, introduced by Wickstrom and Evans
11.45–12.15	Methodologies-concepts, time frames, introduced by Astrom
12.15–13.30	Lunch
13.30–14.00	Methodologies-biomass, escapement and targets, intro by Aprahamian
14.00–14.30	Data Group, introduced by Dekker/Beaulaton
14.30–15.30	Ocean and Climate, introduced by O'Toole and Westerberg
15.30	Coffee
16.00–16.30	Genetics and the EU Regulation, introduced by Maes
16.30–17.00	Genetics, introduced by Zane
17.00–17.15	Update from Norway on marine data on eel, introduced by Knutsen
17.15–17.30	Update from N. America/Canada, introduced by Verrault
until 18.00	Breakout to get organized, subgroups, rapporteurs, approaches, etc.

Thursday-Sub Groups breakout

16.00–18.00	Plenary

Friday-Sub Groups breakout

16.00–18.00	Plenary

Saturday morning-Sub Groups breakout

9.00–10.00	Plenary (optional depending on progress on Friday pm)
14.00–15:00	Present conclusions and recommendations draft 1.
15.30–18.00	Producing draft report [DEADLINE 18:00]

Sunday-Sub Group leaders and Chair to do initial draft of technical advice

Print hard copies of report

Monday

9.00–13:00	Circulate draft advice and hard copy report for comment
14.00–18:00	Discuss and agree Report, and Recommendations

Tuesday

9.00–13:00	Discuss Report, and Recommendations and agree technical advice

Conclude at 14.00 The afternoon is available to tie up loose ends.

Annex 3 – Recruitment, landings and stocking dataseries

Table 1 Part 1 Recruitment dataseries of glass eel: Sweden, Northern Ireland (N.Irl) and Ireland.

COUNTRY	SE	SE	SE	SE	N.IRL	IE	IE
Year	IYFS/IBTS (old data)	IYFS/IBTS (new data)	Ringhals	Viskan	Bann	Erne	Shannon
Unit	Index	Index	Kg	Kg	Kg	t	t
1923							
1924							
1925							
1926							
1927							
1928							
1929							
1930							
1931							
1932							
1933							
1934							
1935							
1936					7333		
1937					9000		
1938					8000		
1939					6333		
1940					9000		
1941					10 000		
1942					7000		
1943					6000		
1944					5333		
1945					5667		
1946					7000		
1947							
1948							
1949							
1950							
1951							
1952							
1953							
1954							
1955							
1956							
1957							
1958							
1959						0.24	
1960					7409	1.23	
1961					4939	0.63	
1962					6740	2.47	

Country	SE	SE	SE	SE	N.Irl	IE	IE
1963					9077	0.43	
1964					3137	0.21	
1965					3801	0.90	
1966					6183	1.40	
1967					1899	0.30	
1968					2525	1.50	
1969					422	0.60	
1970					3992	0.60	
1971				12,00	4157	0.50	
1972				88,00	2905		
1973				177,00	2524		
1974				13,00	5859	0.80	
1975	45.00			99,00	4637	0.40	
1976	655.00			501,00	2920	0.40	
1977	405.00			850,00	6443	0.10	1.00
1978	126.00			532,60	5034	0.30	1.30
1979	122.00			505,20	2089	0.50	6.70
1980	6.00			72,50	2486	1.40	4.50
1981	134.00		849.00	513,10	3023	2.90	2.10
1982	90.00		710.72	472,00	3854	4.50	3.10
1983	355.00		553.48	308,40	242	0.70	0.60
1984	26.00		175.39	20,70	1534	1.10	0.50
1985	54.00		304.64	211,50	557	0.50	1.09
1986	72.00		45.09	150,90	1848	0.90	0.95
1987	24.00		51.78	140,90	1683	2.40	1.61
1988	19.00		168.60	91,90	2647	3.00	0.15
1989	34.00		183.95	32,70	1568	1.80	0.03
1990			186.03	42,10	2293	2.40	0.47
1991		0.001	138.14	0,40	677	0.50	0.09
1992		0.003	282.97	70,30	978	1.40	0.03
1993		0.007	373.94	43,40	1525	1.80	0.02
1994		0.012	636.41	76,10	1249	4.50	0.29
1995		0.009	276.66	5,50	1403	2.40	0.40
1996		0.001	43.80	10,00	2668	1.00	0.33
1997		0.001	116.89	7,60	2533	1.09	2.12
1998		0.002	164.40	5,00	1283	0.74	0.28
1999		0.003	147.19	1,80	1345	1.06	0.02
2000		0.011	399.67	14,10	563	0.91	0.04
2001		0.001	31.89	1,80	315	0.70	0.00
2002		0.003	170.95	26,20	1092	0.11	0.18
2003		0.002	92.00	45,10	1210	0.69	0.38
2004		0.000	30.65	5,00	342	0.29	0.06
2005		0.002	110.44	25,80	852	0.84	0.04
2006		0.001	41.95	2,70	456	0.12	0.04
2007		0.000	102.40	2,10	445	0.19	0.05
2008		0.000	34.00	3,40	25	0.03	0.00

Table 1 Part 2 Recruitment dataseries of glass eels: UK, Denmark, Germany and Netherlands.

***HMRC = nett export data from Her Majesty's Revenue and Customs (see UK Country report)**

COUNTRY	UK	DK	DE	NL	NL	NL	NL	NL
Year	Severn (HMRC)*	Vidaa	Ems	Lauwersoog	DenOever	IJmuiden	Katwijk	Stellendam
Unit	t	Kg	Kg	Index	Index	Index	Index	Index
1923								
1924								
1925								
1926								
1927								
1928								
1929								
1930								
1931								
1932								
1933								
1934								
1935								
1936								
1937								
1938					20.75			
1939					46.68			
1940					17.46			
1941					14.90			
1942					23.61			
1943					15.77			
1944					45.88			
1945								
1946			600		7.56			
1947			1438		7.37			
1948			1640		6.41			
1949			1182		6.34			
1950			875		8.23			
1951			719		16.60			
1952			1516		106.71			
1953			3275		18.17			
1954			5369		27.03			
1955			4795		37.37			
1956			4194		9.76			
1957			1829		21.82			
1958			2263		71.79			
1959			4654		39.37			
1960			6215		29.74			
1961			2995		51.34			
1962			4430		120.66			
1963			5746		172.22			
1964			5054		53.57			

Country	UK	DK	DE	NL	NL	NL	NL	NL
1965			1363		110.71			
1966			1840		26.64			
1967			1071		40.88			
1968			2760		27.91			
1969			1687		23.96	47.30		
1970			683		54.59	31.50		
1971		787.00	1684		24.12			15
1972		780.00	3894		43.24			4
1973		641.00	289		31.05	32.80		13
1974		464.00	4129		35.93	119.30		23
1975		888.00	1031		46.60	66.80		14
1976		828.00	4205	14.40	38.21	73.10		11
1977		91.00	2172	28.40	80.27	159.20	130.25	42
1978		335.00	2024	83.90	54.29	131.70	30.23	42
1979	40.10	220.00	2774	66.20	75.47	176.00	3.23	27
1980	32.80	220.00	3195	80.30	37.82	101.50	171.60	45
1981		226.00	962	55.10	32.09	113.90	31.65	47
1982	30.40	490.00	674	17.40	20.24	20.80	4.13	11
1983	6.20	662.00	92	15.10	13.58	15.60	2.10	14
1984	29.00	123.00	352	7.10	18.07	11.40	23.62	4
1985	18.60	13.00	260	25.20	18.28	1.00	6.67	9
1986	15.50	123.00	89	1.30	19.25	4.70		6
1987	17.70	341.00	8	52.00	7.46	7.70	14.00	10
1988	23.10	141.00	67	0.50	5.72	3.50		8
1989	13.50	9.00	13	12.10	3.95	1.60	3.67	4
1990	16.00	5.00	99	5.00	4.71	4.70		11
1991	7.80		52	6.30	1.44	2.00	5.10	2
1992	17.70		6	7.30	3.79	2.50	8.20	10
1993	20.90		20	20.80	3.80	1.60	13.50	5
1994	22.30		52	22.50	5.98	3.60	15.10	3
1995			40	11.60	8.37	13.10	27.10	3
1996	23.90		20	34.40	9.49	4.00	25.40	0
1997	16.20		5	20.90	15.24	1.30	10.90	3
1998	20.10		4	9.90	2.73	1.20	38.80	1
1999	18.00		3	15.10	4.23	1.60	101.30	1
2000	7.60		4	6.60	2.06	1.50	8.80	6
2001	5.40		1	1.70	0.68	0.40	8.10	1
2002	5.10			3.40	1.36	0.05	9.80	4
2003	10.00			1.20	1.84	0.00	11.80	0
2004	14.40			1.70	1.87	0.11	4.50	0.3
2005	8.80			0.90	1.02	0.00	4.40	0.2
2006	8.20			1.39	0.43	0.07	1.33	0
2007				1.13	1.35	0.09	24.77	0
2008				2.54	0.36	0.06	4.31	0

Table 1 Part 3 Recruitment dataseries of glass eels: Belgium and France.

Country	BE	FR	FR	FR	FR	FR	FR	FR
Year	Ijzer	Vilaine	Loire	Sèvres Niortaise (cpue)	Gironde (cpue)	Gironde	Adour	Adour (cpue)
Unit	Kg	Kg	Kg	cpue	cpue	t	t	cpue
1923						46.0		
1924			65.0					
1925			70.0					
1926			90.0			18.7		
1927			65.0			34.1		
1928			102.0			22.4		
1929						22.5		
1930			1.0			28.2		
1931						26.9		
1932						31.1		
1933						13.5		
1934			90.0			13.4		
1935			150.0			19.7		
1936			30.0					
1937			7.0					
1938			15.0					
1939			17.0					
1940			27.0					
1941			21.0					
1942								
1943								
1944			10.0					
1945			66.0					
1946			43.0					
1947			178.0					
1948			197.0					
1949			193.0					
1950			86.0					
1951			166.0					
1952			121.0					
1953			91.0					
1954			86.0					
1955			181.0					
1956			187.0					
1957			168.0					
1958			230.0					
1959			174.0					
1960			411.0					
1961			334.0			32.2		
1962			185.0	30.00		217.8		
1963			116.0	72.00		363.0		

Country	BE	FR	FR	FR	FR	FR	FR	FR
1964	3.70		142.0					
1965	115.00		134.0	17.00		352.5		
1966	385.00		253.0	13.00		27.6		
1967	575.00		258.0	8.00		162.8		
1968	553.50		712.0	15.00		284.2		
1969	445.00		225.0	14.00		36.6		
1970	795.00		453.0	15.00		203.8		
1971	399.00	44	330.0	12.00		47.1		
1972	556.50	38	311.0	11.00		69.0		
1973	354.00	78	292.0	8.50		20.0		
1974	946.00	107	557.0	9.00		54.6		
1975	274.00	44	497.0	8.50		44.1		
1976	496.00	106	770.0	17.00		120.9		
1977	472.00	52	677.0	15.00		121.6		
1978	370.00	106	526.0	18.00		64.7		
1979	530.00	209	642.0	17.50	19.7	73.2		
1980	252.00	95	526.0	12.00	25.9	124.7		
1981	90.00	57	303.0	9.00	20.0	84.9		
1982	129.00	98	274.0	8.50	15.0	61.0		
1983	25.00	69	260.0	6.00	13.6	66.7		
1984	6.00	36	183.0		19.2	45.0		
1985	15.00	41	154.0		9.6	27.0		2.40
1986	27.50	52.6	123.0		10.6	35.3	8.00	1.5
1987	36.50	41.2	145.0		14.0	44.6	9.50	3.3
1988	48.20	46.6	177.0		10.9	27.9	12.00	3.7
1989	9.10	36.7	87.0		7.2	45.9	9.00	4.1
1990	218.20	35.9	96.0		5.6	29.3	3.20	1.2
1991	13.00	15.35	36.0		7.7	38.4	1.50	0.7
1992	18.90	29.57	39.0		3.7	22.5	8.00	2.9
1993	11.80	31	91.0		8.2	42.4	5.50	2.4
1994	17.50	24	103.0		8.7	45.5	3.00	1.4
1995	1.50	29.7	133.0		8.2	43.5	7.50	2.6
1996	4.50	23.286	81.0		4.8	27.9	4.10	1.53
1997	9.80	22.85	71.0		6.5	49.3	4.60	1.6
1998	2.25	18.9	66.0		4.3	18.4	1.50	1.07
1999		16	87.0		7.5	43.1	4.30	1.82
2000	17.85	14.45	80.0		6.6	28.5	10.00	4.43
2001	0.70	8.46	33.0		1.9	8.2	2.00	0.49
2002	1.40	15.9	42.0		4.9	35.1	1.80	0.89
2003	0.54	9.37	53.0		2.7	9.6	0.60	0.31
2004	0.38	7.49	27.0		2.5	14.4	1.80	0.6
2005	0.79	7.36	17.0			17.2	3.20	1.13
2006	0.07	6.6	15.0			9.3	1.70	0.72
2007	2.21	7.7	21.0			8.0	1.40	0.66
2008	0.96	5.1						0.76

Table 1 Part 4 Recruitment dataseries of glass eel: Spain, Portugal and Italy.

COUNTRY	ES	ES	ES	ES/PT	IT	ALL COUNTRIES
Year	Nalon	Albufera	Minho	Minho	Tiber	Geo mean
Unit	Kg	Kg	Kg	Kg	t	
1923						44.74
1924						58.58
1925						69.37
1926						77.02
1927						89.04
1928						64.77
1929						55.96
1930						39.00
1931						13.00
1932						33.24
1933						106.35
1934						154.02
1935						171.46
1936		35 000				186.74
1937		48 000				237.53
1938		45 000				277.85
1939		30 000				224.47
1940		40 000				240.02
1941						237.68
1942						193.96
1943						165.03
1944						175.47
1945						161.63
1946						158.41
1947						181.24
1948						186.83
1949						201.97
1950						217.48
1951						212.26
1952	14 529					226.69
1953	8318					271.49
1954	13 576					277.86
1955	16 649					261.82
1956	14 351					294.95
1957	12 911					291.36
1958	13 071					298.88
1959	17 975	10 000				315.73
1960	13 060	17 000				375.14
1961	17 177	11 000				400.34
1962	11 507	16 000				359.92
1963	16 139	11 000				346.25
1964	20 364	4000				342.57
1965	11 974	6000				302.23
1966	12 977	5000				295.73
1967	20 556	4000				324.68

Table 1 Part 4 cont. Recruitment dataseries of glass eel: Spain, Portugal and Italy.

COUNTRY	ES	ES	ES	ES/PT	IT	ALL COUNTRIES
Year	Nalon	Albufera	Minho	Minho	Tiber	Geo mean
Unit	Kg	Kg	Kg	Kg	t	
1968	15 628	4000				321.77
1969	18 753	5000				291.24
1970	17 032	1000				284.07
1971	11 219	1000				253.16
1972	11 056	1000				256.52
1973	24 481	2000				250.27
1974	32 611	1000	1600	1650		285.49
1975	55 514	6000	5600	10 600	11.00	308.72
1976	37 661	5000	12 500	20 000	6.70	333.15
1977	59 918		21 600	36 600	5.90	359.93
1978	37 468		17 300	24 300	3.60	380.91
1979	42 110		15 400	28 400	8.40	371.26
1980	34 645		13 000	16 000	8.20	331.89
1981	26 295	1309	18 000	50 000	4.00	268.50
1982	21 837	640	9700	16 400	4.00	207.08
1983	22 541	2387	14 000	30 000	4.00	152.15
1984	12 839	2980	15 300	30 100	1.80	114.54
1985	13 544	402	6000	13 000	2.50	99.85
1986	23 536	2845	6539	16 039	0.20	92.32
1987	15 211	4255	5600	8200	7.40	79.45
1988	13 574	2513	7359	10 359	10.50	77.32
1989	9216	1321	3962	8462	5.50	63.56
1990	7117	1079	5743	8243	4.40	53.62
1991	10 259	831	2835	7335	0.80	48.83
1992	9673	299	4893	8493	0.60	52.91
1993	9900	302	2068	4968	0.50	50.79
1994	12 500	199	4701	10 001	0.50	54.08
1995	5900	271	6523	15 223	0.30	53.06
1996	3656	366	4283	8683	0.10	47.36
1997	3273		2878	7378	0.10	39.70
1998	3815	616	3812	7412	0.13	35.35
1999	1330	323	3812	6812	0.06	26.73
2000	1285	678	1519	2719	0.07	22.88
2001	1569	466	1427	2527	0.04	20.60
2002	1231	357	1755	3198	0.02	16.54
2003	506	233	1562	2376	0.02	14.20
2004	914	209	1331	2505	0.03	12.67
2005	836		320	3056	0.03	11.26
2006	615		1140	2045	0.00	7.91
2007	871	165		750		7.41
2008						5.78

Table 2 Part 1 Recruitment dataseries of yellow eel: Norway and Sweden.

COUNTRY	NO	SE	SE	SE	SE	SE	SE	SE
Site	Imsa	Dalälven	Motala Ström	Mörrumsån	Kävlingeån	Rönne Å	Lagan	Göta Älv
Unit	Numbers	Kg	Kg	Kg	Kg	Kg	Kg	Kg
1900								530
1901								5100
1902								340
1903								858
1904								552
1905								8700
1906								2000
1907								275
1908								
1909								
1910								
1911								5728
1912								6529
1913								20
1914								2828
1915								
1916								
1917						45		
1918						5		
1919								1465
1920								800
1921								1555
1922								455
1923								1732
1924								4551
1925							331	5463
1926						49	358	3893
1927						445	581	4796
1928						0	212	47
1929						0	5	756
1930						147	268	5753
1931							316	2103
1932							408	7238
1933							304	6333
1934							236	6338
1935							54	1336
1936							25	2537
1937							1	8711
1938							107	3879
1939							36	4775
1940							684	1894
1941							321	2846
1942			14				454	427
1943			283				1248	1848
1944			773				1090	2342
1945			406				1143	2636
1946			280			30	767	2452
1947			273			6	441	675
1948			120			6	495	1702
1949			43			39	604	1711
1950			305			94	420	2947
1951		210	2713			1	281.8	1744
1952		324	1543.5			9.1	379.1	3662
1953		241.5	2698			70	802.4	5071

Country	NO	SE	SE	SE	SE	SE	SE	SE
1954		508.5	1030			2.7	511.3	1031
1955		550	1871			42.6	506.9	2732
1956		215	429			14.1	501.6	1622
1957		161.5	826			46.8	336.1	1915
1958		336.7	172			73.2	497.2	1675
1959		612.6	1837			80	910.5	1745
1960		289	799	29		93	552.4	1605
1961		303	706	665.5		143.7	314.8	269
1962		289	870	534.8		113	261.9	873
1963		445.4	581	241.2		32.5	298.1	1469
1964		158	181.6	177.8		34.7	27.5	622
1965		276.4	500	292.3		87.1	28	746
1966		157.5	1423	196.3		48.5	216.5	1232
1967		331.8	283	353.6		6.6	24.4	493
1968		265.5	184	334.8		398	74.4	849
1969		333.7	135	276.8		85.7	117.1	1595
1970		149.8	2	80.4		29.8	24.7	1046
1971		242	1	141.1		53.3	45.3	842
1972		87.6	51	139.9		249	106.2	810
1973		159.7	46	375		282.3	107.1	1179
1974		49.5	58.5	65.4		120.7	33.6	631
1975	42 945	148.7	224	93.3		206.7	78.4	1230
1976	48 615	44	24	147.2		17.1	20.2	798
1977	28 518	176.4	353	89.6		32.1	26.4	256
1978	12 181	35.1	266	168.4		10.8	75.8	873
1979	2457	34.3	112	61.4		56.1	165.9	190
1980	34 776	71.2	7	36.5		165.7	226	906
1981	15 477	6.8	31	72.8		49.2	78	40
1982	45 750	0.5	22	129		40	90.8	882
1983	14 500	112.1	12	204.6		37.6	87.8	113
1984	6640	33.9	48	189.9		0.5	68	325
1985	3412	69.7	15.2	138.1			234.1	77
1986	5145	28.4	26	220.3		8.6	2.5	143
1987	3434	73.5	201	54.5		84.8	69.8	168
1988	17 500	69	169.5	241		4.9	191.7	475
1989	10 000		35.2	30			44	598
1990	32 500		21	72.5		32	21.6	149
1991	6250		2	151			161.3	264
1992	4450	9.6	108	14	12.5		42.2	404
1993	8625	6.6	89	45.7	25.8		8.7	64
1994	525	71.9	650	283	4		30.7	377
1995	1950	7.6	32	72.4	2.9		11.6	
1996	1000	17.5	14	51.9	13.5		2.8	277
1997	5500	7.5	8.1	148	19.4	10.4	31.7	180
1998	1750	14.7	5.5	12.9	15.3	24	62.6	
1999	3750	15.5	85	84.2	22.2	4.2	49.5	
2000	1625	12.4	270.1	1	5		13	
2001	1875	8.2	177.5	19.3	34.5	1.8	26.8	
2002	1375	58.6	338.8	37.4	19.3	27	102	693
2003	3775	126.1	19	11	9.7	9.1	31.7	266
2004	375	26.4	42	1.5	248.3	2	29	125
2005	1550	30.9	24.8	2.5	3.4	0.1	20.5	105
2006	350	35.1	25.9	2.5	94.4	0.1	38.1	0.04
2007	100	18.4	30	112.6	76	4.45	77	>0
2008		30.5					25	>0

Table 2 Part 2 Recruitment dataseries of yellow eel: Ireland, Denmark and Belgium.

COUNTRY	IE	DK	DK	BE	ALL COUNTRIES
Site	Shannon (Parteen)	Tange	Harte	Meuse (Lixhe dam)	GeO mean
Unit	Kg	Kg	Kg	Kg	
1900					431.01
1901					417.75
1902					375.37
1903					656.92
1904					544.76
1905					522.12
1906					565.16
1907					747.03
1908					328.77
1909					556.39
1910					2711.05
1911					402.41
1912					534.63
1913					534.63
1914					318.05
1915					129.79
1916					169.26
1917					135.94
1918					172.77
1919					227.85
1920					229.01
1921					476.60
1922					597.87
1923					758.60
1924					739.67
1925					1118.82
1926					1229.23
1927					1042.09
1928					958.06
1929					1007.62
1930					984.53
1931					1034.89
1932					1039.92
1933					791.69
1934					624.67
1935					325.48
1936					279.10
1937					224.80
1938					300.35
1939					392.97
1940					490.04
1941					558.65
1942					748.44
1943					793.63
1944					743.91

Table 2 Part 2 cont. Recruitment dataseries of yellow eel: Ireland, Denmark and Belgium.

COUNTRY	IE	DK	DK	BE	ALL COUNTRIES
Site	Shannon (Parteen)	Tange	Harte	Meuse (Lixhe dam)	GeO mean
Unit	Kg	Kg	Kg	Kg	
1945					801.02
1946					606.09
1947					449.17
1948					399.33
1949					366.84
1950					454.81
1951					637.36
1952					679.34
1953					743.05
1954					783.63
1955					769.58
1956					656.79
1957					810.48
1958					692.09
1959					721.90
1960					730.62
1961					710.24
1962					492.69
1963					460.66
1964					443.88
1965					354.52
1966					333.47
1967			500		369.91
1968			200		285.38
1969			175		205.28
1970			235		213.55
1971			59		201.87
1972					170.90
1973			117		220.02
1974			212		229.87
1975			325		217.71
1976			91		196.31
1977			386		189.19
1978			334		164.10
1979			291		152.73
1980		93	522		133.34
1981		187	279		122.33
1982		257	239		108.26
1983		146	164		100.89
1984		84	172		100.00

Country	IE	DK	DK	BE	All Countries
1985	984	315	446		103.08
1986	1555	676	260		111.98
1987	984	145	105		120.01
1988	1265	252	253		115.23
1989	581	354	145		112.06
1990	970	367	101		97.76
1991	372	434	44		76.79
1992	464	53	40	5613	74.26
1993	602	93	26		62.15
1994	125	312	35		51.00
1995	799	83	23	4240	50.31
1996	95	56	6		46.37
1997	906	390	9	2706	44.80
1998	255	29	18	3061	42.81
1999	701	346	15	4664	43.72
2000	389	87.9	18.9	3365	48.39
2001	3	239	11.4	2915	52.90
2002	677	278.2	17	1790	45.00
2003	873	260.2	9.6	1842	40.37
2004	320	246.1	8.7	423	33.64
2005	612	87.7	7.4	758	24.01
2006	467	122.5	6.8	559	14.48
2007	757	62	7	6619	11.84
2008	1236				10.06

Table 3 Landings of European eel in Europe (tons). Data obtained from Country Reports 2008.

	BE	DK	EE	FI	FR	DE	IE	IT	LV	LT	NL	NO	PL	PT	ES	SE	UK
1945											2668	102				1664	
1946									1		3492	167				1512	
1947									10	8	4502	268				1910	
1948									10	14	4799	293				1862	
1949									11	21	3873	214				1899	
1950		`							14	29	4152	282			90	2188	
1951									13	32	3661	312			102	1929	
1952									14	39	3978	178			80	1598	
1953									30	80	3157	371			98	2378	
1954									24	147	2085	327			103	2106	
1955									47	163	1651	451			106	2651	
1956									26	131	1817	293			80	1533	
1957									25	168	2509	430			115	2225	
1958									27	149	2674	437			100	1751	
1959						84			30	155	3413	409			98	2789	
1960						51			44	165	2999	430			95	1646	
1961						48			50	139	2452	449			91	2066	
1962						67			46	155	1443	356			95	1908	

	BE	DK	EE	FI	FR	DE	IE	IT	LV	LT	NL	NO	PL	PT	ES	SE	UK
1963						55			64	260	1618	503			92	2071	
1964						56			43	225	2068	440			76	2288	
1965						56			41	125	2268	523			79	1802	566
1966						68			43	238	2339	510			80	1969	617
1967						92			46	153	2524	491			66	1617	570
1968						103			34	165	2209	569			57	1808	586
1969						302		2469	43	134	2389	522			0	1675	607
1970						238		2300	29	118	1111	422			43	1309	754
1971						255		2113	29	124	853	415			44	1391	844
1972						239		1997	25	126	857	422			44	1204	634
1973						257		589	27	120	823	409	705		33	1212	725
1974						224		2122	20	86	840	368	747	0	25	1034	767
1975						226		2886	19	114	1000	407	869	5	17	1399	764
1976				28		205		2596	24	88	1172	386	804	8	14	935	627
1977				63		214		2390	16	68	783	352	911	15	0	989	692
1978				77		163		2172	18	70	719	347	929	7	0	1076	825
1979				77		158		2354	21	57	530	374	1025	13	0	956	1206
1980				79		140		2198	9	45	664	387	1233	3	11	1112	1110
1981				39		131		2270	10	27	722	369	970	32	19	887	1139
1982				38		166		2025	12	28	842	385	939	7	16	1161	1189
1983				38		155		2013	9	23	937	324	896	18	14	1173	1136
1984				28		114		2050	12	27	691	310	846	19	11	1073	1257
1985				28		477		2135	18	29	679	352	1048	10	14	1140	1035
1986				28	2462	405		2134	19	32	721	272	947	13	12	943	926
1987				19	2720	359		2265	25	20	538	282	914	6	15	897	1006
1988					2816	364		2027	15	23	425	513	943	6	10	1162	1110
1989					2266	379		1243	13	21	526	313	813	8	0	952	1172
1990					2170	374		1088	13	19	472	336	768	5	4	942	1014
1991					1925	335		1097	14	16	573	323	670	7	0	1084	1058
1992					1585	322		1084	17	12	548	372	638	7	5	1180	915
1993			59		1736	250		782	19	10	293	340	568	9	5	1210	857
1994			47		1694	246		771	19	12	330	472	635	7	4	1553	1077
1995			45		1832	242		1047	38	9	354	454	638	10	4	1205	1312
	BE	DK	EE	FI	FR	DE	IE	IT	LV	LT	NL	NO	PL	PT	ES	SE	UK
1996			55		1562	220		953	24	9	300	353	632	6	6	1134	1246
1997		797	59		1537	263		727	25	11	285	467	533	5	23	1382	1190
1998		597	44		1345	28		668	30	17	323	331	551	5	43	645	943
1999		717	65		1253	38		634	26	18	332	447	592	4	45	734	963
2000		628	67		1200	36		539	17	11	363	281	438	2	90	561	702
2001		707	65		1103	141	98	438	15	12	371	304	434	1	106	543	742
2002		609	50			130	123	105	19	13	353	311	371	2	80	633	650
2003		649	49			125	111	105	11	12	279	240	359	2	70	565	574
2004		546	39			117	136	382	11	16	245	237	330	2	71	551	634
2005		534	36			108	101	75	11	22	230	249	251	4	74	628	545
2006		595	33			87	133	56	8			293	217	2	39	670	408

	BE	DK	EE	FI	FR	DE	IE	IT	LV	LT	NL	NO	PL	PT	ES	SE	UK
2007	43	537	31			317	114		10		130	194	193	2		568	427

Table 4 Landings of European eel in Europe (tons). Source: FAO.

	BE	DK	EE	FI	FR	DE	IE	IT	LV	LT	NL	NO	PL	PT	ES	SE	UK
1950		4500			500	400	100	895			4200	300	700		100	2200	100
1951		4400			500	400	100	849			3700	300	700		100	1900	100
1952		3900			700	400	100	873			4000	200	900		200	1600	100
1953		4300			600	500	100	846			3100	400	900		200	2400	400
1954		3800			500	300	100	830			2100	300	800		200	2100	500
1955		4800			500	500	100	814			1700	500	1000		700	2600	700
1956		3700			500	400	100	1796			1800	300	900		800	1500	600
1957		3600			500	400	100	1776			2500	400	800		501	2200	600
1958		3300			600	400	100	1754			2800	400	1200		500	1800	600
1959		4000			900	500	100	2614			3400	400	700		600	2800	700
1960		4700			1300	400	100	2276			3000	400	1000		400	1600	800
1961		3900			1300	500	100	2134			2500	500	900		400	2100	800
1962		3900			1300	400	100	2589			1600	400	1000		801	1900	700
1963		4000			1400	2100	100	2939			1900	500	1000		1300	1900	700
1964		3300			1400	1900	100	2884			2500	400	1100		1800	2368	600
1965		3200			1700	1500	200	2524			2600	500	900		1400	1868	800
1966		3700			1300	1700	100	2357			2800	500	1000		1400	2070	1000
1967		3500			2000	1900	100	2286			3100	500	1100		1500	1667	600
1968		4300			2700	1800	100	2306			2700	600	1100		1400	1872	600
1969		3700			1900	1600	100	2418			2800	500	1100		1500	1773	600
1970		3400			3091	1600	200	3292			1500	400	1000		1100	1270	800
1971		3200			4521	1300	200	3408			1200	400	900		1100	1469	800
1972		3300			2600	1300	200	2893			1100	400	900		1500	1274	700
1973		3554			3937	1282	91	2910			1105	409	825	47	700	1213	800
1974		2870			2493	1285	67	2697			1029	368	891	42	1300	1030	817
1975		3293			1590	1398	79	2973			1213	407	917	44	570	1492	833
1976		2926		28	2959	1322	150	2677			1353	386	674	38	675	1023	694
1977		2381		63	1538	1317	108	2462			961	352	996	52	666	1084	742
1978		2379		77	2455	1162	76	2237			891	347	941	44	655	1162	877
1979		1860		77	3144	1164	110	2422			729	374	1007	25	460	1038	879
1980		2254		64	1921	1051	75	2264			877	387	910	32	344	1205	1053
1981		2229		31	1425	1033	94	2340			898	369	752	33	250	976	858
1982		2538		30	1469	1027	144	2087			1153	385	895	14	269	1250	1032
1983		2120		30	1856	1029	117	2076			1288	324	1103	11	188	1302	1113
1984		1855		24	2306	911	88	2361			723	310	1698	20	170	1161	957
1985		1601		23	2228	866	87	1907			688	352	1337	16	215	1211	781
	BE	DK	EE	FI	FR	DE	IE	IT	LV	LT	NL	NO	PL	PT	ES	SE	UK
1986		1643		25	2687	887	87	1928			685	272	1134	42	226	922	997
1987		1273		1	1978	731	230	2076			359	282	962		297	703	939

	BE	DK	EE	FI	FR	DE	IE	IT	LV	LT	NL	NO	PL	PT	ES	SE	UK
1988	<0.5	1784	11	1	2109	746	215	2165	3	94	433	513	1087		224	965	715
1989	30	1696	32	1	1672	678	400	1301	8	81	332	313	1109		119	952	1075
1990	30	1674	74		1674	978	256	1199		120	209	336	913	28	104	941	1039
1991	125	1464	3		1450	1010	245	1106		16	160	323	1097	44	85	1085	822
1992	125	1448	9		1164	1026	234	1662	19	12	89	372	1095	52	97	1180	782
1993	125	1081	59		864	1027	260	1307	18	10	419	340	1116		77	1144	752
1994	125	1200	54		607	585	300	986	39	12	358	472	1090		80	1298	873
1995	125	904	38		320	584	400	886	28	10	433	454	627		68	1100	808
1996	125	735	54	22	403	696	400	883	26	12	336	353	639		68	1042	895
1997	125	796	56	22	1782	746	400	1010	29	11	316	497	489		72	1073	807
1998	125	600	44	22	449	717	400	682	27	17	344	363	454		23	645	741
1999	100	711	60		289	746	250	645	17	18	372	475	474	30	39	736	697
2000	100	620	67		399	686	250	549	15	11	351	281	429	29	70	561	796
2001	100	658	67		415	638	110	446	19	12	374	304	425	37	62	580	595
2002		569	55		402	636	104	402	11	13	373	311	361	36	93	634	571
2003		620	64		412	251	81	458	11	13	366	240	321	13	40	565	588
2004		534	47		321	243	119	387	12	16	331	237	270	11	57	568	504
2005		531	69		186	285	87	115	17	22	317	249	220	9	55	668	493

Stocking

- Lithuania: the first stocking was in 1928–1939, when 3.2 million elvers were released in the lakes. Since the 1960s, about 50 million elvers or young yellow eels have been stocked.
- Estonia: stocking on a national level.
- France: no stocking on a national level.
- Italy: historic stocking in considerable amounts in lagoons and lakes, but no national recording.
- Germany: No national database for eel stocking, but data available for some river basins. Situation will improve next year, when all data become available in the EMP's. Stocking data for the Elbe RBD-system 1950–1980 are restricted to about 30% of the total basin area.
- Lithuania: stocking of glass eel on a national level.
- Spain: no stocking on a national level.
- Poland: stocking in the Vistula and Szczecin Lagoons on a national level.
- Portugal: no stocking on a national level.
- Ireland: no stocking on a national level. Upstream transport of glass eel (elver) and young yellow (bootlace) eel on the Shannon and Erne-see Country Report.

Table 5 Stocking of glass eel. Numbers of glass eels (in millions) stocked in (eastern) Germany (DE)*, Lithuania (LT), the Netherlands (NL), Sweden (SE), Poland (PL), Northern Ireland (N.Irl), Belgium (BE), Estonia (EE), Finland (FI) and Latvia (LV).

*** Values for Germany are for East Germany until 1990 and for East Germany and data from some western German states in the River Elbe RBD since 1991.**

	DE	NL	SE	PL	N.Irl.	BE	EE	FI	LT	LV
1927										0.3
1928									0.1	0.0
1929									0.2	0.0
1930										0.0
1931									0.2	0.4
1932									0.2	0.0
1933									0.2	0.3
1934									0.3	0.0
1935									0.6	0.2
1936									0.3	0.0
1937									0.3	0.3
1938									0.4	0.0
1939									0.1	0.2
1940										0.0
1941										0.0
1942										0.0
1943										0.0
1944										0.0
1945										0.0
1946		7.3								0.0
1947		7.6								0.0
1948		1.9								0.0
1949		10.5								0.0
1950	0.0	5.1								0.0
1951	0.0	10.2								0.0
1952	0.0	16.9		17.6						0.0
1953	2.2	21.9		25.5						0.0
1954	0.0	10.5		26.6						0.0
1955	10.2	16.5		30.8						0.0
1956	4.8	23.1		21.0			0.2		0.3	0.0
1957	1.1	19.0		24.7						0.0
1958	5.7	16.9		35.0						0.0
1959	10.7	20.1		52.5						0.0
1960	13.7	21.1		64.4			0.6		2.3	3.2
1961	7.6	21.0		65.1			0.0			0.0
1962	14.1	19.8		61.6			0.9		2.0	1.9
1963	20.4	23.2		41.7			0.0		1.0	1.5
1964	11.7	20.0		39.2			0.2		2.4	0.9
1965	27.8	22.5		39.8			0.7		2.1	0.4
1966	21.9	8.9		69.0			0.0	1.1	0.7	0.0
1967	22.8	6.9		74.2			0.0	3.9	0.5	1.0
1968	25.2	17.0		16.6			1.4	2.8	3.0	3.7
1969	19.2	2.7		2.0			0.0		0.0	0.0
1970	27.5	19.0		23.5			1.0		2.8	1.8
1971	24.3	17.0		17.4			0.0		1.6	0.0

	DE	NL	SE	PL	N.Irl.	BE	EE	FI	LT	LV
1972	31.5	16.1		21.5			0.1		0.3	1.6
1973	19.1	13.6		61.9			0.0		1.4	0.0
1974	23.7	24.4		71			1.8		1.8	0.0
1975	18.6	14.4		70			0.0		2.2	0.0
1976	31.5	18.0		68			2.6		1.0	0.6
1977	38.4	25.8		77			2.1		1.4	0.5
1978	39.0	27.7		73			2.7	3.7	2.7	0.0
1979	39.0	30.6		74.3			0.0		0.75	0.0
1980	39.7	24.8		52.9			1.3		1.8	0.0
1981	26.1	22.3		60.5			2.7		3.0	1.8
1982	30.6	17.2		64			3.0		4.6	0.0
1983	25.2	14.1		25.1			2.5		3.7	1.5
1984	31.5	16.6		49.2	4		1.8		0.0	0.0
1985	6.0	11.8		36.3	11		2.4		1.6	1.5
1986	23.8	10.5		54.4	17.8		2.5		2.6	0.0
1987	26.3	7.9		56.8	13.7		2.5			0.3
1988	26.6	8.4		15.9	6.3		0.0			2.2
1989	14.3	6.8		5.9	0.0		0.0	0.0		0.0
1990	16.7	6.1	0.7	8.6	0.0		0.0	0.1		0.0
1991	3.2	1.9	0.3	1.7	0.0		2.0	0.1		0.0
1992	6.5	3.5	0.3	13.8	2.4		2.5	0.1		0.0
1993	8.6	3.8	0.6	10.6	0.0	0.8	0.0	0.1		0.0
1994	9.5	6.2	1.7	12.2	2.3	0.5	1.9	0.1	0.1	0.0
1995	6.6	4.8	1.5	23.7	2.1	0.5	0.0	0.2	1.0	0.6
1996	0.8	1.8	2.4	2.8	0.1	0.5	1.4	0.1	0.4	0.0
1997	1.0	2.3	2.5	5.1	0.2	0.4	0.9	0.1		0.0
1998	0.4	2.5	2.1	2.5	0.1	0.0	0.5	0.1	0.1	0.0
1999	0.6	2.9	2.3	4.0	3.6	0.8	2.3	0.06		0.3
2000	0.3	2.8	1.4	3.1	0.5	0.0	1.1	0.06		0.0
2001	0.3	0.9	0.8	0.7	0.0	0.2		0.05		0.0
2002	0.3	1.6	1.7	0.0	3.0	0.0		0.06		0.23
2003	0.1	1.6	0.8	0.5	3.9	0.3		0.0	0.4	0.0
2004	0.2	0.3	1.3	2.3	1.2	0.0		0.06		0.0
2005	0.6	0.1	1.0	0.0	2.4	0.0		0.06		0.12
2006	0.0	0.6	1.1	0.0	1.0	0.3		0.05		0.006
2007	0.0	0.2	1.0	0.0	3.6	0.0		0.1		0.018
2008	0.0	0.0		0.0	1.3	0.3		0.1		0.0

Table 6 Stocking of young yellow (bootlace) eel. Numbers of young yellow eels (in millions) stocked in (eastern) Germany (DE)*, Lithuania (LT), ´The Netherlands (NL), Sweden (SE), Denmark (DK), Belgium (BE), Estonia (EE), Finland (FI) and Latvia (LV).

*** Values for Germany are for East Germany until 1990 and for East Germany and data from some western German states in the River Elbe RBD since 1991.**

	D E	NL	SE	DK	BE	EE	FI	LT	LV	PL
1946									0.0	
1947		1.6							0.0	
1948		2.0							0.0	
1949		1.4							0.0	
1950	0.9	1.6							0.0	
1951	0.9	1.3							0.0	
1952	0.6	1.2							0.0	
1953	1.5	0.8							0.0	
1954	1.1	0.7							0.0	
1955	1.2	0.9							0.0	
1956	1.3	0.7							0.0	
1957	1.3	0.8							0.0	
1958	1.9	0.8							0.0	
1959	1.9	0.7							0.0	
1960	0.8	0.4							0.0	
1961	1.8	0.6					0.1		1.0	
1962	0.8	0.4					0.1		0.7	
1963	0.7	0.1					0.0		0.4	
1964	0.8	0.3					0.1		0.4	
1965	1.0	0.5					0.1		0.3	
1966	1.3	1.1					0.1		0.0	
1967	0.9	1.2					0.0		0.8	
1968	1.4	1.0					0.0		0.0	
1969	1.4	0.0					0.0		0.0	
1970	0.7	0.2					0.0		0.4	
1971	0.6	0.3							0.0	
1972	1.9	0.4							0.0	
1973	2.7	0.5							0.0	0.2
1974	2.4	0.5							0.0	
1975	2.9	0.5					0.0		0.0	
1976	2.4	0.5					0.0		0.3	
1977	2.7	0.6					0.0		0.0	0.1
1978	3.3	0.8					0.0		0.0	
1979	1.5	0.8					0.1		0.0	
1980	1.0	1.0							0.0	
1981	2.7	0.7							0.0	
1982	2.3	0.7							0.3	0.1
1983	2.3	0.7							0.4	2.3
1984	1.7	0.7							0.0	0.3
1985	1.1	0.8							0.0	0.5
1986	0.4	0.7							0.0	0.2
1987	0.3	0.4		1.6					0.0	
1988	0.2	0.3		0.8		0.2			0.8	0.1
1989	0.2	0.1		0.4					0.0	0.7
1990	0.4	0.0	0.8	3.5					0.0	1.0

	D E	NL	SE	DK	BE	EE	FI	LT	LV	PL
1991	0.5	0.0	0.9	3.1					0.0	0.1
1992	0.4	0.0	1.1	3.9					0.0	0.1
1993	0.7	0.2	1.0	4.0	0.2				0.0	
1994	0.8	0.0	1.0	7.4	0.1			0.1	0.0	0.1
1995	0.8	0.0	0.9	8.4	0.1	0.2			0.0	
1996	1.1	0.2	1.1	4.6	0.1				0.0	0.5
1997	2.2	0.4	1.1	2.5	0.1				0.0	1.1
1998	1.7	0.6	0.9	3.0	0.1			0.1	0.0	0.6
1999	2.4	1.2	1.0	4.1	0.04			0.1	0.0	0.5
2000	3.3	1.0	0.7	3.8	0.003				0.0	0.8
2001	2.4	0.1	0.4	1.7	0.004	0.4			0.0	0.6
2002	2.4	0.1	0.3	2.4	0.008	0.4			0.2	0.6
2003	2.6	0.1	0.3	2.2	0.005	0.5				0.5
2004	2.2	0.1	0.2	0.8	0.009	0.4		0.1		0.5
2005	2.1		0.1	0.3	0.008	0.4				0.7
2006	5.5		0.0	1.6		0.4				1.1
2007	4.7		0.0	0.8		0.3				0.9
2008		0.2		0.8		0.2				1.0

Annex 4 – The use of genetics in the management of European eel

A working paper presented to the WGEEL by: Gregory Maes, Lorenzo Zane and Filip Volckaert.

Note: This working paper was used by the WGEEL to inform its discussions within the various subgroups and reviewed text is included in the relevant chapters. The whole document is annexed here for reference, but may not reflect the views of the Working Group.

Introduction

The life history of the catadromous European eel (*Anguilla anguilla* L.) depends on oceanic conditions; maturation, migration, spawning, larval transport and recruitment dynamics are completed in the open ocean (Knights, 2003; Tesch, 2003; Van Ginneken and Maes, 2005; Kettle and Haines, 2006). Despite the biological importance of the marine phase (Knights, 2003) to date most research has focused on the fresh-water phase of the life history. European eels have several life-history characteristics that make them particularly vulnerable to overexploitation: they are long-lived, are large, mature late, produce all their offspring at once, are subject to heavy mortality, and migrate long distances, right across the Atlantic. There is significant international trade demand for the species, both for live glass eels (from Europe to Asia) and the highly valued meat of adults. Given that poaching and the illegal trade are of major concern, as indicated by several reports, a better regulation of international trade is necessary. In addition, the decline may be exacerbated by other anthropogenic factors such as fresh-water and coastal habitat loss, pollution, parasitism, climate change, change in ocean currents, and blocking of inland migration routes (Dekker, 2003; Knights, 2003). A synergy between all these factors seems the most likely cause of the declines (Wirth and Bernatchez, 2003). All these factors have contributed to some extent that the European eel is beyond safe biological limits (Dekker, 2003), and recruitment is at a historical minimum (1% of the 1960 recruitment level). Many questions on the basic biology eel remain unanswered. For example, genetic data may help **assess species integrity within the North Atlantic**, evaluate the **number of genetic stocks** of the European eel, **clarify the spatio-temporal stability of genetic structure**, **estimate the population sizes**, define the **influences of oceanic conditions on genetic variability**, and **evaluate the effect of population decline on genetic variability, the origin of biological material (tracing)** and the overall fitness of eels.

The European Commission recently produced a community action plan for the recovery of the European eel stock , which aims to strengthen the return rate of adult eels to the Sargasso Sea and includes the development of eel management plans (EMP) (CEC, 2007). Further, the European eel has been added recently to Appendix II of CITES, implying drastic restrictions on trading. A number of restorative eel management responses are envisaged including; 1) assessing and reducing the impact of the fishery, 2) monitoring recruitment, 3) preserving migration routes (removing migration barriers), 3) the translocation of glass eel within the natural range of the species using glass eels from sources where there is still a demonstrable surplus and the assessment of the impact of the restocking practice (preserving potential local populations, disturbing homing behaviour, competition between local and introduced organisms), 4) the stocking of eels sourced from aquaculture production (justified on the basis that these are developed entirely on the basis of wild recruits), 5) assessing anthropogenic influences (pollution, parasites), and estimating the spawning population size (CEC, 2005; ICES, 2006).

When considering the use of genetics to complement these measures, immediately the need arises to assess the spatio-temporal population genetic structure at **spawning grounds** (in the Sargasso Sea), to **analyse the census population size (*Nc*) and to determine the relationship between historical and current effective population sizes (*Ne*)**, to **analyse genetic markers located in functional regions to unveil possible adaptive variation** under natural and anthropogenic conditions, and to gain understanding of molecular mechanisms involved in important traits for **aquaculture** and **artificial reproduction**. Knowledge of population structuring will provide insights on the appropriateness of trans-locating eels between river basins and between regions such as between the Mediterranean and the Atlantic or even the North Sea and the Baltic. To transfer eels between genetically different populations maybe counter productive to the long-term health of the resource. To protect the species, it is **important to maintain intraspecific genetic diversity**, to **develop sound restocking programmes for broodstock (wild spawning stock) enhancement** (avoiding the risk to introduce genetic depauperate individuals), and to **help realize profitable artificial breeding**. The present text synthesizes the most recent genetic knowledge of the European eel and provides an overview of possible better use of genetics in future management decisions on this declining species.

Genetic structure of the European eel populations

The European eel has been studied for more than 100 years, and hypotheses concerning its population structure have been tested using novel techniques each time they appeared. The most recent genetic information has answered several evolutionary challenges along the life cycle of the European eel (Figure 1). Many factors of its catadromous life strategy increase the chance of panmixia, such as the variable age-at-maturity, the highly mixed spawning cohorts, the protracted spawning migration, the sex-biased latitudinal distribution, and the unpredictability of oceanic conditions.

Historically, early population genetic studies, based on differences in transferrins and liver esterases, resulted in claims that European eel populations differed between continental European locations (Drilhon *et al.*, 1966, 1967; Pantelouris *et al.*, 1970), suggesting a southeastern Mediterranean reproductive area. Later allozymatic studies failed to detect obvious spatial genetic differentiation (de Ligny and Pantelouris, 1973; Comparini *et al.*, 1977; Comparini and Rodinò, 1980; Yahyaoui *et al.*, 1983). Mitochondrial DNA initially provided only limited insight into the geographical partitioning of genetic variability in the European eel, suggesting a single common gene pool (Lintas *et al.*, 1998). This commonly accepted view of a panmictic genetic population structure, based on oceanographic (Sinclair, 1988; Tesch, 2003) and genetic features, was, however, recently challenged by three independent studies (Daemen *et al.*, 2001; Wirth and Bernatchez, 2001; Maes and Volckaert, 2002). Wirth and Bernatchez, 2001 and Maes and Volckaert, 2002 detected a relationship between genetic and geographic distance (the so-called Isolation-By-Distance, IBD), suggesting a subtle spatio-temporal separation of spawning populations, with some degree of gene flow. Hydrodynamics, causing differential distribution of eel larvae, have also been suggested to explain partly the observed clinal genetic variation (Kettle and Haines, 2006). However, the unstable genetic architecture of European eel populations over time may be linked to oceanic factors (Dannewitz *et al.*, 2005). Neutral genetic markers are generally able to discriminate between populations with a gene flow of less than 1%. Hence, a lack of structure does not mean that there is no structure, but prompt for the use of more discriminatory markers to detect potential structuring.

Most recently, Maes and Volckaert, 2007 wrote a comprehensive review on the population genetics of the European eel, which should be consulted for a more detailed synthesis of the most recent research. In this review, the suggestion that the eel be managed as a catadromous species (including the crucial marine phase) is a significant insight on how the eel should be viewed in terms of its likely population organization, at least from the genetic perspective. The eel in fact, because of its assumed reproductive biology i.e. a prolonged spawning period, variance in age-at-maturity, high variability in parental contribution and reproductive success, might be expected to exhibit a high level of genetic variability, high exchange between populations (gene flow) resulting in low genetic differentiation (low genetic signal/noise ratio) and a high genetic population size, all of which are characteristics observed in other typically marine pelagic species with high migration potential such as cod, *Gadus morhua* (Nielsen *et al*., 2006) and herring, *Clupea harengus* (Bekkevold *et al*., 2005). Also, as has been observed by Rousset, 1997, widely distributed species are rarely fully panmictic (mating randomly), but are commonly divided into subgroups in a pattern that can be described by one of the classical population models, such as the island model, stepping-stone model or Isolation-by-Distance (IBD) model. In populations composed of a mixture of individuals reproducing at different times within a reproductive season, temporal differentiation can supplement possible geographical partitioning. Under these conditions, gene flow is expected to be limited between early and late reproducers, possibly creating a pattern of Isolation-by-Time (IBT) (Hendry and Day, 2005; Maes *et al*., 2006). Additionally, temporal heterogeneity in the genetic composition of recruits is likely to result from a large variance in parental reproductive success driven by the unpredictability of the marine environment (Waples, 1998, Pujolar *et al*., 2006). Under the hypothesis of "sweepstakes reproductive success" (Hedgecock, 1994), chance events determine which adults are successful in each spawning event, attributing the variation in reproductive success of adults to spatio-temporal variation in oceanographic conditions, occurring within and among seasons. Many marine species split their reproductive effort among several events during a protractive spawning season, to maximize their reproductive success (Hutchings and Myers, 1993; Maes *et al*., 2006).

Ocean currents and diffusive processes, resulting in a differential distribution of eel larvae, have recently been suggested to explain this observed genetic structure (Kettle and Haines, 2006). Maes *et al*., 2006 detected a significant correlation between genetic distance and temporal distance among recruitment waves indicative of Isolation by Time. Yet, despite these glimpses of putative structuring, Dannewitz *et al*., 2005 still concluded from their detailed investigations that European eels from the coasts of Europe and Africa most probably belong to a single spatially homogeneous population. However the existence of discrete and stable spawning aggregations is not completely unrealistic. In explaining the high incidence of American and European eel (*Anguilla rostrata* and *Anguilla anguilla*) hybrids in Icelandic rivers, Albert *et al*., 2006 suggest that intermediate larval development times for the hybrids are plausible with the effect that ocean currents will deliver the hybrids to rivers positioned in the middle of the natural range. Larval development times would have to be adaptive (transporting American eels into American rivers and European eels into European and African rivers) and therefore has to have some heritable basis. That American and European eels are described as two distinct species in itself suggests that possibility of structuring and maintenance of structuring over time, as it has been suggested that the spawning grounds of both species overlap in space and time (McCleave, 1987). It is also plausible that larvae and glass eel imprint during ocean transport and that this allows homing of adult eel to natal spawning areas (Maes, 2005).

Identifying and sampling discrete reproductive aggregations in the spawning areas will most effectively resolve the genetic structure of the European eel. This is a challenge because European eels spawn in an area that is not well defined and very remote. Since Schmidt, 1923 identified concentrations of eel leptocephali in the Sargasso

Sea in the 1920s there has been little progress in locating eel spawning areas. However it is likely that recent advances in physical oceanography (Kettle and Haines, 2006) offer a reasonable opportunity of overcoming this deficit in the near future. In addition, tagging and tracking of fish has progressed such that monitoring from feeding to spawning ground is feasible. An international project (http://www.Galathea3.dk, Spring 2007) lead by Danish scientists has recovered geolocational pop up tags in the Sargasso Sea from adult eels previously tagged leaving European rivers. Adult eels were tracked swimming to the spawning grounds for the first time.

There is now sufficient evidence available to suggest that small but significant levels of genetic structuring exist in European eel and that this diversity should be protected:

- Geographical clinal variation at enzymatic and neutral genetic markers between recruiting glass eels and adults.
- Large (yearly) and small (seasonal) scale temporal genetic differences between spawning cohorts and recruiting glass eels.
- Homing behaviour between North-Atlantic eel species and even hybrid individuals endemic to Icelandic waters. This points to the possibility of intraspecific homing behaviour based on adaptive traits, instead of neutral variation (see further).
- Correlation between genetic variability and fitness traits in natural populations, prompting for maintenance of genetic diversity for long-term survival of the entire species.

Within a precautionary principle framework, eel fisheries management should be aware of the genetic structure suggested by recent studies and that management strategies designed for recovering stocks should incorporate this possibility. Besides the existence of these small-scale level of genetic differentiation, many new initiatives are ongoing to determine the long-term genetic (effective) population size of eel, the presence of functional/adaptive genetic diversity which is more relevant to changing life-history traits, the assessment of oceanic influences on larval survival and the monitoring of individual responses to pollutants and parasites at the gene expression level (see further).

Genetic research perspectives and management of the European eel

Earlier conclusions drawn from molecular studies are not only important for inferring the panmictic status of the eel, but also to preserve the genetic resources in European eels and to define additional research priorities. For each priority, one can define a specific management objective and the time frame during which changes or reversal may be achieved (Table 1). It is obvious, for instance, that genetic diversity may be lost rapidly (i.e. genetic erosion), and that it recovers very slowly within populations (ICES, 2005). To assist with a sound management of European eel, future genetic research may therefore focus on the conservation issues listed above. We propose **four major lines of research**: assessment of the **spawning population structure and effective population size**, inclusion of **adaptive genetic variation** in management plans, **monitoring stress responses of eels** under heavy anthropogenic pressure (pollution, physical barriers and parasites) and **improving artificial reproduction** through aquaculture genomics.

Spawning population structure and size

The genetic structure of natural marine populations is best understood by identifying, sampling and analysing discrete reproductive aggregations (Waples, 1998). Our knowledge of the spawning biology and migration routes of North Atlantic eels remains poor. Identifying the precise location of the spawning grounds, nurseries and retention zones, along with a greater knowledge of the ecosystem where spawning takes place would help management decisions considerably. To date no observations have been made of adult eels in the Sargasso Sea, and their eggs have yet to be identified there (Tesch, 2003). In the Pacific Ocean, based on the distribution of newly hatched larvae, the spawning grounds of the Japanese eel have been reconfirmed by genetic identification techniques (Tsukamoto, 2006). The continental populations constitute mixed feeding aggregations, complicating interpretation of patterns of genetic structure (Dannewitz *et al*., 2005; Maes *et al*., 2006b; Pujolar *et al*., 2006). Sampling putative populations on the continental shelf remains challenging, because of the confounding effect of overlapping generations in adults and the site-dependent age structure. The most effective solution is to sample spawning eels and newly hatched larvae across the Sargasso Sea, and to analyse them with a representative set of genetic markers. This would allow a reassessment of the spatial and temporal segregation found so far and a rough calculation of the size of the spawning stock (*Ne*), which still poses problems in marine fish. The development of precise, performing genetic markers (such as SNPs) for application on highly degraded or old DNA, would also provide new opportunities to compare present genetic patterns with the patterns found some 100 years ago, based on the available larval samples of Schmidt, 1923. Importantly, as a consequence of the long **restocking practices** since the 1950s, one can expect to see a homogenization of populations as a consequence of such large-scale translocations. To fully assess the effect of such translocations on the species level, it would be of interest to study the population structure before such major translocations. This can be done by studying historical material from different European sources from the mid-century and comparing this pattern with the present one at neutral and adaptive genetic markers (see later). Potential translocations of exotic species in Europe (such as American eel or other less exploited eel species) for restocking is also an important issue, requiring up to date molecular identification methods (Maes *et al*., 2006a). This problem is already of great importance in Asia (Okamura *et al*., 2002; 2004). This would enable **reliable tracing** of the location and species of origin of glass eels to be stocked.

Additionally, analysis of successive recruitment waves of European eels at sites with year-round recruitment would permit better understanding of the fine-scale genetic composition of glass eels and possibly pinpoint discrete spawning groups. A sharp break or clinal pattern in relatedness and genetic differentiation may point to reproductively isolated aggregations (Maes *et al.*, 2006b). In turn, stochastic variance in genetic composition might point to genetic patchiness, most likely under the influence of annual and seasonal oceanic and climatological fluctuations (such as the North-Atlantic Oscillation; Knights, 2003; Friedland *et al*., 2007). These are thought to influence the reproductive success of adults and the survival rate of larvae (Dekker, 2004; Pujolar *et al.*, 2006).

Accurately estimating the effective (genetic) population size (*N*e) is another aim to develop appropriate conservation strategies for eels. *N*e predicts the rate of loss of neutral genetic variation, the fixation rate of deleterious and favourable genetic variants, and the rate of increase of inbreeding experienced by a population (Frankham *et al*., 2002). Importantly, the *N*e of a population is often several orders of magnitude smaller than the census size (*N*c) of the population, owing to unequal sex ratios, variance in reproductive success and assortative mating. In marine fish (including eels)

*N*e/*Nc* ratios may be expected to be more extreme than in other vertebrates because of the high female fecundity that allows large census numbers to be obtained from minimal numbers of breeding animals. Indirect methods for estimating *N*e based on molecular marker data have been developed to facilitate the inference of population size, a very difficult task in marine fish with their lack of confined geographic boundaries. When considering census population data of European eels, which indicate that the species is in serious decline over most of its range, it is essential to maintain the spawning stock(s) at sufficiently large levels to ensure that effective population sizes (Ne) as well as absolute population sizes (Nc) are optimized above safe limits. European eels are long-lived animals with reproductive ages roughly ranging from 6 to 60 years (Tesch, 2003). To assess fully the temporal fluctuation in population size (Ne), a long-term analysis over several generations would be ideal. An analysis of time-series of historical material may increase the confidence in genetic estimates of population sizes. This should be done over a period as long as possible to avoid the shifting-baselines trap and the influence of overlapping generations (Jorde and Ryman, 1995; Pauly, 2007). Realistically, the past 100 years should suffice, because anthropogenic impact seems to have been greatest during that period (e.g. endocrine disruption of spawning, overfishing, river management). Such an analysis is now feasible thanks to the development of appropriate genetic techniques for ancient DNA (Nielsen *et al*., 1997). For example, reliable estimates of population size have been calculated for several fish species in a pre- and post-industrial fishery (Nielsen *et al*., 1997; Turner *et al*., 2002; Hauser *et al*., 2002). This knowledge is of great importance in managing genetic variation, which is known to correlate with fitness components in eel (Maes *et al*., 2005; Pujolar *et al*., 2005), and to define sound management strategies.

Finally, the accurate interpretation and extrapolation of genetic results in eels requires an assessment of demographic scenarios through the development of new population dynamics models. Such models have been the basis of fisheries research for a long time, but here we ask for a joint assessment of demographic, hydrodynamic and genetic parameters. Simulating a range of scenarios of reproductive success, migration, survival, dispersal, age structure, maturation, fisheries pressure, and anthropogenic stress, preferably in an ecosystem perspective, looks a promising field. Subsequent validation with empirical genetic and population dynamic data may confirm the key factors.

Adaptive genetic variation for fisheries management

Heavy fishing and other anthropogenic influences, such as pollution and barriers of migration, will not only impact the census size and the effective population size of eels. Large declines in mature adults and recruiting individuals may trigger phenotypic and adaptive genetic changes over generations of harvesting (Law, 2000). Such phenotypic changes may include shifts in age- and size-at-maturity, less reproductive success, greater mortality, changes in growth patterns of juveniles and adults, lower fecundity and fertility, and changes in the sex ratio. If changes are heritable, this may lead to almost irreversible genetic changes in life-history traits (Law, 2000). Recent recommendations from the EU (ICES, 2005) urge the assessment of fisheries and climatologically induced changes in declining marine stocks. A suitable strategy would be a joint analysis of phenotypic and genetic data from contemporary populations, compared with a reference situation (preferably before the population decrease). There is clearly the need for reliable investigations of possible adaptive responses in exploited marine organisms using archival material (Nielsen *et al*., 1997; Myers and Worm, 2003). Although some evidence exists for phenotypic changes in the European eel stock throughout the past 50 years (increasing adult size and decreasing glass eel size since the 1960s), the evolutionary interpretation of overfishing is complicated by there being too few age-specific data, such as on age-at-maturation and growth rate (Dekker, 2004). The long-term genetic consequences of heavy fishing at the adaptive molecular level, such as a decrease or shift in genetic variability at important functional genes related to maturity and growth, have not been assessed yet.

Further, the presence of only a small level of geographical genetic differentiation at neutral microsatellites may lead to seriously underestimating quantitative and adaptive differentiation between populations that might be present but not detectable with these molecular markers. Indeed, apart from analysing neutral genetic variation to assess the demographic independence and stability of fisheries stocks, knowledge of geographic and temporal scales of adaptive genetic variation is crucial to species conservation (Conover *et al.*, 2006). Local adaptation is one of the most significant components of intraspecific biodiversity, and the relevance of local adaptation to fisheries management can be divided into two main issues, each differing in temporal scale (ICES, 2006). First, local adaptations and population structure affect short-term demographics through effects on local recruitment patterns. Second, local adaptations and genetic heterogeneity affect long-term population dynamics, with respect to the connectivity among stocks/populations and their resilience and response to environmental change and harvesting. Local adaptation and the maintenance of biodiversity on the long term for sustainable fisheries management has yet to be implemented into management strategies (ICES, 2006). Unfortunately, the understanding of these phenomena is particularly difficult in marine organisms. The spatial and temporal scale of adaptive divergence has been assumed to be very large. However, evidence of geographically structured local adaptation in physiological, morphological and functional genetic traits has become apparent (Giger *et al.*, 2006; Nielsen *et al.*, 2006). The proportion of quantitative trait variation at the among-population level (Q_{ST}) has repeatedly been demonstrated to be much higher than for neutral markers (F_{ST}) (Cousyn *et al.*, 2001; Conover *et al.*, 2006). As both metrics of genetic variation are poorly correlated, knowledge of neutral variation does not provide much information about adaptive variation (McKay and Latta, 2002; see Conover *et al.*, 2006, for a review). Given the important link between population genetics and dynamics, and the strong potential for selection in species with large population sizes, the application of both selected and neutral markers is obviously needed to resolve the stock structure of marine fish effectively.

Genetic stress responses to pollution and parasitic load

Organic and inorganic pollutants can significantly reduce the quality and reproductive capacity of vertebrates. This is especially the case in fish, where pollutants can accumulate in the aquatic and sedimentary environment and in the benthic biota (food). A benthic feeder can at the same time be seen as a good candidate to monitor environmental quality of aquatic habitats, but at the same time suffers most from the ability to bioaccumulate strongly all kinds of lipophilic substances, leading to the possible destabilization or even extinction of the species. Additionally, parasitic infection and pollution have been revealed to impair strongly the survival and reproductive capacity of eels in experimental, resulting in an even stronger response to pollution and vice-versa (Palstra *et al.*, 2006; 2007). However, although recent results have displayed a strong correlation between pollutants and decrease body fat concentration (crucial to spawning migration and egg production), the influence of stressors need a more in depth analysis at the population or stock level, to allow a reproductive success assessment and sound management options (Belpaire, 2008). A thorough analysis of pollutants and parasite stress level and better understanding of the organismal response is crucially needed. This will enable parallel analysis of responses (or not) and find out the synergetic fitness influences of pollution and parasite load.

Indeed, genetic diversity is the product of thousands of years of evolution, yet irreversible losses may occur rapidly (Kenchington *et al.*, 2003). It is essential to long-term survival, to adapt to climate change and anthropogenic pressure leading to the loss of populations, with the likely subsequent loss of adaptive variation. For fisheries management, the extent of genetic variability within populations is crucial in assessing the quality of stocks, the potential productivity or growth of a population, and the sustainability of fisheries. Pujolar *et al.*, 2005 and Maes *et al.*, 2005 assessed whether the genetic background of European eels could be linked to two fitness traits, early growth and pollutant bioaccumulation. Summarizing both studies here, there was strong evidence of Heterozygosity-Fitness-Correlations (HFC), likely explained either by an effect of direct overdominance at functional markers. The positive consequence of the catadromous life history of eels is that locally polluted rivers will only have a low impact on the entire population, because of the lack of spatial genetic structure at a local level. Nevertheless, selection during each generation will erode local genetic variability differentially, slowly reducing overall genetic variability. Differential selective pressures might induce variation between spawning cohorts in time and space, possibly increasing the temporal differentiation pattern described by Maes *et al.*, 2006b and Pujolar *et al.*, 2006.

Recently, it became possible to reliably quantify the gene and protein expression levels during exposure to pollutants and parasites, allowing the early detection of decreased fitness and survival. Such knowledge would provide the chance for early management actions before major mortality events in natural populations and provide a long-term assessment of success rates of conservation measures. Using sufficient background information on the identity and concentration of pollutant, this approach can yield better insights into the factors influence the recently observed decrease in fat content, a crucial measure for eels' fitness to reach the Sargasso Sea.

Artificial reproduction and aquaculture genomics

Current fishing pressure on European eels could be decreased considerably if artificial reproduction were possible (but see Palstra *et al.*, 2005 and references therein). Despite numerous attempts over the past 30 years, it remains impossible to produce economically profitable quantities of eels in aquaculture. Until now, naturally recruiting glass eels are caught and grown in tanks for later consumption. Additionally, eel aquaculture individuals are often used for restocking purposes, with the aim of rescuing depleted rivers and lakes. However, the fitness consequences of this practice remains to be thoroughly studied, as the fast growers and most fit individuals are first sold for food consumption and the remaining (most likely less fit) individuals are sold for restocking. No study has ever monitored life-long fitness of such individuals, an important point considering the link between genetic variability and fitness in eel and other organisms such as salmonids (Pujolar *et al.*, 2005; McGinnity *et al.*, 2003).

Recently, methodologies developed to produce eel larvae of *A. japonica* have been tested in Europe on *A. anguilla* resulting in fertilized eggs, embryonic development, and occasional hatching (Palstra *et al.*, 2005; Kagawa *et al.*, 2005). Success, however, remains low, calling for further study of the husbandry of eels, and of reproductive and general eel biology. Original insights on physiology and endocrinology may be expected from advanced genomic tools. For instance, Miyahara *et al.*, 2000 produced 196 Expressed Sequence Tags (ESTs) from a spleen library of Japanese eels, and Kalujnaia *et al.*, 2007 was able to identify, through subtractive hybridization and microarrays, a large number of genes down- and unregulated during osmoregulation in gill, kidney, and intestinal tissue. As new genetic tools become available in related *anguillids* (e.g. Japanese eel; Nomura *et al*., 2006) and related genome information rich species, promising insights in functional and comparative genomics are expected in the near future. EST sequencing and linkage maps may be other feasible genomic approaches, representing the first steps toward identifying important genes and Quantitative Trait Loci (QTL), the basis for Marker Assisted Selection. Although larvae of Japanese eel have only been bred with great effort, Nomura *et al*., 2006 have managed to prepare a low-density linkage map based on 43 microsatellite markers, and many more are being developed (K. Nomura, pers. comm.). Given the numerous genetic markers known to cross-amplify between *Anguilla* species (Maes *et al*., 2006a), once progeny become available for European eels, reliable paternity screening, gene expression and microarray analyses and a linkage map become realistic goals. Quantitative traits such as growth rate, food conversion, postponed maturity, stress tolerance, and parasite resistance strongly correlate with the possibilities of artificial rearing. One long-term issue where QTL may be of great help is in the management of feed supply. Currently, wild-caught fishmeal is an important ingredient of dry feeding pellets, but it is expected to shift to a proportionally larger vegetarian diet.

Genetic implications and recommendations for the Eel Management Plan

The importance of maintaining genetic diversity can be divided into a **short-term impact (in the order of few generations),** by avoiding inbreeding and fitness decrease (population survival) and a **long-term impact (over decades or even centuries)**, by conferring the possibility to adapt to changing conditions (species survival). Genetic data may help to **assess species integrity within the North Atlantic**, evaluate the **genetic stock structure** of the European eel, **clarify the spatio-temporal stability of the genetic structure**, define the **influences of oceanic conditions on genetic variability**, **monitor** and **guide** the **stocking policy** in Europe, and **evaluate the effect of population decline and habitat degradation on genetic variability** and the overall fitness of eels. For the current ToRs genetic considerations can be focused on the issues of **restocking policies** and **eel quality assessment**.

Genetic consequences of stocking practices

Stocking of glass eels has been defined as a practice to increase the population abundance of European eel. Although an immediate effect on populations can been seen in an early phase, the long-term success of this practices has not been assessed yet, neither the genetic consequences. Stocking should be performed carefully and with knowledge of potential negative implications on eel populations. Importantly, **stocking should not been seen as the only solution for stock recovery**, as the fishing pressure may dramatically increase at source locations for glass eels and later spawning success of stocked individuals is not at all guaranteed. To supplement river populations impacted by migration barriers, hydropower, pollution, pathogens, a standard strategy to catch glass eels from the estuaries (or neighbouring sites) and transport them upstream to repopulate low-density habitats or surplus good habitat. Ideally, high quality habitats should be chosen and rivers with the least anthropogenic impacts selected. There should be a long-term plan to improve habitat in disturbed basins over the full river basin. In areas with no recruitment, the origin of glass eels should be the nearest from the target location. In areas with low recruitment, care must be taken to reduce competition and to stock smaller individuals. Areas with heterogeneous recruitment should focus on relocating recruits from neighbouring rivers and not from distant sites.

Below we list some important points to consider when planning restocking measures and provide some advice for sustainable stocking.

Deciding on mass stocking practices to supplement populations, can lead to the rapid **introduction of non-native genetic material**. Monitoring the correct species identity (tracing) is therefore crucial to preserve genetic integrity of the European eel. Examples of this phenomenon have already been observed, mainly in Germany (Trautner *et al.*, 2006), prompting for up to date molecular identification methods for species discrimination (Maes *et al.*, 2006a). The European eel has been listed under CITES, potentially leading to an increased import of other eel species. Such exotic eel introductions have been a major problem in Asia, where European eels were introduced to supplement Japanese eel stocks (Okamura *et al.*, 2002; 2004).

Aquaculture glass eels (grown from glass eels to 10 cm elvers) are often **used** for **stocking purposes**. Although at first sight no significant problem is expected from the genetic diversity point of view (glass eels are natural recruits), **fitness consequences could be higher than expected**. Indeed, keeping glass eels too long in such facilities will **adapt** them to **aquaculture conditions** (such as artificial food and temperature regimes), and will lower their competitiveness and fitness in the natural environment. Second, a common practice in aquaculture facilities is to **deliberately infect new glass eels with the highly virulent Herpes virus,** to decrease later mortality during grow-out. As such, after a large initial mortality, stocked eels are in many cases infected with Herpes (up to 50%) and can infect natural populations. Additionally, such practices create already a **high selective pressure on glass eels, reducing total genetic diversity and directionally selecting at the functional level for specific disease resistance genes (such as MHC)**. This has been demonstrated to have a very detrimental effect in salmonids when such individuals are released in the wild, as a consequence of a lower fitness for natural pathogens. Further, **large restocked individuals might cannibalise local recruits**, which are much younger. Stocking should be performed at well-chosen moments, namely at the end of the natural recruitment season. Additionally, attention should be paid that **stocked individuals** are not only composed of the **slow growers** of aquaculture, which have been demonstrated to exhibit a lower functional genetic diversity and could demonstrate lower survival rates under pollution stress (lower fitness). Additionally, using slow growing and small individuals for **stocking can significantly bias the sex-ratio** of stocked fish, inducing a non-natural distribution of sexes in stocked systems. We advise to **perform experiments** on competitiveness, survival and reproductive capacity of stocked glass eels, besides the marking of stocked individuals and their recapture at sexual maturity.

At the population level, **stocking practices can have major consequences on the intraspecific biodiversity**, as a consequence of the mixing of genetically differentiated populations. Although no stable geographical differentiation could be detected using past research efforts (Wirth and Bernatchez, 2001; Dannewitz *et al.*, 2005; Maes *et al.*, 2006), as a consequence of the long **restocking practices** since the 1950s, one can expect to contribute to a homogenization of populations as a consequence of massive translocations. Indeed, the presence of only a small level of geographical genetic differentiation at neutral genetic markers may lead to seriously underestimating quantitative and adaptive differentiation between populations. From recent studies on marine fish populations we know that adaptive differences might be present but not detectable with the current molecular markers. Indeed, apart from analysing neutral genetic variation to assess the demographic independence and stability of fisheries stocks, knowledge of geographic and temporal scales of adaptive genetic variation is crucial to species conservation (Conover *et al.*, 2006; Maes and Volckaert, 2007). For eel, no assessment has been made of the functional diversity yet, although work is in progress to contrast data on neutral and adaptive markers (Maes, Zane, pers. comm.), besides novel data on differing life-history traits (Feunteun, pers. comm.). **If distinct populations exist**, the introduction of genetically different glass eels can potentially break up any existing adaptation in local stocks and have major fitness consequences on life-history traits, such as migration duration and timing, temperature resistance and size at maturation sizes. The homogenization of these traits can lead to a decrease in diversity and the loss of important traits for survival. However, until results are available (within 1–2 years) we can only advise on the following stocking strategies, depending on the natural recruitment level.

Regions with no recruitment and very low escapement: Preserve natural recruits (if any) and escapees, while stocking glass eels in high quality habitats originating in the same main hydrographical region (Northern Europe, West Atlantic, Southern Europe, Mediterranean).

Regions with low recruitment: Preserve natural recruits and escapees, while preferably stocking glass eels from estuaries or neighbouring river basins in high quality upstream habitats.

Regions with high recruitment: care should be taken not to overfish glass eels for stocking purposes, as this will weaken the source region and deplete the rivers from escapees.

On the other hand, **if neither neutral nor adaptive differences can be detected** in the European eel, stocking practices may have a beneficial effect, as they would expand the feeding habitat size of eels, and help recover the total population. The question however remains, whether stocked individuals will find their way to the Sargasso Sea and ultimately contribute to the spawning stock. The most important issue is then to preserve the total genetic diversity to allow adaptation to a changing environment. Keeping the highest level of biodiversity in phenotypic (quantitative) and genetic traits is crucial to the survival of the entire species.

Lastly, the **ongoing investigation of the historical genetic** (neutral but especially adaptive) **structure and stability** before the start of large-scale stocking practices (1950s) and the monitoring of the evolutionary consequences from 50 years of re-stocking will enable to fully assess the effect of such translocations on the species level. This is being done by studying historical material (otoliths) from different European sources in the mid-twentieth century and by comparing this pattern with today's observations at neutral and adaptive genetic markers.

Quality assessment of spawners using genomic tools

Eel decline might depend not only on the quantity of adult eels leaving the continent but also, if not mainly, upon their quality. Good quality spawners are those that succeed in crossing the Atlantic Ocean and reproduce. Parasites, such as the exotic swimbladder nematode *Anguillicola crassus* can impair eel viability by both increasing continental mortality and affecting the swimming ability of adult eels. Organic and inorganic pollutants may significantly reduce the quality and reproductive capacity of vertebrates. This is especially the case in fish, where pollutants may accumulate in the water and sediment and in the benthic biota (food). Additionally, infections and pollution have been revealed to impair strongly the survival and reproductive capacity of eels in experimental trials, resulting in an even stronger response to pollution and vice-versa (Palstra *et al.*, 2006; 2007). A thorough analysis of pollutants and pathogen stress level and a better understanding of the organismal response (besides measures of condition index) are missing. Pujolar *et al.*, 2005 and Maes *et al.*, 2005 assessed whether the genetic background of European eels could be linked to two fitness traits, early growth and pollutant bioaccumulation. Summarizing both studies here, there was strong evidence of a relation between genetic diversity and fitness measures (also called Heterozygosity-Fitness-Correlations or HFCs). It might be explained either by an effect of direct overdominance at functional markers. Recently, it became possible to reliably quantify the gene and protein expression levels during exposure to pollutants and parasites, allowing the early detection of decreased fitness and survival. Such knowledge would provide the chance for early warning systems, facilitating management actions before major mortality events in natural populations and provide a long-term assessment of success rates of conservation measures. Using sufficient background information on the identity and concentration of pollutant, this approach may yield better insights into the factors influencing the recently observed decrease in fat content, a crucial measure for eels' fitness to reach the Sargasso Sea. The ongoing analyses of northern (Belgium) and Southern (Italy) eel populations for their gene expression level and health status will allow adding a quality status tag on silver eels, while identifying good quality habitat for preservation.

Recommendations

Using the current knowledge of the genetic structure, pollution and pathogens influence on eel and the potential risks of using aquaculture eels for restocking, we draft some conclusions, main recommendations for further research and management options, and potential advice to be issued by ICES. Besides developing the control of **artificial reproduction**, it is our opinion that an **integrated analysis of phenotypic, demographic and genetic data of contemporary and historical (otoliths) populations** would significantly increase our knowledge of human vs. natural impacts on eel stocks the last century (genetic baseline). Additional research focus on the **marine part of its life cycle**, including **hydrodynamics, ecotoxicology, archived material, and neutral vs. adaptive genetic variation**, are the next steps in developing a global management strategy. This should be integrated in a broader ecosystem perspective. The consequences of **earlier and future restocking** practices needs more attention to avoid weakening even more the species and disturbing the natural spawning cycle of this species. In light of emerging information suggesting putative stock structure of European eel it is recommended from the genetic viewpoint that glass eels, elvers and other life-history stages should not be trans-located between distant river basins for restocking purposes. However, given the need for rapid action and that stocking is one of the actions proposed by the EC, the precautionary approach should still apply in order to avoid imminent collapse of specific river stocks, where possible the translocation should be done within geographically proximate areas e.g. within the Mediterranean basin, the West Atlantic, the North Sea or the Baltic Sea. It is of crucial importance to assess the success of this practice and to overview actions to be taken along the complete life cycle of eels.

Finally, a thorough assessment of the success of such management options should be done in 2012, a time frame where new results on potential adaptive differences between eel stocks and loss of functional diversity the last 50 years will also be available.

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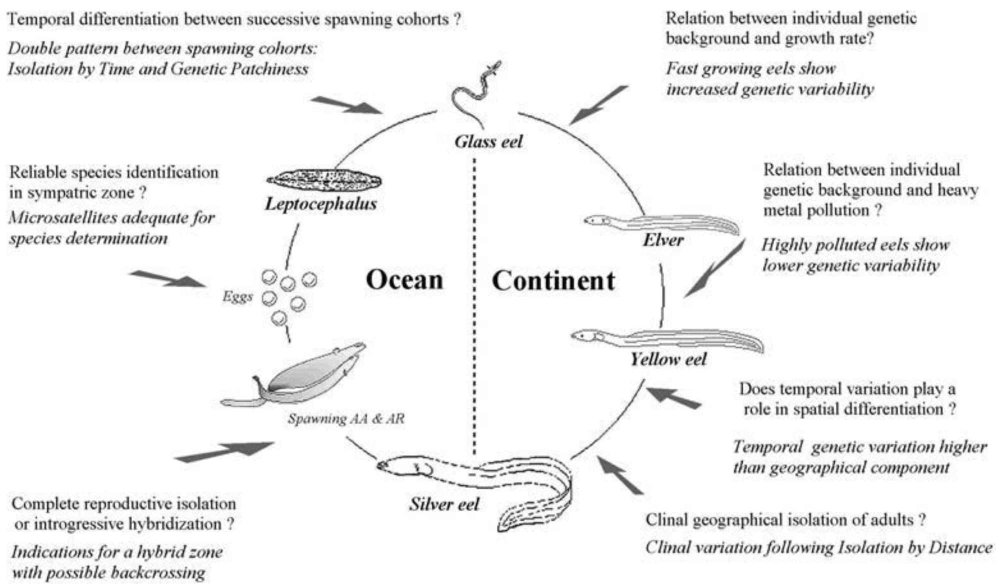

Figure 1. European eel: life cycle of the main recent evolutionary questions relevant to the management of eels (Maes and Volckaert, 2007).

Table 1. European eel management objectives related to the loss of genetic diversity (Maes and Volckaert, 2007).

Consideration	Example management objective	Time-scale (generations)
1. Genetic integrity at the species level	1.1. Avoid species translocations for restocking or aquaculture	1
	1.2. Trace species identity of endangered fish (products)	
2. Genetic diversity within and among populations	2.1. Maintain population size in river sheds	>100
	2.2. Decrease glass eel fishery and export	
	2.3. Increase silver eel escapement to contribute to spawning stock	
3. Population structure and relative abundance	3.1. Avoid large-scale translocations within Europe and between continents	>100
	3.2. Detect possible local adaptation between river basins	
	3.3. Maintain relative size of populations	
4. Effective population size and demographic stability	4.1. Maintain large number of individual populations	>10
	4.2. Minimize environmental degradation (pollution, habitat fragmentation)	>10
	4.3. Assess influence of parasites (e.g. Anguillicola) and pathogens (e.g. virus infection - EVEX) on reproductive potential	>10
5. Evolutionary potential	5.1. Minimize fisheries-induced selection	>10
	5.2. Avoid directional adaptation to anthropogenic and environmental changes	>10

Annex 5 – Country overview of contaminant and parasite/pathogens in eel

Contaminant analyses: Overview by country

Belgium

Extensive information has already been provided in the WG Eel 2006 and WG 2007 reports. During WGEEL 2008 a considerable amount of new information has been made available to the Working Group and to the EEQD (see the Belgian country report and Belpaire, 2008).

Canada

Concentrations of many contaminants in the North American environment were high in the 1960s and 1970s, then decreased as bans and restrictions took effect. The St. Lawrence River-Great Lakes system receives a wide variety of pollutants, some of which have lethal (Dutil *et al.*, 1987; Castonguay *et al.*, 1994a) or sublethal (Couillard *et al.*, 1997) effects on eels. Concentrations of most contaminants, including PCBs and mirex, in eels migrating through the St. Lawrence Estuary fell in the 1980s (Hodson *et al.*, 1994). This trend presumably reflects decreased contaminant exposure, but does not takes into account the presence of new contaminant (for example the brominated compounds) and the increasing number of non native species in the Great Lakes watershed that alter fish community composition and foodweb energy flow, leading to subsequent change to pathways and fate of contaminants.

Recently, a 3-year research project on the role of chemicals in the decline of the American eel was initiated to evaluate if eels accumulate sufficient chemical contaminants during their growth and maturation to cause embryo toxicity, and to estimate when contaminants might have affected eel. Under the leadership of Dr Peter V. Hodson (Queen's University), a team of university and government scientists, including colleagues in the US and Europe are collecting fresh and archived samples of eels from reference and contaminated ecosystems. The eels are analysed for concentrations of chemicals known to be embryo-toxic, such as chlorinated and brominated organic compounds, selenium, and alkyl tin. The toxicity of extracted chemicals will be assessed with a battery of tests using fish embryos and fish cells in culture.

Denmark

There are few surveys and mostly of older date. Recent data for PFAS and organotin-compounds in the aquatic environment extracted from report by Strand *et al.*, 2007 and unpublished data from Århus Amt, 2003. (see Appendix. A in the Danish country report).

Estonia

During last 20 years the feeding and the condition factor of eel in L. Võrtsjärv have been studied. The data will be provided to the EEQD.

France

Some data on PCBs and heavy metals in yellow and glass eel were made available from the Gironde and Adour basins, and will be included in the EEQD.

Germany

Concentrations of pollutants/contaminants in the musculature of eels from the river Elbe have been measured by the Elbe River Water Quality Board (ARGE ELBE) in 1999 and 2000 (e.g. ARGE ELBE 2000). Along the entire German length of the Elbe, contaminant levels were measured in excess of the maximum allowable levels. This was particularly evident for HCB (hexachlorobenzene) content. Occasionally, maximum levels were also exceeded for other contaminants, e.g. DDT. The most recent publication from the ARGE Elbe (ARGE ELBE 2008) provides data on concentrations of contaminants for eels from the river Elbe from a location close to the border to the Czech Republic in 2005 and 2006. Concentrations of mercury have remained rather constant (around 0.25 mg/kg wet weight), whereas the values for cadmium demonstrated a decreasing tendency (<0.008 mg/kg w. w.). Several PCB's had constant levels or a slightly decreasing tendency. Clearly decreasing values were observed for HCB (from 1.8 mg/kg Fat in 2001 to 0.56 mg/kg Fat in 2006). However, HCB-concentrations are still on a critical level.

The data are provided in detail for inclusion into the quality database. The reports from the Elbe River Water Quality Board are available at www.arge-elbe.de.

Concentrations of PCB's and dioxins were clearly below the maximum allowable levels in eels from the Baltic Sea (Bladt, 2007, cited in Karl, 2008). Mean values were 7.4 ng/kg w. w. for dioxin/dl-PCB.

Ireland

Some samples have been taken in 2005 and 2007 and these have been analysed for contaminants (PCBs, dioxins, BFRs) and presence of *Anguillicola* (included in the EEQD).

Italy

Only incidental samplings within specific research projects have been performed in the past and examined contaminants loads, eel condition and fat levels. Some recent data based on available information has been provided to the database. Some analyses for contaminants in relation to human or veterinary health have been monitored by official sanitary or veterinary services, but no information is ever made available, and it's most likely that only scattered sporadic samplings have taken place.

Latvia

No contaminant analysis is undertaken.

Lithuania

No contaminant analysis in eel is currently undertaken; however analyses are performed for other species. Lithuania will propose to analyse contaminants and fat levels in eels in future.

Netherlands

There is a long dataseries for bioaccumulation of contaminants in eels is available from the Netherlands, where a monitoring network for PCBs, OCPs and mercury in eel is in place since the 1970s.

This year, no new information about contaminants in the Netherlands was provided.

Norway

Data on PCBs and pesticides from 1996 and 2000 were provided during the WGEEL 2007 session for inclusion in the database.

An extensive set of data of contaminants in eels from 1970 onward from southern Norway is available at the NIVA institute. Data will be incorporated in the database as soon as possible.

Poland

In 2008 research on several factors influencing quality of eel was made in the Sea Fisheries Institute in Gdynia. Samples of eel were collected during autumn 2007 and spring 2008 in Vistula Lagoon and Szczecin Lagoon. Number and size of fish collected are in Table PL.H

In the laboratory chemical examinations were made on:

- fat contents,
- dioxins, furans and dl-PCB’s
- heavy metals: Cd, Pb, As, Cr, Ni, Hg.

Results of heavy metals and PCDD/F and dl-PCB’s were compared to maximum allowable values obligatory in UE and described in Regulation (EC) 18881/2006 and assessed to classes described by Belpaire and Goemans, 2007. The results were also compared to maximal values given in FAO Fisheries Circular No 825, 1989.

Resulting data of those all examinations were supplied to ICES WGEEL database.

Fat contents

Values of fat contents ranged from 15,1% to 31,4% with mean 15,1% ±5,46. There was observed slight tendency to increase fat contents with increase of eel length.

Heavy metals contents

It was found that presence of all heavy metals, of which contents in the food is limited in EU countries, was much lower in eel tissue comparing to allowed levels given in EU regulations.

The maximum contents of those metals in eel ranged from 2% (Cd) to 22,5% (Hg) of allowed values. In case of Ca, Pb and Cr all samples were classified as Class I, according to As as Class II, and according to Ni and Hg as Class I or II.

PCB’s contents

It was found that according to majority of indicative congeners, all samples were of class I or class II. According to sum of six indicative PCB’s six of seven samples were qualified as class I. Comparing results to very restrictive German regulations it was found that in none of samples allowed limits were not achieved.

Results of eel samples were also compared to samples from herring, sprat, flounder, cod and salmon. Sum of seven indicative PCB’s expressed as μg/kg of tissue in case of eel was comparable to those of salmon and higher in case of rest of species.

Chloroorganic pesticides

In case of HCB four of seven samples were classified as class I and three others as class II. In case of ∑DDT four samples were classified as class I, two as class II and one as class IV. None of samples exceeded limits of ∑DDT 4 and HCB given in FAO Fisheries Circular No 825, 1989.

Dioxin-like-PCB's

In all samples the dominating congener among non-*orto* PCB's was congener penta-PCB 126, which demonstrated highest toxicity in that group, and dominating congener among mono-*orto* PCB's was congener 118.

Dioxin/furans (PCDD/Fs)

In most of samples concentration of PCDF was twofold higher than PCDD concentration, except sample no WTN1, where both concentrations were similar. In none of samples was found exceeding of limits PCDD/F nor sum of PCDD/F and dl-PCB's.

In all samples highest share of total toxicity constituted non-*orto* PCB's and that share was of 40–50% depending on sample.

Portugal

At national level several eco-toxicological studies using eels from different catchment areas have been published, e.g.: Aveiro lagoon (Ahmad *et al.*, 2006; Pacheco and Santos, 2001), Pateira de Fermentelos (Ahmad *et al.*, 2006; Maria *et al.*, 2006; Teles *et al.*, 2007) and Minho, Lima, Douro rivers (Gravato *et al.*, 2007). Information about trace metals in several fish species of the Ria de Aveiro, including eels is also provided by Cid *et al.* 2001.

Information about trace metals in several fish species of the Ria de Aveiro, included eels is given by Cid *et al*., 2001 and PCB's in Minho River by Santillo *et al*., 2005. Neto, 2008 analysed and compared Cd, Cu, Pb and Zn concentrations in muscle and liver of eels and sediment of the Tejo estuary.

Spain

Although there is not any specific survey to analyse the presence of contaminants on eel, eel is sometimes among the species included in the biomonitoring of water masses made by the public administrations. Additionally, in some studies that evaluate the contamination in the biota, the eel is among the studied species. In this way, information regarding PCBs, pesticides and heavy metals bioaccumulation in eels from rivers of the Basque Country (Sanchez *et al*., 1998), from the river Ebro (Santillo *et al.*, 2006), river Miño (Santillo *et a*.,. 2006), river Jucar (Bordajandi *et al*., 2003) and river Guadalquivir (Usero *et al*., 2003) is available. Few studies represent a specific survey to analyse the presence of contaminants in eel, as heavy metals determination in eels from the Albufera lacuna (Alcaide and Esteve, 2007). These authors concluded that among the tested HM. bioaccumulation of Cd, Hg, Zn, and Cu in liver tissue is related to the age/length of individuals [W and B values; $p \leq 0.01$] and so recommendations are remarked on standardization on length and/on age of the eels used in such studies (Alcaide and Esteve, 2007). On the other hand, Ureña *et al*., 2007 concluded for the same location of the latter study that the eels with similar length demonstrate different pattern of metal distribution among tissue depending on there are from the wild or farmed.

Sweden

The National Food Administration in Sweden has analysed both yellow and silver eels sampled in 2000 and 2001 from nine different sites in Sweden with respect to 17 dioxins and furans and 10 dioxin-like PCB congeners (www.slv.se). Pooled samples demonstrated that eels had less than 1 pg TEQ/g fresh weight of sum TCDD/F in muscle (TEQ = Toxic Equivalents, TCDD = $C_{12}H_4O_2Cl_4$). To this came about 3.8 pg PCB-TEQ/g fresh weight. Silver eels had higher levels than yellow ones. Compared to the other fish species analysed, eels have a higher ratio of PCB to dioxins. Due to the high costs for this type of analyses only few eels will be sampled regularly in future.

Recently yellow eels from the Sound (between Sweden and Denmark) outside a heavily loaded industrial area in Helsingborg were analysed for dioxins and dioxin-like PCBs. Pooled samples from 2005 contained 5.7 WHO-PCDD/F-TEQ pg/g and 11 WHO-PCB-TEQ pg/g, both based on fresh weights. In 2006 another five pooled samples from the same area were analysed. The dioxins varied between 0.9 and 4.7 with an average of 2,2 WHO-PCDD/F-TEQ pg/g. The PCBs varied between 3.9 and 12.7 with an average of 6,6 WHO-PCDD/F-PCB-TEQ. At some sites the level of dioxins in eel muscle exceeded by that the 4 p/g level of dioxins or the 12 pg/g level of summed up dioxins and dioxin-like PCBs, set as maximum allowed levels in eel by the Commission of the European Communities. In 2007 further samples were analysed from this area. Both yellow and silver eels were analysed in seven pooled samples. The dioxin levels varied between 0,6 and 2,7 pg/g and the summed up dioxins and dioxin-like PCBs between 2.3 and 8.3 pg/g, i.e. all below the maximum allowed levels. However, the sample sites were not exactly the same as in 2005 and 2006 (Source: SLV (The National Food Administration)).

Recent analyses of mercury (Hg) in eels from a number of lakes did demonstrate very low levels.

UK

Recent surveys investigating concentrations of most metals including mercury, arsenic, cadmium, chromium, copper, lead, nickel and zinc, Poly-chlorinated biphenyls (PCBs), Dichloro-diphenyl-trichloroethanes (DDTs), Hexa-chlorocyclo-hexanes (HCHs) and Aldrin and Endrin ('Drins) found they had decreased substantially in eels from Sussex rivers between 1994–1995 and 2005–2006 (Foster and Block, 2006). The EU regulation limit of 8 pg/g of dioxin-like PCBs in eels was significantly exceeded for the dioxin-like PCB-118 at 100% of sampled sites in 1994–1995 and 2005–2006. Current levels of dioxin-like contaminants in eels in Sussex rivers are higher than those necessary to impair survival of fertilized eel eggs (Palstra *et al.*, 2006). Whilst Northern Ireland has the largest eel fisheries in the UK no contaminant analysis of eels is undertaken. However, from 2006 samples of silver and yellow eels from Lough Neagh are now routinely monitored for lipid content.

England and Wales

Concentrations of most metals including mercury, arsenic, cadmium, chromium, copper, lead, nickel and zinc, Poly-chlorinated biphenyls (PCBs), Dichloro-diphenyl-trichloroethanes (DDTs), Hexa-chlorocyclo-hexanes (HCHs) and Aldrin and Endrin ('Drins) decreased substantially in eels from Sussex rivers between 1994–1995 and 2005–2006 (Foster and Block, 2006). In 2005–2006 more eels were in the low to moderate risk bands (to people) and fewer eels were in the high risk band for PCBs proposed by the Oslo and Paris Commissions. The EU regulation limit of 8 pg/g of dioxin-like PCBs in eels was significantly exceeded for the dioxin-like PCB-118 at 100% of sampled sites in 1994–1995 and 2005–2006. Current levels of dioxin-like contaminants in eels in Sussex rivers are higher than those necessary to impair survival of fertilized eel eggs (Palstra *et al.*, 2006).

Northern Ireland

No routine sampling undertaken but available by request.

Scotland

No assessments of contaminants in eels have been undertaken in Scotland.

Parasites/pathogens: overview by country

Belgium

Since WGEEL, 2006 no new information is available on *Anguillicola* in Belgium. *Anguillicola* infection rates were monitored in 1987, 1997 and 2000 in which year 139 of 140 sites had the infection. The high infection level in Flanders is thought to be the result of restocking with glass eel and yellow eel, both of which are susceptible to *A. crassus*. For distribution maps of the parasite, see Belpaire, 2006 or Audenaert *et al.*, 2003. Previous studies into endoparasitic helminth communities of eel have been undertaken (Schabuss *et al.*, 1997).

Canada

To avoid parasite transfers, screenings are routinely done for elvers caught in Nova Scotia and southern New Brunswick before their stocking in fresh-waters locations in the upper St-Lawrence River and estuary. Screenings for viruses (IHNV, ISAV, IPNV and EVH) and *Anguillicola crassus* in individuals prior to stocking were negative during these years. During summer 2006 and 2007, 914 yellow eels were collected from 17 sites in the Maritime provinces, Québec and Ontario and *Anguillicola crassus* was found for the first time in the country. This swimbladder parasite is now present in New Brunswick and Nova Scotia (Antigonish and Cape Breton) (Ken Oliveira, University of Massachusetts, pers. comm.).

Denmark

Anguillicola crassus was discovered in Danish wild eels in 1986. Since 1988 a monitoring programme on the abundance of the parasite in the eel population in different fresh and brackish water bodies has been continued annually.

Estonia

Since 1992 the intensity of *Anguillicola* infection in the eel population of L. Võrtsjärv has been studied. The data will be provided for inclusion in the EEQD.

France

No new information from France was made available.

Germany

Detailed information of *Anguillicola crassus* has been provided in WGEEL, 2007. Monitoring has been established at the rivers Elbe and Weser and Ems, which are all important rivers for eel. For this monitoring, commercial fisher collect eel swimbladders from commercial catches on a weekly basis. As a consequence, no data on length or weight of the fish are available.

Generally, the prevalence in eels from German waters appears to be between 80% and 90% (Knösche *et al.*, 2004; Lehmann *et al.*, 2005; Leuner, 2006; 2007; Lehmann *et al.*, 2007). Lehman *et al.*, 2007 also reported the presence of *Trypanosoma granulosum* in more than 90% of all investigated eels from the Rhine system.

The German country report presents more details with data of monitoring of infection of eels from the Rivers Weser, Elbe and Ems with *Anguillicola crassus.*

Ireland

Anguillicola crassus was first recorded in Irish eels in the Waterford area in 1997. They were subsequently recorded in the Erne (see below) and this invasion probably occurred between 1997 and 1998, as they were apparently absent in 1996 (Copely and McCarthy, 2005). *Anguillicola* has now also spread to the R. Shannon (McCarthy and Cullen, 2000). A summary of the known distribution of *Anguillicola* in Ireland was compiled in 2003 (McCarthy *et al.*, in press) and the database is currently being updated, following discovery of the species in small and reputedly unexploited western Irish catchments. Current information would indicate that *Anguillicola* is now present in approximately 50% of the wetted area in Ireland, see map and Figure I.1 in the Irish country report.

Investigations of parasites assemblages of eels in marine, mixohaline and fresh-water habitats in the Shannon and other Irish rivers are being undertaken by the National University of Ireland, Galway, as part of a research project funded by the Higher Education Authority (HEA PRTLI-3).

Annual surveys of yellow and silver eels in the Shannon fisheries, undertaken since 1992, demonstrate that *Anguillicola* was first detected in 1998 at Killaloe and that since then it has become well established in the lower catchment and that it has more recently spread to lakes further up in the river system.

Eight parasitic endohelminth worm species (2 Cestoda, 3 Nematoda and 3 Acanthocephala) were found in the intestines of 1089 brown eel examined from throughout the Erne system, 1998–2001. Of greatest concern was the discovery of the pathogenic blood-sucking nematode *Anguillicola crassus* in the swimbladder of brown and silver eel from the Erne.

Initially detected in the R. Barrow in 1997, the parasite has since spread to the lower reaches of the R. Shannon and was first recorded from brown eel in southern Lower Lough Erne in 1998 (Evans and Matthews, 1999). By 1999 the parasite was detected as far upstream as L. Garadice with 90% of brown eel from the Narrows, Lower L. Erne is infected.

Anguillicola has not been recorded to date in Burrishoole.

Preliminary analysis of information available on the presence of *Anguillicola* in different catchments would indicate that approximately 50% of the wetted area is now potentially infected by the parasite (Figure I.1).

Italy

Among the samplings and examinations performed within specific parasitology research projects, the presence of *Anguillicola crassus* has occasionally been examined but no eel specific monitoring is in place. The infection is widespread throughout Italy but temporal variations in infection parameters have been noted.

Latvia

There is no new information from Anguillicola in Lithuania.

Lithuania

There is no new information from Anguillicola in Lithuania.

Netherlands

No new information from *Anguillicola* in the Netherlands was provided.

Norway

Infection of eels from the river Imsa by *Anguillicola crassus* was first reported in July 2008. In total seven out of 22 silver eels contained the parasitic nematode *Anguillicola crassus* in their swimbladder, therefore a prevalence of 32%.

All eels were female and at the silver migrating stage. Infected eels tended to be bigger in length and weight, but their condition factor was not significantly different (Mann-Whitney test, P=0.934). Two eels contained mature worms filled with eggs, in their swimbladder. Small and medium sized worms were also found.

Poland

During recent fishery surveys in the Vistula Lagoon eels were analysed by SFI for stomach fullness, and presence of *Anguillicola crassus* in the swimbladder. In 2006, 190 eels were inspected and infection rate indicated almost 90% were infected.

The most recent data on occurrence of parasite *Anguillicola crassus* in eel of Polish waters was collected in 2007–2008, however, some earlier data are also presented.

Data were collected and calculated according to three categories:

- Prevalence-proportion between infested eel and number of eel in sample.
- Mean intensity of infection-mean number of parasites per one infected eel.
- Density-mean number of parasites per one eel in sample.

The range of prevalence varied from 0,0 in Szczecin Lagoon in 1971 to 100,0 in Lake Łebsko (2001, 2004).

Intensity of infection varied from 0,0 in Szczecin Lagoon in 1971 to 14,6 in Lake Łebsko (2007).

The density varied between 0,0 in Szczecin Lagoon (1971) to 9,4 in Lake Jamno (2007).

In 2007–2008 total of 168 samples of eel were collected from 15 places of rivers, lakes and lagoons in both RBD's, namely Vistula and Odra. Those samples were examined on presence of viruses EVEX, AgHV-1, VHS, IHN, SVC and IPN. All examinations were made in the Department of Pathology and Immunology of Inland Fisheries Institute in Olsztyn.

Portugal

Anguillicola crassus is present in several regions but no standard monitoring programmes have been established to examine its distribution. Different works dedicated to eel parasites are available:

- Nematoda-Ria de Aveiro (Cruz *et al*., 1992), Douro River catchment (Saraiva *et al*., 2002; Saraiva *et al*., 2002).
- Intestinal Helminth communities-Lima, Cavado, Ave and Douro catchment areas (Saraiva *et al*., 2005).
- Protozoa-Âncora, Lima, Cávado, Douro and Tejo catchment areas (Carvalho-Varela, 1984; Cruz and Davies, 1998; Cruz and Eiras, 1997).

- Parasite fauna in general including *Anguillicola*-Minho River catchment (Antunes, 1999; Aguilar *et al*., 2005; Hermida *et al*., 2006), Tejo river estuary (Neto, 2008), several rivers (Saraiva and Molnar, 1990; Saraiva, 1994, 1995, 1996; Saraiva and Chubb, 1996; Saraiva and Eiras, 1996; Rodrigues and Saraiva, 1996; Cardoso and Saraiva, 1998).

Spain

Some studies have been carried out regarding the presence of *Anguillicola crassus* in rivers from Spain (See Table. ES.j. in the Spanish country report). These studies have demonstrated that the parasite is widespread in Spain. However, there are still some rivers **in Asturias** and **Galicia** that have not been colonized yet; therefore special measures should be taken to avoid the infection of these basins. It is difficult to follow the sequence of *A. crassus* introduction in Spain since the first data we have is from 2000 and probably the nematode arrived before that data. However, it looks like in the Mediterranean the presence of the parasite is lower than in the Atlantic (lower prevalence, intensity and abundance). In the **Basque Country**, comparing the results of Gallastegi *et al*., 2002 in the Butron in year 2000, with those of Díaz *et al*., 2007 in the Basque rivers in 2006, we can see that there is an increase in the prevalence of the parasite, but that the infection intensity has decreased.

Researchers of the University of Valencia have studied the incidence of infectious diseases in the Albufera´s eel population (Jucar basin, Valencia), through a 3-years period (from October 2003 to July 2005. They analysed 122 individuals of different growth stage (Durif *et al*., 2005) and health condition and observed that eels suffer from acute diseases such as those produced by highly virulent bacteria belonging to *Edwardsiella tarda* and *Vibrio vulnificus* species (Alcaide *et al*., 2006; Esteve *et al*., 2007; Esteve and Alcaide, 2007). *Edwardsiella tarda* disease was present along the study period with a prevalence ranging from 5.6 to 27.8% in the nine surveys performed (Esteve and Alcaide, 2007). *Vibrio vulnificus* disease had a sporadic incidence during the study; it was detected in November 2003 with a very high prevalence of 77.2% (Esteve *et al*., 2007). In addition, chronic and mixed infections caused by weakly virulent bacteria (*Aeromonas* sp. and *Pseudomonas* sp.) and fungi (*Saprolegnia* sp.) were observed along the study period with a prevalence ranging from 10.5 to 22.2% in the nine surveys performed (Esteve and Alcaide, 2007). In fact, authors remarked that pathogenic bacteria may play a leading role in the decline of Albufera´s eel population as the prevalence of each bacterial disease was at the same level than that observed for the swimbladder parasitic disease (Esteve and Alcaide, 2007).

Interestingly, the correlation between the sanitary status of an eel [Healthy; Acute bacterial disease; and Chronic disease] and its growth stage [Young Yellow; Sexually differentiated Yellow; and Mature Silver] was statistically significant: observed number of both "young yellow eels which present acute bacterial disease" and "silver eels which present chronic illness" notably exceed those expected [Pearson X^2= 10.812; *P*(4 d.f.)= 0.029] (Esteve and Alcaide, 2007). Thus, authors suggested that youngest eels could suffer high mortality rates in the natural habitat (Albufera lacuna), and that low quality of mature adults could reduce their survival along the downstream migration to the sea.

Sweden

The swimbladder parasite (*Anguillicola*) does occur in eels from most sites. All eels dissected at the Swedish Board of Fisheries are analysed macroscopically for the prevalence (at both Institutes involved) and intensity (at the Institute of Freshwater Research only) of *Anguillicola* in their swimbladders. The prevalence in coastal waters in 2002–2005 was close to 10% in the marine habitats of RBD 5 and about 60% in the central parts of RBD 4. The straight between Sweden and Denmark (Öresund, SD 23) took an intermediate position.

Prevalence of *Anguillicola crassus* is a mandatory variable in all coastal sampling of eel in Sweden, including the DCR sampling. The rate of infestation in the pooled data from 2002–2006 was less than 15% in the most marine areas, 47% in Öresund and close to 60 in the Baltic sites.

Between 2000 and 2008 the Institute of Freshwater Research analysed 3608 eels from 41 different fresh-water sites. Infested eels were found in all sites and the prevalence varied from 37% to 91%. Data have been presented for inclusion in the EEQD.

UK

England and Wales

Anguillicola crassus is now considered ubiquitous throughout the UK (Nigel Hewlett, Environment Agency National Fisheries Laboratory, pers. comm.). Foster and Block, 2006 reported infestation levels in eels (~300 mm total length) sampled across the Sussex area in 2005–2006 ranging from 60% to 88% (regional mean 72%). Similar levels of infestation were reported for eels in Kent rivers in 1996–1998 (Cave, 2000).

In October 2007, 50% and 83% of eels from the River Thames (respectively the estuary and the fresh-water part) were infected *A. crassus.*

On 30 elvers examined from UK glass eels (Gloucester, April 2008) low level granulomas were present in kidney region of one elver. In 30 elvers examined from River Severn at Maisemore (April 2008) occasional trichodinids were found on the gills.

A. crassus was found in small numbers in 23% of fish (n=30) from tidal River Thames (June 2008); also P. laevis found in small numbers in 7% of fish.

A. crassus was found in small numbers in 73% of fish (n=30) from Roman River (July 2008);

Eight eels were examined from Southern Leisure Lake (August 2007)-*A. crassus* was recorded in the swimbladder and kidney, *Myxobolus* sp. in fins and nematodes likely to be *Daniconema anguillae* in the muscle. Significant pathology was recorded in the gills of the fish examined, indicative of a water quality problem. Bacterial examination returned negative results. Virology testing was also negative for the presence of Infectious Pancreatic Necrosis (IPN) and Eel Rhabdovirus.

Northern Ireland

L. Erne

Anguillicola crassus was first recorded in the swimbladders of eels in Ireland during an extensive fykenet survey of the Erne system in July 1998. Of 328 yellow eels examined in 1998, 24 (7.3%) were infected, with a mean intensity of 4.3 worms per eel. Infected eels were only recorded in southern Lower Lough Erne and northern Upper Lough Erne. Examination of 432 yellow eels in 1999, demonstrated an increase in both mean intensity (6.7 worms per eel) and prevalence (9.9%) of *A. crassus*. The range of the parasite had also increased, with infected eels recorded from the lower reaches of the Erne, 30 km downstream of the original area of infection. Monthly samples of silver eels taken by commercial nets near the outlet of the Erne during October–December 1998 and 1999 confirmed active migrants contained the parasite.

Prevalence and mean intensity among silver eels rose from 4.5% and 2.5 worms per silver eel in 1998 to 15% and 8.6 worms per eel in 1999 (Evans *et al*., 2001).

L. Neagh

A. crassus was found in Lough Neagh yellow and silver eels for the first time in 2003, and its spread has been monitored via the analysis of a total of 1100 yellow and 400 silver eels from 2003 to 2006. Samples were stored in 70% alcohol and in the lab; swimbladders were examined macroscopically for the presence of pre-adult and adult *A. crassus*, but not for larval *A. crassus*. Recorded prevalence and mean intensity in yellow eels rose from 24.4% and 2.2 in 2003 to 69% and 3.6, and to 100% and 7.7 in 2004 and 2005, respectively. However, the same infection parameters recorded for silver eel were significantly different, with almost 60% infected in 2003 rising to almost 90% in 2004. By 2005, 100% of yellow and silver eels were found to be infected with *A. crassus* (Evans and Rosell, 2006). In 2007 the prevalence of *A. crassus* in both yellow and silver eels had fallen to 70% and 76%, respectively.

Scotland

There is to date only a single reported instance of *Anguillicola crassus* in Scottish RBD (Lyndon and Pieters, 2005), for a fish farm near Bridge of Earn, on the Tay system. However, the absence of targeted effort on the identification of *A. crassus* in the Scottish RBD may have led to under-recording. The parasite is currently being sought in eel samples collected in the catchments of central Scotland, and there is an unconfirmed report of an infected eel from the Forth (Willie Yeomans, pers. comm.). However, the likelihood is that *A. crassus* is not sufficiently widespread as yet in Scotland, as a consequence of low levels of stock transfer, to have had possible impacts on eel populations.

Annex 6 – Draft WGEEL terms of reference 2009

2008/2/ACOM15 The **Joint EIFAC/ICES Working Group on Eels** [WGEEL] (Chair: Russell Poole, Ireland), will meet in ICES, 9–15 September 2009, to:

a) assess the trends in recruitment and stock, for international stock assessment, in light of the implementation of the Eel Management Plans;

b) Evaluate the EU eel management plan;

c) develop methods to post-evaluate effects of management plans at the stock-wide level;

d) develop methods for the assessment of the status of local eel populations, the impact of fisheries and other anthropogenic impacts, and of implemented management measures;

e) establish international databases on eel stock, fisheries and other anthropogenic impacts, as well as habitat and eel quality related data, and the review and development of recommendations on inclusion of data quality issues, including the impact of the implementation of the eel recovery plan on time-series data, on stock assessment methods;

f) review and develop approaches to quantifying the effects of eel quality on stock dynamics and integrating these in stock assessment methods;

g) respond to specific requests in support of the eel stock recovery Regulation, as necessary; and

h) report on improvements to the scientific basis for advice on the management of European and American eel

WGEEL will report by 22 September 2009 for the attention of ACOM and DFC.

Annex 7 – Technical minutes Eel Review Group 2008

- RGEEL
- By correspondence 29–30 October 2008
- Participants: André Forest (Chair), Russell Poole (WG Chair), Martin Castonguay (Canada), David Cairns (Canada), Dietrich Schnack (Germany), Maris Pliskhs (Latvia), Henrik Svedäng (Sweden).
- Working Group: WGEEL

General comments

This is a comprehensive, informative and well organized report. It is at the same time highly educational, as it includes a great amount of basic scientific background information for a good understanding of the specific problems related to the assessment of an eel stock. However, the report is clearly a result of an ongoing process that started years ago, and therefore does not present a comprehensive overview but should be read in conjunction with previous reports.

A great deal of emphasis is put on various risks of impaired reproduction and similar ecosystem based considerations but no data were presented on neither population dynamics nor the fisheries and a section dedicated to the fishery is not included. At least some studies aiming to describe fishing mortality and efforts have been performed over the years; these should be referred to.

The main message is that the eel stock is in a very poor state since many years, and this is consistent with the previous report. Obviously, securing fish with the highest fitness should be a top priority given the low recruitment, i.e. a ban on silver eel fishery is the quickest and safest measure to protect the European eel stock from a final and total collapse. The possibility that the effective spawning biomass is lowered due to parasite loads and contaminants, underscores the necessity of reducing the fishing pressure in both the short and long term perspectives as well as improving the habitat conditions.

The WG group has put a lot of effort to summarize available information on eel ecology (predation, mortalities), possible anthropogenic impacts, etc. There is listed a very wide range of possible measures that have to be taken into account, but a judgement of the potential efficiency or relative value of these measures is missing; so there is no basis for ranking the measures giving no guidance to the managers.

A certain number of questions were posed by the Review Group in 2007, but the majority remains unanswered.

Section 2 Trends in recruitment, stocking, yield and aquaculture

Landings

Existing data should be very or more(?) thoroughly analysed as it is probably the best indicatives on what is going on regarding the SSB (NB: increased catchability due to technological creeping).

Recruitment

Some observations concerning recruitment and stock size are overstated whereas others are neglected or considered to be of less importance without any obvious reason (for instance, commercial cpue series on glass eels fishery have been given greater weight than non-commercial series on yellow eel upstream migration).

Annex 3 includes the data basis for presenting trends in recruitment for different European rivers (Figures 2.1 and 2.2.), and defines also the different measures that have been used. It is however not clearly defined, how the "all countries" line has been obtained. It seems to be the geometric mean of the scaled data from the individual systems, but this should be mentioned in the heading of the table and the legend of the Figure.

The trend analysis on the commercial glass eel indices should have as a starting year when most if not all indices were running, i.e. about 1970. Otherwise, great weight is given to a few fishery-dependent catch records. It is also questionable why fisher-dependent data are given greater emphasis than upstream migration of yellow eels. The Göta älv index is a strong indication on a decline in recruitment already in the beginning of the 1950s, 30 yrs before such a decline was recognized in the commercial cpue time series. The Göta älv index and similar evidence from the Baltic region is now presented as a problem for this region and its data collection as two rather irrelevant hypotheses are put forward. The thing is that the recruitment decline in this region that began already in the 1950s, and the subsequent fall in the silver eel fishery in the Baltic Sea about a decade later fit strongly together. Moreover, the indices from the Mediterranean are similar to the Baltic development. This observation points at a declining recruitment (due to decline in SSB?) occurred much earlier than the 1980s, as it is reasonable that a fall is detected in the periphery of a species distribution rather at the core (i.e. the Celtic arc).

In Chapter 2.2.1 (and several other places where a corresponding summary is given) it is stated that "the decline is stronger in northernmost and southernmost area of the species distribution than in the central part". This cannot be seen from the data presented. The Baltic Sea and North Sea river systems are not more northern than the British Isles systems and the Mediterranean systems are hardly more southern than the Atlantic systems indicated in Figure 2.11. The decline is stronger in the more eastern areas or least in the more western areas, i.e. at the Atlantic cost.

In Figures 2.1 and 2.2 the scaling is done relative to the average over the period 1979–1994, whereas in all later figures the reference period is 1970–1979. Is there any reason to not use the same reference period for the scaling of the trend data?

Figure 2.5 compares eel landings from country reports with data from FAO. It would be helpful to receive some information on the time periods compared in each case and to include some comment on the possible reasons of major discrepancies in some cases.

In Figure 2.6 the legend for non-commercial catches does not show up.

In Chapter 2.2.2 (and corresponding summaries) it is argued that "we can thus build an index of recruitment of all Europe … calculated as the geometric mean of each of the monitoring indices" (based on different sampling methods). This argument is not convincing. It has been pointed out that the recruitment index is different among areas and also that sampling types are largely specific for the individual areas; thus each method is not representative for all Europe and any mean from all methods may not be expected to be representative for all Europe as well. Thus, it could be suggested presenting even in a summary the range of recruitment levels of 1–10% compared to the period 1970–1979, obtained for the different areas. It can also be stated that in all areas apart from the Atlantic coast the lever is below 5%.

Section 3 International stock assessment and data needs

In Chapter 3.3.3 it is argued that "the intervals in the reporting cycle under the EU Regulation are far too long to enable any rapid progress by WGEEL". It may sound like a contradiction to the statement given before that the restoration process for the eel stock will take decades. It may be important to state that to get an international assessment started and supported by adequate data, a yearly availability of data would be necessary, though on a long run assessment could perhaps be arranged on a multiannual scale.

Last sentence in second paragraph of Chapter 3.3.8 seems difficult to understand. Also the message of the last paragraph of Chapter 3.4 is not obvious.

Section 4 Assessing stocks and management actions

Table 4.1 is not readable.

Chapter 4.4: Achieving a reasonable estimate of the total spawning stock biomass appears to be a rather difficult and demanding task for the eel stock. It could be asked, if it has ever been thought of carrying out regular larval surveys in the Sargasso Sea to receive an index of effective spawning stock size? This would be rather demanding as well, but compared to the effort required for receiving an estimate of the total effective spawning stock size on the basis of silver eel escapement (if at all possible with sufficient reliability), the effort for a larval survey campaign e.g. every 3 years may not be too unrealistic. This would provide an index completely independent of all other methods and could allow at the same time to develop research programmes on the oceanic phase of the species.

Section 5 Stocking and aquaculture

Stocking

The effectiveness of using stocking of glass eels/ elver/ yellow eels as a way of handling the eel decline is debatable:

(a) Compiled data in the report quite effectively demonstrates the low rewards from already performed stockings, even on a regional scale. In spite of intense stockings in the 1960s in East Germany and Poland in the Baltic Sea region, the yield in the Danish and Swedish eel fisheries declined in the 1970s,

(b) The most important objection is the still unknown fate of translocated eels in terms of ability to return to their natal spawning area(s). There is some evidence that eel for instance removed from Western Europe to the Baltic Sea do not find their way back at spawning, whereas no data support the opposite.

(c) Unless the fishery on yellow and silver eel is completely stopped, there is an apparent risk of rather boostering the eel fishery, i.e. increasing the fishing pressure on those individuals that are naturally recruited. Accordingly, it should be stated crystal clear that stocking is NOT an option but a cul-de-sac unless it can be proved that the navigational skills of the stocked eels are as good, or at least almost as good, as the ability of the naturally recruited ones. It may be considered, however, that in cases where eels are so depleted that a river basin is at risk to fail completely in contributing to the spawning population, stocking might be used as a last resort, provided that a surplus of glass eels is locally available. In such cases, procedures to prevent the introduction and spreading of parasites and diseases according to the European fish disease prevention policies have to be applied.

In conclusion, the contribution of translocated eels to SSB is not known; this means that it might be nil, but it could as well have a positive effect. This chance, thought uncertain, should be utilized as a last resort in case it does not conflict with other demands and where an adequate river basin is otherwise depleted from eel.

Section 6 Eel quality

Section 7 Ocean climate and recruitment

Section 8 Research needs

There is listed of very wide range of additional research required in order to fill many gaps in the biology, stock assessment, post-evaluation of management actions, etc. However these proposals are not prioritised and as money will be a limiting factor for research in the future, a clear ranking of research needs as basis for management advice is imperative.

Annex 8 – Country Reports: Eel stock and fisheries reported by country – 2008

In preparation to the Working Group, participants of each country have prepared a Country Report, in which the most recent information on eel stock and fishery are presented. These Country Reports aim at presenting the best information, which does not necessarily coincide with the official status. This Annex reproduces the Country Reports in full detail.

Participants from the following countries provided an (updated) report to the 2008 meeting of the Working Group:

- Norway
- Sweden
- Finland
- Estonia
- Latvia
- Lithuania
- Poland
- Germany
- Denmark
- The Netherlands
- Belgium
- Ireland
- The United Kingdom of Great Britain and Northern Ireland
- France
- Spain
- Portugal
- Italy
- Canada

For practical reasons, this report presents the country reports in electronic format only, available at: http://www.ices.dk/reports/ACOM/2008/WGEEL/Country_reports_2008.pdf In the printed version, these can be found on an enclosed CD-ROM.

Report on the eel stock and fishery in Finland 2007

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Reporting period: This report was completed in June 2008, and contains data up to 2007.

FI.B. Introduction

In Finland eels are on their North-Eastern limits of natural geographical distribution. Natural eel populations have probably always been very sparse, and the overall importance of the species has been low. In fresh waters only in few areas in Southern parts of the country eel has been a target in the recreational fisheries. According to old fishers the catch and the importance of eel to local fisheries were still high in 1940–1960 in some parts of the Gulf of Finland, mainly in the estuary of the river Kymijoki and east of the city of Kotka. Also in Finnish Archipelago eel was a common species at that time. Almost all rivers running to the Baltic are closed by hydroelectric power plants. Natural eel immigration is possible only in few fresh water systems near the coast and in the coastal areas of the Baltic. Eel populations and eel fisheries in Finnish inland waters depend almost completely on introductions and re-stockings (Table FI 1). Until now the most numerous introductions were made in the sixties and 1970s. Some 8 000 000 glass eels (originating France) and 700 000 elvers (Denmark, Germany) were introduced in 250 inland lakes and coastal waters (Pursiainen and Toivonen, 1984). During the years 1979–1988 it was not allowed to import eels because eel was detected to be a possible carrier of some viral fish diseases. For this reason it was decided in 1989 to carry on re-stockings only with glass eels reared in a careful quarantine. Since then 1 452 000 glass eels originating in River Severn in the UK have been imported through a Swedish quarantine and re-stocked in almost one hundred lakes in Southern Finland and in the Baltic along the South coast of Finland.

FI.C. Fishing capacity

There is no exact data available but for the professional fisheries eel is of no importance. Some semi-professional fishers may have minor income from eels mainly as a bycatch. Therefore the recreational fisheries mainly catch the eels. The number of recreational fishers in Finland is high (1.9 million out of 5 million) but only a very small portion of those catch eels as a main target (with fykenets, longlines, angling, spears, etc.). For most of the people eel is a surprising bycatch.

FI.D. Fishing effort

There is no exact data available.

Table FI 1. Eel stockings in Finland in 1961–2007 (number of individuals).

	Glass eels	Quarantined glass eels	Elvers
1961			53 000
1962			143 000
1963			
1964			83 000
1965			114 000
1966	1 077 000		53 000
1967	3 935 000		
1968	2 803 000		4 000
1969			35 000
1970			30 000
1971	no	introductions	allowed
1972	no	introductions	allowed
1973	no	introductions	allowed
1974	no	introductions	allowed
1975			38 000
1976			19 000
1977			30 000
1978	368 000		12 000
1979			75 000
1980-88	no	introductions	allowed
1989		9 700	
1990		58 840	
1991		108 515	
1992		102 450	
1993		105 000	
1994		103 500	
1995		216 600	
1996		74 580	
1997		82 200	
1998		77 550	
1999		62 500	
2000		61 015	
2001		45 500	
2002		55 000	
2003		0	
2004		63 500	
2005		64 000	
2006		55 000	
2007		107 000	
2008		120 000	

FI.E. Catches and landings

The re-stockings in the late sixties and in 1970s gave a catch of 60–80 tonnes a year at the end of 1970s and the beginning of 1980s (Pursiainen and Toivonen, 1984). Introductions and re-stockings ceased in 1979, which caused a radical reduction in the annual eel catch (Table FI 2). After the year 1986 the catch decreased to less than 20 tonnes a year. Therefore the eel was not detected as a species in the official statistics, but included into the group "other species". There is no data available on the present catch. Pursiainen and Toivonen, 1984 find out that 1000 stocked individuals/year in fresh waters in Southern Finland gave a catch of 90 kg/year about ten years later. Using the same figures the re-stockings in 1990s probably give nowadays a catch between 5–10 tonnes/year.

Table FI 2. Eel catches in Finland 1975–1987 (2005), x 1000 kg. The statistical data are collected and published by the FGFRI. The figures after 1987 are rough estimates by the writer.

	Marine fisheries		Freshwater fisheries		
Year	Professional	Recreational	Professional	Recreational	Total catch
1975	0	0	0	0	0
1976	4	15	2	7	28
1977	2	14	2	45	63
1978	1	14	2	60	77
1979	2	14	2	59	77
1980	2	14	3	60	79
1981	1	8	2	28	39
1982	1	8	1	28	38
1983	1	8	1	28	38
1984	1	4	1	22	28
1985	1	4	1	22	28
1986	1	4	2	22	28
1987	0	?	1	?	<20
1988-					<20 (?)
2007					<10 (?)

FI.F. Catch per unit of effort

There is no exact data available.

FI.G. Scientific surveys of the stock

No scientific surveys are carried out today.

FI.H. Catch composition by age and length

There is no exact data available.

FI.I. Other biological sampling

During 1974–1994 over 2000 eels were collected in thirty lakes and in some lake outlets in Southern Finland. Length, weight, eye diameter, colour of the sides and belly, sex and weight of the gonads (not always) were determined and after 1986 also swimbladders were examined for *Anguillicola*. Age and growth were also determined.

The aim of the study was to evaluate the biological outcome of eel stockings made in 1960s and 1970s and to estimate the yield to fishery and the proportions of eels escaping the lakes. The results were published mainly in 1980s (Pursiainen and Toivonen, 1984; Pursiainen and Tulonen, 1986; Tulonen, 1988; Tulonen, 1990; Tulonen and Pursiainen, 1992). The concentrations of radionuclides ^{134}Cs and ^{137}Cs and PCB in eels were also investigated (Tulonen and Saxen, 1996; Tulonen and Vuorinen, 1996).

There were no routine biological sampling programmes or eel research projects during 1994–2005. Some occasional samples were taken in few lakes on the author's personal interest. Also in some small water systems silver eel escapement has been monitored since 1974 (one place), 1980 (two places) and 1989 (two places) with eel boxes in the outlets. Eels in the lakes have been re-stocked there in 1967, 1978 and 1989 respectively. One sample of "natural" elvers has been collected in 2002 in South-West Finland and on the coast of the Bothnian Bay. One third of the elvers were infected with *Anguillicola*. This was the first time *Anguillicola* had ever been found in Finland (Tulonen, 2002).

In 2006 a four year study on the biological and economical outcome of eel stockings made since 1989 and on the state of natural eelstocks was established in FGFRI. In that study sampling is done in ten lakes in southern Finland and in eight areas in the Baltic along the coasts of Gulf of Finland and Bothnian Bay and in the rivers running into them. Due to sparse populations the sample sizes are still only in few cases big enough (>100 individuals) to make any scientific evaluations. Considering eel's low status for fisheries and low economic value in Finland, it is obvious that collecting data more effective is difficult.

FI.J. Other sampling

No other sampling is carried out at the moment.

FI.K. Stock assessment

There is no routine assessment of the stock.

FI.L. Sampling intensity and precision

There is no exact data available.

FI.M. Standardisation and harmonization of methodology

Nothing to report.

FI.N. Overview, conclusions and recommendations

1. In the ongoing study the present natural distribution of eel in Finland is going to be examined, and suitable "unused" growing areas are to be determined. These areas could be used as some kind of refuges for the European eel (slow growth, high survival, long period before silvering phase).
2. *Anguillicola* infection level should be investigated in the natural and introduced eel populations. Eel populations in Finnish fresh waters over the hydroelectric dams are probably mostly still uninfected. If *Anguillicola* is one factor in decreasing the number of spawners in the Sargasso Sea, these uninfected eels might have extra value in the future.
3. Stock surveys are carried out to find out the biological outcome of the stockings conducted since 1989. Natural and fishing mortality and espe-

cially recruitment of yellow eels to silver eels and the possibility of silver eels to reach the sea undamaged are going to be studied.

FI.O. Literature references

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Report on the eel stock and fishery in Ireland 2007/2008

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Reporting Period: This report was completed in August 2008, and contains data up to December 2007 and some provisional data for 2008. The recruitment trends and catch statistics have been updated for all years.

Contributors to the report:

- Eastern Regional Fisheries Board
- Southern Regional Fisheries Board
- South Western Regional Fisheries Board
- Shannon Regional Fisheries Board
- Western Regional Fisheries Board
- North Western Regional Fisheries Board
- Northern Regional Fisheries Board
- Marine Institute
- Central Fisheries Board
- Electricity Supply Board, Ardnacrusha and Ballyshannon
- Galway Fishery
- Dept. of Zoology, National University, Galway
- Dept. of Zoology, Trinity College Dublin

IR.B. Introduction

This report continues the sequence of reporting annual national eel data to the ICES/EIFAC Eel Working Group. In line with the requirements of the EU Eel Recovery Plan (Action Plan; COM 2003, 573: Regulation; COM (2005) 472) and the EU Data Collection Regulation for fisheries (Council Regulation 1543/2000 and Commission Regulations 1639/2001, 1581/2004) the National Eel Reports have now been restructured under the standard headings of the DCR. The EU has also recommended in the proposed regulation (COM (2005) 472) that Eel Management Plans be established and implemented on a Waterframework Directive River Basin District level and this report includes reporting catch data by Fisheries Region and by River Basin District.

IR.B.2 The Irish National programme

The Irish National Programme is conducted in close cooperation between the following organizations, although the details in relation eel and inland fisheries have yet to be established.

Department of Communications Energy and Natural Resources (DCENR)

DCENR is the main governmental department with responsibility for inland fisheries policy, management, control and enforcement.

Department of Environment, Heritage and Local Government (DEHLG)

DEHLG is the main governmental department with responsibility for core functional areas of environment, water and natural heritage, built heritage and planning, housing, local government and meteorological services and implementation of the Habitats and Waterframework Directives.

The Marine Institute (MI)

The MI is a semi-state marine research organization with national responsibility for the provision of scientific advice on eel and the collection of scientific data on the fisheries sector and the implementation of the module on evaluation of inputs, fishing capacities and fishing effort and the module of evaluation of catches and landings as defined in the Application regulation of EU Council Regulation 1543/2000.

A Bord Iascaigh Mhara (BIM-The Irish Sea Fisheries Board)

BIM is a semi state sea fisheries development agency charged by DCMNR with the collection of economic data on the marine fisheries sector.

The Central (CFB) and Regional Fisheries Boards (RFBs)

The CFB is a statutory body, established under the Fisheries Act 1980, operating under the aegis of the DCMNR. The principal functions of the CFB are to advise the DCMNR on policy relating to the conservation, protection, management, development and improvement of inland fisheries and sea angling, and to support, coordinate and provide specialist support services to the RFBs. The seven statutory RFBs are responsible for maintaining and improving environmental quality and developing and protecting the fisheries resource in their regions (Figure IR.1). Eel fishing licences and authorizations are issued on a Regional basis.

Electricity Supply Board (ESB)

ESB has a statutory role in preserving and developing the Shannon fishery, because the establishment of a hydroelectric scheme on the river when the government handed over all fishing rights to the company in 1935.

The Loughs Agency

The Loughs Agency aims to provide sustainable social, economic and environmental benefits through the effective conservation, protection, management, promotion and development of the fisheries and marine resources of the Foyle and Carlingford Areas.

IR.B.3 The Irish eel fishery

IR.B.3.1 Introduction

Glass eel and elver fishing in Ireland is prohibited by law (1959 Fisheries Act, Section 173) and its current government policy that fishing for juvenile eel may only be carried out under Section 18 authorization from the Regional Fisheries Boards for the purposes of stock enhancement. Capture of juvenile eel for supply to eel farms or export requires a Section 14 Authorisation from the Dept. of Communications, Marine and Natural Resources. Capture of glass eel did not take place in Ireland until the 1990s. This is a tidal activity using a variety of techniques such as anchored nets (tela), fykenet, trawl and dipnet. Upstream migrating elver have been captured since 1959 under statute, for transfer upstream around barriers; first on the Shannon and more latterly on other rivers under the control of the Electricity Supply Board (ESB).

This is usually carried out using fixed elver traps incorporating elevated ladders and collecting boxes. All juvenile eel captured are released upstream for enhancement. There is no National sampling programme for the glass eel/elver fishery.

The commercial eel fishery involves harvesting both brown and silver eel in fresh water and in estuarine or tidal waters. Brown eel are fished using a variety of techniques, the most common of which are baited longline, fykenets and baited pots. When silver eel are migrating downstream in autumn they are caught in fykenets and stocking-shaped nets called "coghill nets" which are attached to fixed structures in the river flow, often at "eel weirs".

The declared commercial eel catch (not including mortalities) in the Irish Republic, 2001–2007, ranged from 86 t to 120 t involving about 150–200 part-time fishers, but inadequate reporting and illegal fishing makes this difficult to quantify accurately and it may be a substantial underestimate. The value of the reported catch was therefore in the order of €0.5 million to 0.75 million. A total maximum of 278 licences were issued in 2006 and a maximum of 182 licences were actively fished in 2005. In all 265 licences (brown and silver) were issued in 2007, of which 259 were reported on and 204 were actively fished.

Recreational eel fishing is only carried out by a minority of anglers and there is no legal, or voluntary, declaration of catch. Some "recreational" fishing using fykenets and baited pots takes place and this is authorized under the commercial legislation.

Currently, there are no statutory instruments for the coordinated management of the European eel stock, its exploitation or other impacts. Management of the Irish eel fishery is currently (2007) hampered by a number of factors, such as no national closed season, size limit, policy on estuarine and coastal fishing and a lack of accurate information on stock, catch returns or sales. There is no register of fishing effort, landings or sales and illegal fishing and unreported catches are believed to be considerable.

Byelaws were introduced in 2008 limiting the fishing season for both yellow and silver eel and setting a national size limit of 30 cm.

IR.B.3.2 Fisheries byelaws 2008

Byelaw No. C.S. 297

In May 2008, the Minister for Communications, Energy and Natural Resources introduced a byelaw (Conservation of Eel Fishing (Annual Close Season) Byelaw No. C.S. 297, 2008). This Byelaw prohibits the taking or fishing for brown eel under 30 cm in length. The Byelaw also provides for a close season for brown eel, from 1 September to 31 May of the following year. The Byelaw also provides for a close season for silver eel from 1 January to 30 September in any year.

Byelaw No. 838, 2008

In May 2008, the Minister for Communications, Energy and Natural Resources introduced a byelaw (Conservation of Eel Fishing (Restriction on Issue of Licences) Byelaw No. 838, 2008). This Byelaw caps the number of eel fishing licences which may be issued in each Fishery District in 2008 or any year thereafter.

IR.B.4 The catchment approach

IR.B.4.1 Introduction

The coast of Ireland is covered by ICES Areas VI and VII (Figure B.1), which is in the single NE Atlantic category.

The EU has proposed (COM (2005) 472) that Eel Management Plans be established and implemented on a Waterframework Directive River Basin District level. The WFD subdivides the Republic of Ireland into four River Basin Districts and three International River Basin Districts (Figure B.2). Full descriptions of each RBD are given in the individual RBD Eel Management Plans.

Inland and estuarine eel fisheries in Ireland are managed by seven Regional Fisheries Boards, which are divided into Fisheries Districts (Figure B.2) and the Loughs Agency. Fisheries District boundaries largely conform with the arrangement of river catchments, although coastal boundaries may also relate to prominent coastal features such as headlands.

In general, eel fisheries managed on a Fisheries District basis fall naturally within the boundaries of the RBDs. In some cases individual catchments may differ on the boundaries as to which District and RBD they are in but in all cases, none of these contain active fisheries. (FigureB.3).

There is relatively little information on eel stocks in transitional and tidal waters in Ireland. Eels are known to inhabit extensive areas of estuaries and tidal lagoons (Arai *et al*., 2006; Harrod *et al*., 2005; Moriarty, 1988; Poole and Reynolds, 1996; Poole, 1990). The amount of habitat utilized by eel in tidal and transitional waters is unknown and the escapement of silvers is also unknown. The eel fisheries in tidal and transitional waters are managed under the Inland Fisheries legislation and management structures.

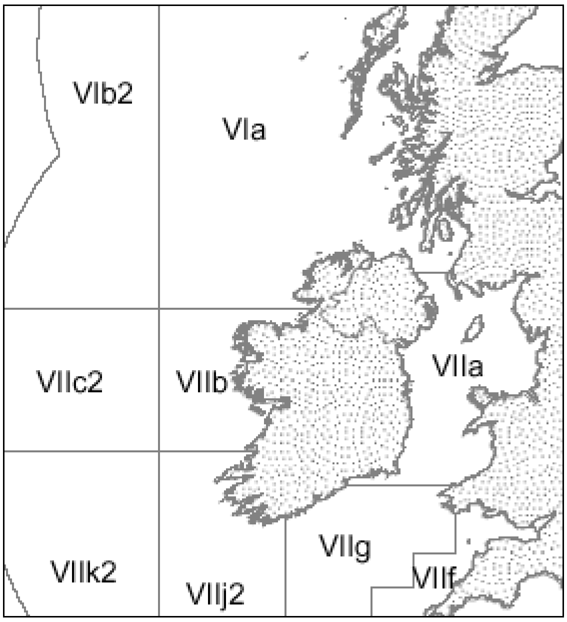


Figure B.1. Map indicating ICES areas around Irish shorelines (Source: ICES).

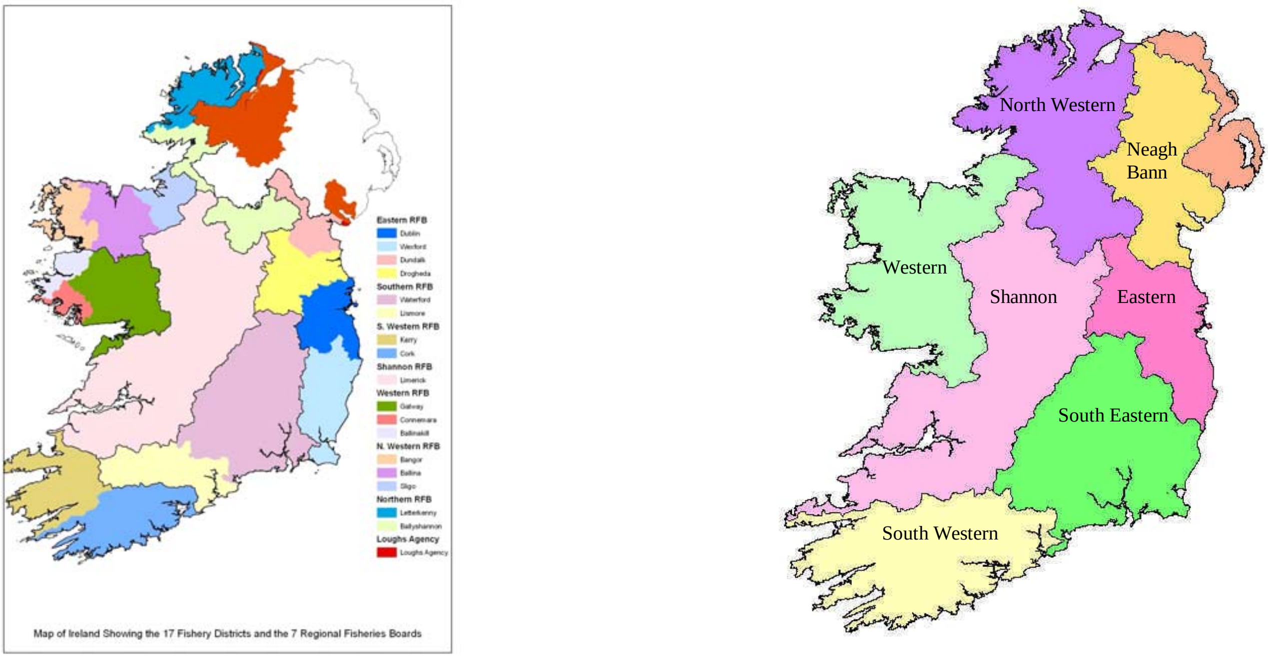


Figure B.2. Map of Ireland on the left showing the seven Regional Fisheries Boards and the 17 Fishery Districts and on the right, showing the Waterframework River Basin District.

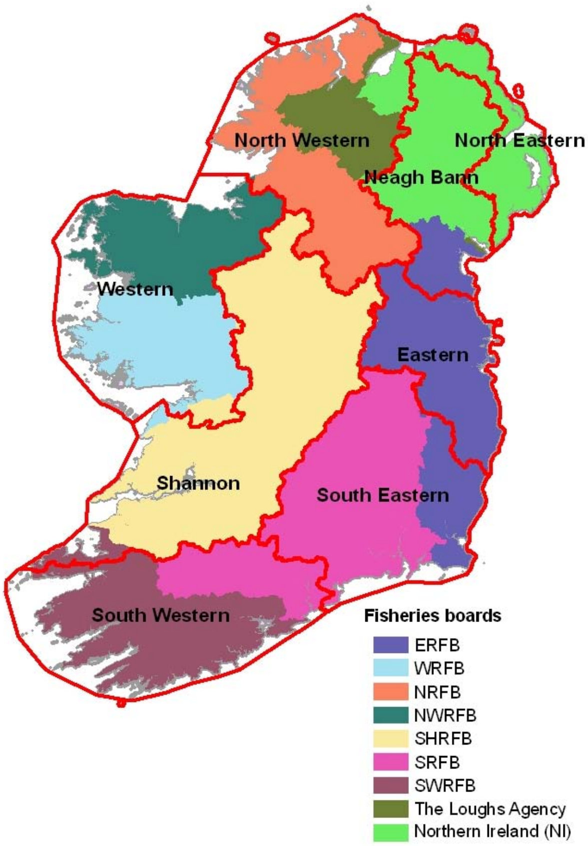


Figure B.3. Map showing the Waterframework River Basin Districts and Regional Fishery Board areas.

IR.B.4.2 River inventory

For the past number of years management of migratory species, salmon and sea trout, has been at the catchment level and it is therefore logical to expand this to encompass the management of eel.

A series of datasets (including river catchment topography, riverine gradient, lakes, catchments and Fisheries Districts) with national coverage (RoI) were acquired for the development of an integrated, G1S based, data model for the quantification of the fresh-water salmon habitat asset and for the determination of the quantity of habitat available to migratory salmonids. 261 discrete migratory salmonid 'Fishery Systems' were identified nationally of which 173 are recorded as being 'salmon and seatrout' and 88 as being 'seatrout only' (McGinnity *et al*., 2003). An additional three Northern Ireland catchments have been included in the quantification in support of the NWIRBD transboundary management plan. It is likely that eels are present in the majority or all of these systems although commercial fishing probably only takes place in 4.6% of them accounting for 71% of the total wetted area. It is also possible that this number of 264 catchments may change in the future as more information becomes available.

The estimated total wetted area[1] of the 264 lake, river and stream habitat accessible to migratory fish (including first order streams) in Ireland (including the Northern Ireland part of the Erne and the Loughs Agency Rivers in the Foyle and Carlingford ar-

[1] Data supplied by Central Fisheries Board, Compass Informatics, the Loughs Agency and EHS Water Management Unit, Northern Ireland.

eas) is 153 881 ha (Table B.1). The 264 "migratory" systems were estimated to contain 132 275 ha of lake habitat, 21 606 ha of fluvial habitat, of which 2826 ha is estimated to be first order stream (calculated at a nominal width of 0.8m). The ShRBD, WRBD and NWIRBD are clearly dominated by lacustrine habitat (Figure B.4).

It is intended to refine this database in the future, adding in additional information such as obstacles to migration and natural barriers and ground-truthing the potentially productive area with the presence/absence of eels.

Habitat quality data using the Amiro (Amiro, 1993) and Rosgen (Rosgen, 1994) gradient classification systems are available. For example, in the Kerry Fisheries District 48% of the potential salmon producing habitat has a gradient of < 0.5% (Amiro Class 1; McGinnity *et al.*, 2003).

Table B.1. Total wetted areas (ha) for lake, first order fluvial and greater than first order fluvial habitat for each River Basin District, including Northern Ireland (Erne, Drowes, Foyle, Roe and Faughan).

	Lake	>first order fluvial	first order fluvial	Total Wetted Area
EEMU	4861	1920	262	7043
SERBD	178	3626	412	4216
ShRBD	40 241	4487	590	45 317
SWRBD	7534	2714	419	10 666
WRBD	46 602	2869	473	49 944
NWIRBD	32 859	3165	670	36 694
Total	132 275	18 780	2826	153 881

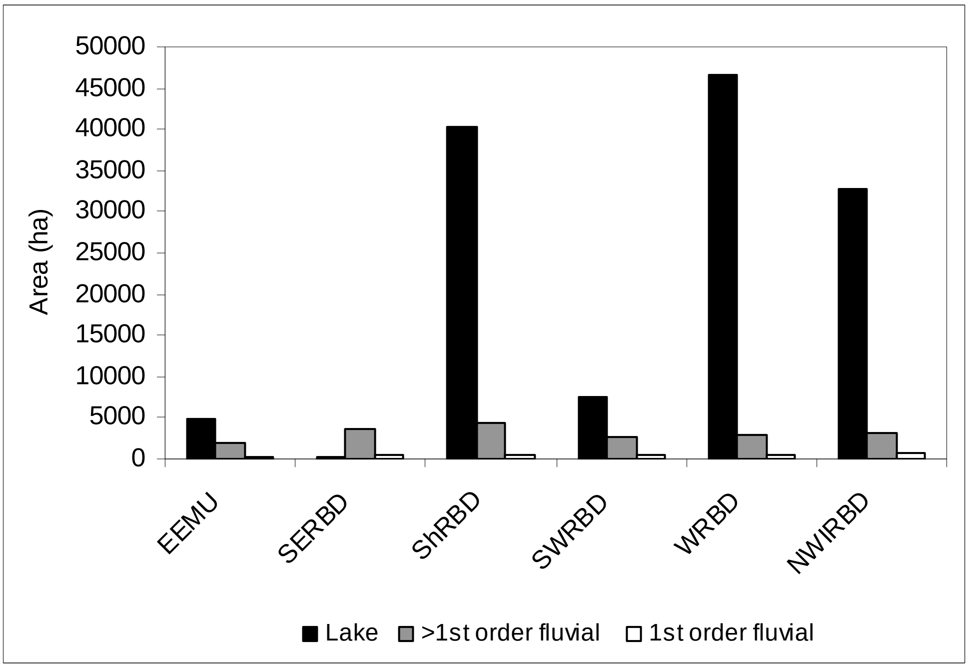


Figure B.4. Total wetted areas (ha) for lake, first order fluvial and greater than first order fluvial habitat for each River Basin District, including Northern Ireland (Erne, Drowes, Foyle, Roe and Faughan).

IR.B.4.3 Habitat types-national overview

Overview on methodology for descriptions at the River District Level, of the nature of catchments-Alkaline/ acidic, Oligo/ Meso/ Eutrophic.

Potential productivity

In Article 2, of the Regulation, it states:

4. The target level of escapement shall be determined, taking into account the data available for each eel river basin, in one or more of the following three ways:
   a) use of data collected in the most appropriate period prior to 1980, provided these are available in sufficient quantity and quality;
   b) **habitat-based assessment of potential eel production**, in the absence of anthropogenic mortality factors;
   c) with reference to the ecology and hydrography of similar river systems.

In support of this approach, the total catchment areas have been classified on the basis of their underlying geology into calcareous and siliceous (non-calcareous) types. Following on from this classification, the wetted areas have been nominally assigned as either calcareous or siliceous waters based on this catchment ratio (Table B.2; Figure B.5). This broad scale classification will allow for rough categories of eel productivity to be calculated which can be used in the assessment of potential production in the absence of sufficient eel data. More detailed information on catchment productivity using water chemistry (pH, Conductivity, alkalinity) might improve this system in the future and this will be done during the final phase of the NDP Eel project.

The dominance of lacustrine habitat is also evident for ShRBD, WRBD and NWIRBD in Figure 3.5, although there is a change in proportion between the ShRBD and the WRBD, with more siliceous area in the WRBD than in the ShRBD.

Table B.2. Total wetted areas (ha) for lake, first order fluvial and greater than first order fluvial habitat for each River Basin District, separated by catchment geology.

	Wetted area		%
	Calcareous	Siliceous	Calcareous
EEMU	5557	1486	79
SERBD	2480	1736	59
ShRBD	42 104	3213	93
SWRBD	2893	7774	27
WRBD	35 376	14 569	71
NWIRBD	27 659	9035	75
Total	116 068	37 813	75

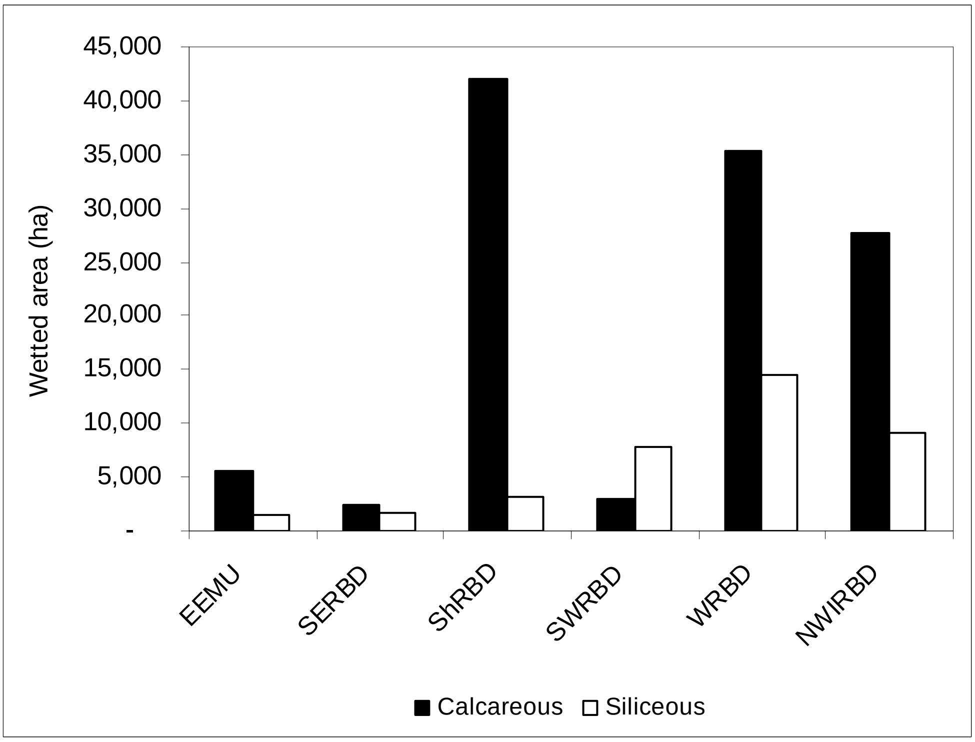


Figure B.5. Total wetted areas (ha) for lake, first order fluvial and greater than first order fluvial habitat for each River Basin District, separated by catchment geology.

IR.B.4.4 Water quality

Ireland is generally in a good position to implement the Waterframework Directive. Irish legislation provides (since 1977) for water quality planning on an integrated basis (i.e. to include surface and ground waters, including estuarine and tidal waters) and for inter-authority planning.

Since 1997 Ireland has promoted a catchment-based, national strategy to combat eutrophication in rivers and lakes. Major catchment-based initiatives have been carried out in respect of Loughs Derg, Ree and Leane and the Rivers Suir, Boyne and Liffey, linked to a major programme of investment in sewage infrastructure in these catchments. The work done in the context of these projects will be carried forwards and developed in the context of River Basin Management Projects.

Water quality in Ireland is generally good and compares very favourably with other Member States. The main challenge for water quality is to deal with eutrophication arising from excess inputs of phosphorous from all sources. The extent of eutrophication in the river system has been increasing persistently since the 1970s and has been identified by the EPA as probably the most serious environmental pollution problem in Ireland.

Poor water quality impacts on the potential for rivers to produce salmon. It is unknown at this point whether similar water quality levels that affect salmon have an affect on eel. The Environmental Protection Agency monitor water quality at over three thousand sites nationally from which a preliminary estimation of the area of channels with inadequate water quality which has been made.

Nationally (RoI), the water quality in 82.7% of the habitat available for salmon production is unpolluted, a further 12.8% is considered slightly polluted, and the remaining 4.5% is considered to be moderately or seriously polluted. Recent studies carried out by the Central Fisheries Board (Kelly *et al.*, 2007) suggest that salmon distribution and productively are significantly impaired in both of the latter categories. The EPA has recently updated the 2002 data to cover the period up to 2006.

River by river water quality data are available from the EPA and these will be integrated into the eel habitat GIS database by May 2009. Ground-truthing of the impact of water quality on eel stocks will be required in the future.

IR.C. Fishing capacity

NOTE: To date, the collection of inland fisheries data has not been managed, organized or presented under the WFD structure. In the following report, the national data will be subdivided by RBD, but the catch will also be reported by Fisheries Region to allow comparisons. IRBD reports only include Rep. of Ireland data.

IR.C.1 Gear types

Fykenets

Fykenets come in many shapes, sizes and configurations, but all operate on the principle of a leader net which guides fish into a hoop net trap with a tapering codend. Many fykenets have double leaders which funnel the catch towards the trap and are staked out. The fykenet type authorized for use in Ireland is known as a small Dutch fyke, or summer fykenet (Moriarty, 1975; Poole, 1990). These consist of two funnel shaped traps facing each other, joined by a leader net, which usually has a mesh size of 16 mm. Each trap consists of two chambers and a codend with knot to knot mesh sizes of 16, 12 and 10 mm and the entrance is usually 50–60 cm in diameter. The standard fyke has a leader length of about 8.2 m and each trap end is 3.4 m long, giving an overall length of about 15 m when set. There may be variations in mesh size and length dimensions and these are not stipulated in the legislation. These fykenets are usually joined end to end and fished in trains of multiple nets, often 5 or 10 in a train. Other fykenet designs with one metre diameter hoops and leader net height require special authorization.

Coghill nets

Coghill nets are used to capture downstream migrating silver eels in rivers and at the outlets from lakes. They come in a variety of shapes and sizes, but essentially all operate on the same principle, similar to a stationary trawlnet either stakes instream or mounted on a frame, often at a bridge, which can be lifted by a winch to allow for passage of boats, migration of other fish species and servicing of the nets. The codends are either lifted and emptied into a shute or are emptied by boat. Major coghill fisheries occur at Killaloe (Shannon) and Corrib (Galway). The Galway Fishery coghill nets have dimensions overall Length 11.8 m. Mouth-4.5 m Length with 5 cm knotted mesh. Middle Section-6 m length with 3 cm Knotless Mesh. Codend-1.3 m length from Ring with 1 cm fine mesh.

Silver eel are fished in the upper and middle Shannon catchment using instream coghill nets, similar to single chamber fykenets with "v" configuration wing leader nets. These vary in shape and size depending on local conditions, ranging from 20 m wings (3 m high) and 15 m chamber to 5–10 m wings (1–2 m high) and 5 m chamber.

Longlines

Baited (earthworm, mealworm, fish, shrimp) longlines are used to catch brown eel in lakes. In most Regions the maximum licenced number of hooks is 1000. Longline fishing is highly skilled and labour intensive. Matthews *et al.*, 2001 describes the preparation of a typical longline of 300 hooks which includes arranging of hooks and droppers in sequence on trays, replacing droppers which have been cut off following capture of an eel, can take 1 to 1.5 hours depending on the amount of eel (and therefore removed droppers) caught on that line the previous day). Lifting of a longline of 360 hooks takes between 1 hour and 1 hour and 15 minutes depending on catches. Baiting and setting of one longline of 360 hooks takes on average 1 hour to 1 hour and 15 minutes. Fishing of a series of longlines requires 3–5 hours for lifting, removal and storage of eel. Lines are normally set again that afternoon or evening. The later that longlines are set, the smaller the bycatch of coarse fish will be as they are mostly visual predators, while eel are most active just after dusk and before dawn. Daily lifting of longlines is essential to minimize mortalities of captured eel.

Baited pots

Until the 1960s the pot used in Waterford was a wicker basket about 1 m long and 50 cm in diameter. These were made in Carrick on Suir. In the late 1960s a visiting Dutch fisher introduced gear known locally as the 'beck', a trap made from nylon mesh supported on plastic hoops. These must be baited with freshly caught small estuarine fish such as herring.

Fixed traps

Fixed traps are rigid structures in rivers for capture of downstream migrating silver eel. There are a variety of structures fished including modified smolt wolf type traps. Smolt traps are also used for sampling silver eels and for the Burrishoole the entire run is trapped and monitored.

IR.C.1 Licensed capacity

Little data are available as reporting of effort is not a national requirement.

Fishing effort was not monitored in the Irish eel fishery. There was no logbook or compulsory recording system for fishers and there is no eel dealer register or regular monitoring of eel dealers. There is also no registration of fishing boats in the eel fishery. Efforts have been made to improve on the data collection by circulating an agreed catch reporting form (Figure C.1) which may lead to data discontinuity.

The Management of Eel Fishing Byelaw No.752, 1998 capped the number of longline licenses that a Regional Fisheries Board may issue for longline fishing for eels in any district. In addition, the Fisheries (Amendment) Act 1999 delegated authority to the Regional Fisheries Boards to issue authorizations for the use any fishing engine for the capture of eels including any longline, as it sees fit.

Each Regional Fisheries Board has a policy on the number of fykenets permitted for each licence and in some cases the locations where they are permitted to fish. It is difficult to convert the number of licensed nets in Tables C.1–C.2 into an actual fishing effort, as many licensed fishers either don't fish at all or only fish for a limited period of the year. In some areas for example, such as in the southeast, fykenets are used during the weaker tides and baited pots are used when the tides are too strong for fykenets.

A preliminary analysis of the number of licences issued the number of end of year catch reports submitted and from that, the number of licences that fished and submitted a catch record was undertaken. The number of "actively fished" licences, grouped by gear type and by RBD, was examined as a proxy for "effort". This has been presented for the national catch in Section IR.D but the data were not suitable for analysis at a smaller scale.

Brown eel effort

Brown eels are fished for using either standard or deeper ("other") fykenets, usually 20 per licence, longlines, usually limited to 1000 hooks per licence or baited pots (17 per licence?; Table C.2). The total numbers of licences, for Ireland, issued and fished are shown in Figure 4.3. No data are available for the effort of each licence about nights fished or comparisons between gear types or amounts.

Since 2001 there has been an increase in the number of licences issued and in the number being actively fished for brown eel (Figure C.2).

Silver eel effort

Silver eels are fished using fykenets, fixed v-wing nets and coghill nets (Table C.2), although standard fyke licences are only listed in the table for brown eel (Table C.1). Effort is often targeted at short time windows in autumn and winter during optimum conditions, such as dark moon and high water. The total numbers of licences (not including fykenets), for Ireland, issued and fished are shown in Figure C.3. No data are available for the effort of each licence about nights fished or comparisons between gear types or amounts. (Note: coghill nets above Killaloe in the Shannon have been grouped under "v-wing fykes").

Since 2001 there has been an increase there has been an increase in the number of licences issued and in the number being actively fished for silver eel (Figure C.3) with a steadying in 2007.

Shannon IRBD

The ESB are issued a single licence for the R. Shannon for brown and silver eel and they have authorized crews who partake in the survey/fishery using longline, fykenets and coghill type nets (Tables C1–C2). The collection of glass eel, elver and other juvenile eels for lake-stocking is supervised by staff from the Shannon Regional Fishery Board and researchers from the National University of Ireland, Galway, and daily records are available.

Brown eel fishing involves authorized fishing crews, two persons per boat, entitled to use one or other of two methods (decided by fishery management, on biological advice); i.e. up to 50 fykenets or earthworm baited longlines, not exceeding 1000 hooks. Authorizations are issued by the ESB subject to weekly provision by crews of data on: Fishing locations, fishing effort, eel catch, bycatch and some environmental data (daily logbook records, analysed at end of season, and checked by fishery-independent monitoring). At present no records of fuel consumption, other than by research crews, are maintained.

Silver eel fishing, at ESB eel weirs (coghill nets) and sites fished by authorized crews (coghill and fykenets) is also monitored by means of daily logbook records and fishery-independent surveys. An annual, end of season report is compiled.

Eel Catch Return Year: 2006

Fishery Region: ______ **Licence Number:** ______

Name of Fisherman ______ **Signature** ______ **Date** ______

Month Fished	River/Lake Fished	Indicate Method Longline, Fyke Net Pot, Coghill Net	No. Days Fished	Indicate Brown or Silver eel	Catch Sold kg / lbs or St*	Undersize Catch Mortalities kg / lbs or St*	Undersize Catch Released kg / lbs or St*	Dealer

Optional: Please provide an indication of price euro/kg or euro/lb offered throughout the season:

* Please delete as appropriate: give weights in kg, lbs or stone and indicate on the form which.

Figure C.1. Catch declaration form issued with each licence from 2005 onwards.

Table C.1. Table of brown eel licences for each Eel Management Unit, 2001 to 2007.

Management	Year	Longline			Standard Fyke			Baited pot			Total		
Unit		I	R	A	I	R	A	I	R	A	I	R	A
NWIRBD	2001	32	10	10	15	4	4				47	14	14
(ROI)	2002	30	11	11	18	8	8				48	19	19
	2003	30	0		16	0					46	0	0
	2004	24	8	8	13	2	2				37	10	10
	2005	25	14	14	18	18	8				43	32	22
	2006	24	20	19	21	15	13				45	35	32
	2007	27	25	16	19	17	11				46	42	27
SERBD	2001				8	0		27	0		35	0	0
	2002				32	13	13	27	0		59	13	13
	2003				16	14	14	20	19	14	36	33	28
	2004				16	16	16	20	10	9	36	26	25
	2005				15	7	5	20	13	10	35	20	15

Management	Year	Longline			Standard Fyke			Baited pot			Total		
	2006				13	9	7	20	10	9	33	19	16
	2007				16	12	10	20	13	6	36	25	16
EEMU	2002		7	7		4	4				0	11	11
	2003	4	4	4	3	3	3				7	7	7
	2004	5	5	5	5	5	5				10	10	10
	2005	3	2	2	3	2	1				6	4	3
	2006	4	2	2	3	2	1				7	4	3
	2007	3	3	2	3	2	2				6	5	4
SHIRBD	2001		14	11		13	13				0	27	24
	2002		19	16		18	15				0	37	31
	2003		13	12		15	13				0	28	25
	2004	24	16	16	23	15	15				47	31	31
	2005	22	18	16	21	19	19				43	37	35
	2006	22	17	2	21	10	1				43	27	3
	2007	22	21	17	21	13	10				43	34	27
SWRBD	2001	4	4	0	5	3	3	1	1	1	10	8	4
	2002	4	4	0	7	3	3	1	1	1	12	8	4
	2003	5	0		7	1	1	2	0		14	1	1
	2004				4	1	1	1	0		5	0	0
	2005				10	3	1	1	1	1	11	4	2
	2006				5	2	2	1	0		6	2	2
	2007				4	0		1	0		5	0	0
WRBD*	2001	15	0		24	19	14				39	19	14
	2002	8	5	5	25	23	20				33	28	25
	2003	16	15	15	25	20	13				41	35	28
	2004	14	15	11	28	24	20				42	39	31
	2005	15	13	13	28	28	25				43	41	38
	2006	32	13	12	29	22	21				61	35	33
	2007	32	26	19	28	21	18				60	49	39

I = number issued, R = number reporting catch and A = the number that actively fished.

*** WRFB Standard Fykes includes 3 "other fykes" issued, reported and fished in each year.**

Table C.2. Gear, not including fykenets, licensed for silver eel fishing in each Management Unit, 2001–2007.

Management	Year	Coghill			Fixed trap			V-wing fyke*			Total		
Unit		I	R	A	I	R	A	I	R	A	I	R	A
NWIRBD	2001	0									0	0	0
(ROI)	2002	0									0	0	0
	2003	0									0	0	0
	2004	4	0		1						5	0	0
	2005	1	0		1	0					2	0	0
	2006	3	1	0	1	0					4	1	0
	2007	1	1	0							1	1	0
SERBD	2001										0	0	0
	2002	2	0								2	0	0
	2003	2	2	2							2	2	2
	2004	2	2	2							2	2	2
	2005	2	2	0							2	2	0
	2006	2	2	2							2	2	2
	2007	2	2	0							2	2	0
EEMU	2002		7	7		2	2				0	9	9
	2003	8	6	6	2	2	2				10	8	8
	2004	7	8	7	3	2	2				10	10	9
	2005	7	5	5	0	0	0				7	5	5
	2006	7	7	7	2	2	2				9	9	9
	2007	6	2	2	0						6	2	2
SHIRBD	2001		0						19	13	0	19	13
	2002		20	20					19	17	0	39	37
	2003		0						19	16	0	19	16
	2004	26	20	20				21	21	20	47	41	40
	2005	22	21	21				23	23	19	45	44	40
	2006	22	20	20				23	21	19	45	41	39
	2007	2	0					23	21	19	25	21	19
SWRBD	2001										0	0	0
	2002										0	0	0
	2003										0	0	0
	2004										0	0	0
	2005										0	0	0
	2006										0	0	0
	2007										0	0	0
WRBD	2001	28	19	18	1	0					29	19	18
	2002	27	21	21	1	0					28	21	21
	2003	27	23	19	1	0					28	23	19
	2004	27	27	24							27	27	24
	2005	24	24	17	1	1	1				25	25	18
	2006	26	22	22	1	0					27	22	22
	2007	26	18	18	1	0					27	18	18

* V-wing fykes includes instream coghill nets.

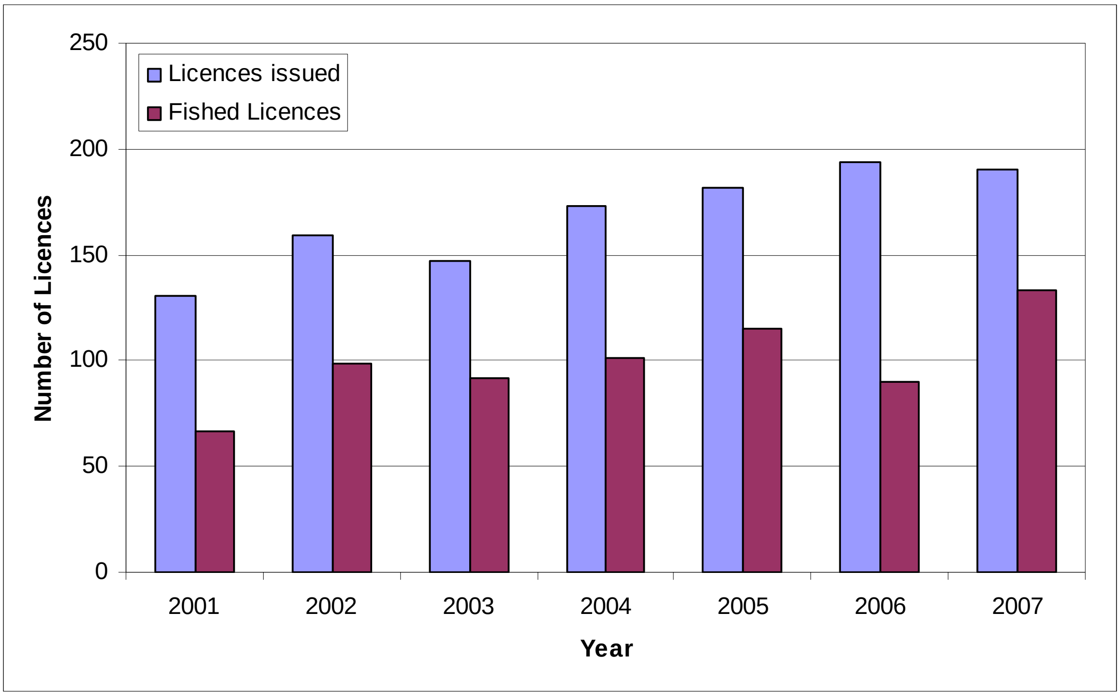


Figure C.2. The total number of brown eel licences issued in Ireland and the number actively fished, 2001 to 2007.

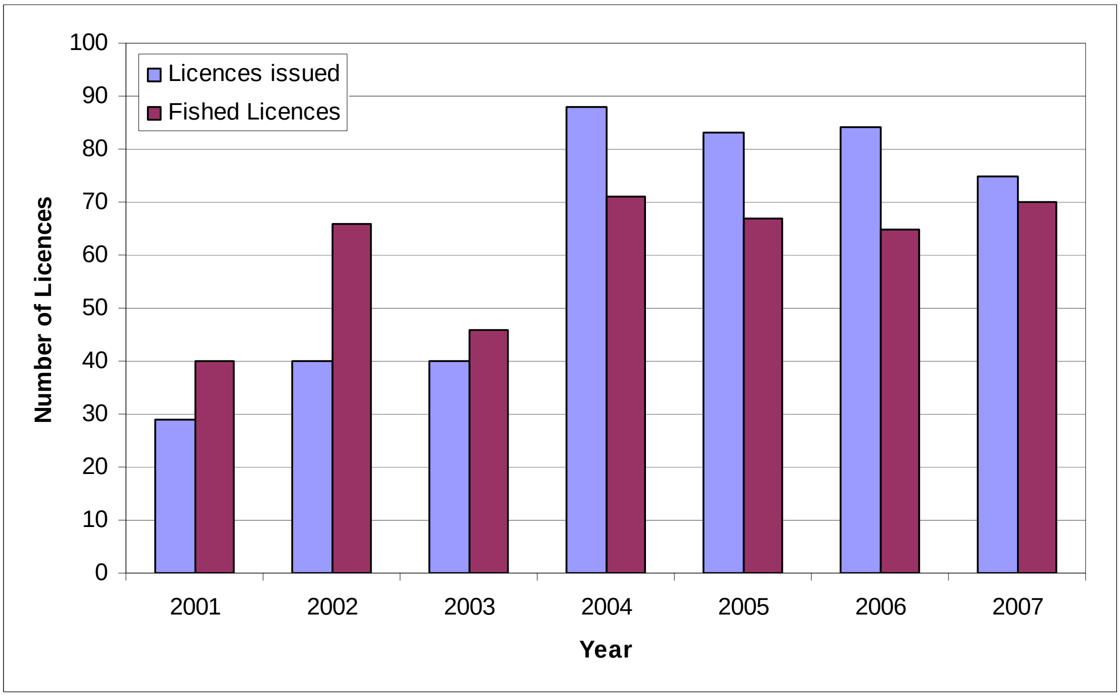


Figure C.3. The total number of silver eel licences (coghill, v-wing fyke and fixed trap) issued in Ireland and the number actively fished, 2001 to 2007.

IR.D. Fishing effort

IR.D.1 National synopsis

DCR Requirement for Eel, specific effort must reach Threshold 1-30% of the catch in a day.

Little data available as reporting of effort is not a national requirement.

Fishing effort is not generally monitored in the Irish eel fishery. There is no logbook or recording system for fishers and there is no eel dealer register or regular monitoring of eel dealers. There is also no registration of fishing boats in the eel fishery.

It is difficult to convert the number of licensed nets in Tables C1–C2 into an actual fishing effort, as many licensed fishers either don't fish at all or only fish for a limited period of the year. In some areas for example, such as in the southeast, fykenets are used during the weaker tides and baited pots are used when the tides are too strong for fykenets. A preliminary analysis of fishing effort was carried out using the number of days fished as the standard unit, regardless of the gear type used, fykenet or longline. This analysis was undertaken for brown and silver eels separately.

IR.D.2 Brown eel effort

Brown eels are fished for using either fykenets, usually 20 per licence, or longlines, usually one line of 1000 hooks per licence. In 2006, there was a close relation between the number of days fished and catch and it is hoped that over time this analysis will allow cpue to be used as a proxy indicator for changes in stock level.

IR.D.3 Silver eel effort

Silver eels are fished using fykenets, fixed v-wing nets and coghill nets. Effort is often targeted at short time windows in autumn and winter during optimum conditions, such as dark moon and high water.

IR.E. Catches and landings

As stated in Section IR.B, Ireland falls entirely into the NE Atlantic Area, VI and VII. Landings data are required separately for glass eel, brown eel and silver eel, by Quarter, by Gear Type for the Minimum Programme, and Monthly by ICES Statistical Rectangle (catchment for eel) by Gear Type.

One of the main components of the Eel Recovery Plan is the development of Eel Management Plans for each River Basin District. To facilitate proper implementation and monitoring of each plan, landings data will need to be reported for each River Basin District, and, if possible, at the individual catchment level.

IR.E.1 National commercial catch

IR.E.1 .1 Catch of glass eel/elver

There is no authorized commercial catch of juvenile eel in Ireland and some fishing has been authorized in the past under Section 18 of the Fisheries Act for enhancement of the fisheries.

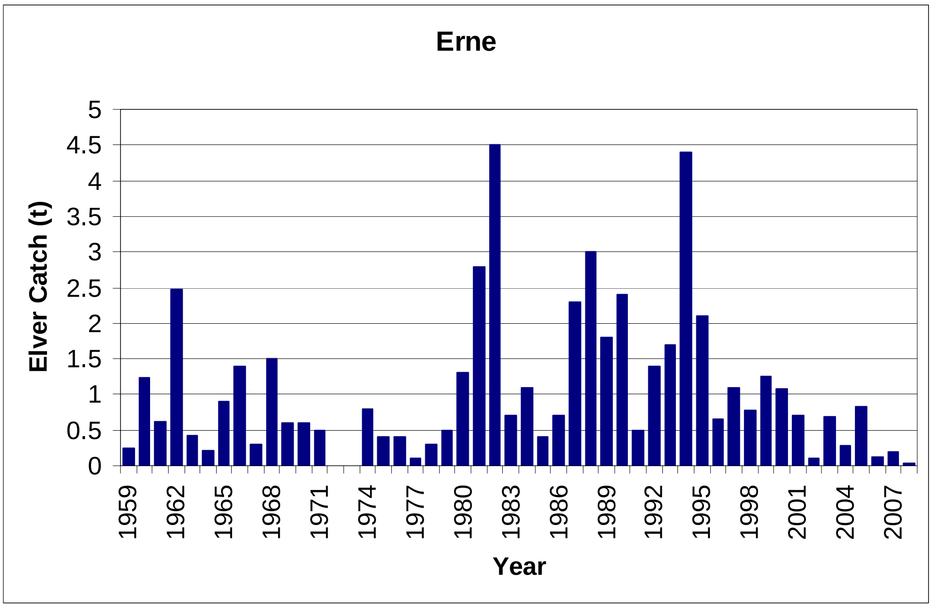
Monitoring of elver migrating at the impassable hydro-barriers at Ardnacrusha (Shannon) and Cathleens Falls (Erne) is undertaken by the ESB (Figure E.1). Indications are that recruitment remains low. Catches in 2004 for both Erne and Shannon were the second lowest recorded. Numbers in 2005 were more unpredictable, with good catches of elvers recorded in the Erne (45% of the 1979–84 mean) and a poor catch in Ardnacrusha (1.4% of the 1979–1984 mean).

A new dataset has come to light which extends the Shannon series back from 1977 to 1959. There are some discrepancies in the overlap data as shown on Figure E.1. It is hoped that these can be resolved.

The Erne elver dataset has also been double checked and the presented data has now been agreed by DCAL and AFBINI, the ESB, NRFB and MI. Any discrepancies were not major and the data trend and pattern has not changed.

IR.E.1.2 Restocking

All of the catches reported in Section IR.E.1.1 are used for restocking, primarily in the Erne and Shannon catchments.



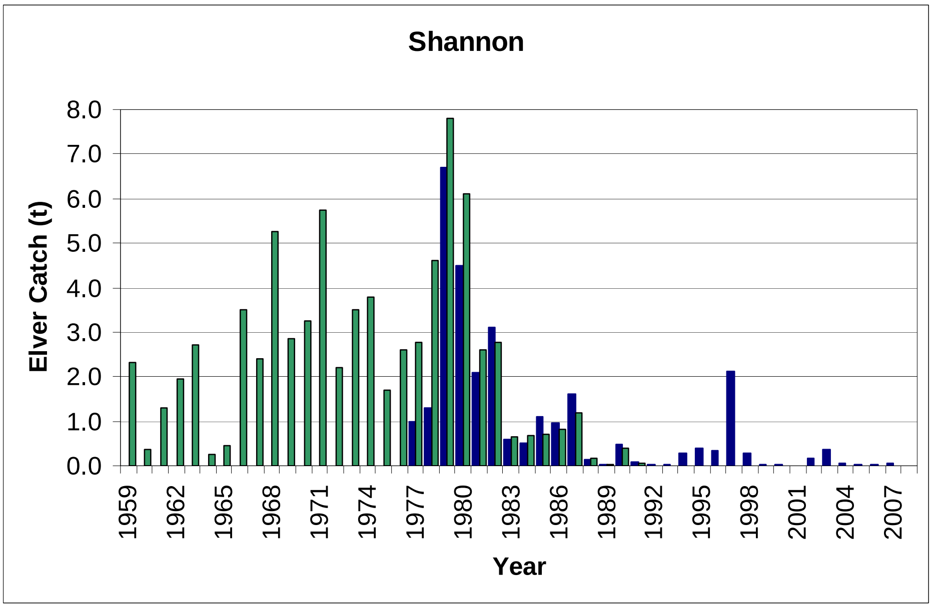


Figure E.1. Annual elver catches (kg) in the traps at Ardnacrusha (Shannon) and Cathleens Falls (Erne)-data from ESB. The green bars in the Shannon graph are for a historical dataset that differ from the current dataset.

IR.E.1.3 Catch of brown and silver eel

There is no compulsory declaration of eel catch in Ireland and in many Regions, declarations of catches are not complete and underreporting is probably widespread. Currently, reported catches are available on an annual basis at the Fisheries Regional Level, with most RFBs reporting on a District basis. The introduction of the new catch reporting form has led to considerable improvement in the system since 2005.

For the Eel Management Plans, catches (RoI) of brown and silver eel have been collated from the District returns and are presented in Table 4.5 for 2001 to 2007 for each Eel Management Unit (RBD). Also included in Table E.1 are the catches for N. Ireland on the Erne supplied by DCAL and AFBINI.

Mortalities in the catch have not been consistently reported and the data have only been requested since 2005. Therefore, the landings reported here are for the declared up to 2005 and for the catch, not including mortalities, after 2005. Mortalities in 2006 and 2007 were 0.3% and 1.3% respectively.

Since 2001 the ESB has embarked on a programme of transporting a proportion of the silver eels captured in the Shannon silver eel fishery around the dams and releasing them for onward migration to the sea. These released eels are included in the data presented in Table E.1 and this has ranged from 5% to 22% of the total silver eel catch on the Shannon.

There has been no discernible trend in the reported catch of either brown or silver eel (Figures E.2 and E.3).

Reporting of silver eel in the NWIRBD ceased after 1997 although it is understood that fishing has continued though the following years.

Also presented, in Tables E2–E5, are the catch data sorted by Fisheries Region as originally presented in the Country Reports and also updated with the confirmed data as included in the Irish Eel Management Plans and with the 2007 data. The differences were relatively minor in most cases.

Table E.1. Declared catches of brown, silver and total catch for each management unit, 2001–2007. [1]The catch released below the dam on the Shannon is also listed separately with the (%). *RoI part of RBD only, **N. Ireland part of RBD only, * total RBD. NR = no report.**

Brown eel

	2001	2002	2003	2004	2005	2006	2007
EEMU	305	7806	6060	5420	841	703	1487
SERBD	8555	13 027	9786	7753	5569	3327	4413
SWRBD	552	960	70	35	22	250	NR
SHIRBD	15 983	18 116	22 196	21 535	18 736	17 591	24 635
WRBD	22 126	15 043	23 415	21 142	17 851	18 276	17 922
NWIRBD*	4743	8911	NR	6793	7311	16 865	9 929
NWIRBD**	12 300	15 300	16 160	15 700	13 600	15 700	19 600
NWIRBD***	17 043	24 211	16 160	22 493	20 911	32 564	29 529
Total RoI	52 264	63 863	61 527	62 678	50 330	57 012	58 503
Total	64 564	79 163	77 687	78 378	63 930	72 712	77 986

Silver eel

	2001	2002	2003	2004	2005	2006	2007
EEMU	127	2360	2460	1810	396	364	90
SERBD	0	2004	1218	800	260	840	0
SWRBD	0	0	0	35	22	250	0
SHIRBD	24 107	25 248	17 075	37 116	21 535	34,478	18 122
1Catch rel.	1300 (5)	3900 (15)	1600 (9)	2900 (8)	1500 (7)	7700 (22)	3665 (20)
WRBD	9581	14 386	12 596	17 849	14 624	23 971	16 541
NWIRBD*	28	31	NR	NR	NR	564	947
NWIRBD**	NR	NR	NR	NR	NR	NR	NR
NWIRBD***	28	31	NR	NR	NR	564	947
Total RoI	33 843	44 029	33 349	57 610	36 837	60 467	35 700
Total	33 843	44 029	33 349	57 610	36 837	60 467	35 700

Total catch

Total RoI	86 107	107 893	94 876	120 288	87 167	117 479	94 203
Total	98 407	123 192	111 036	135 988	100 767	133 179	113 686

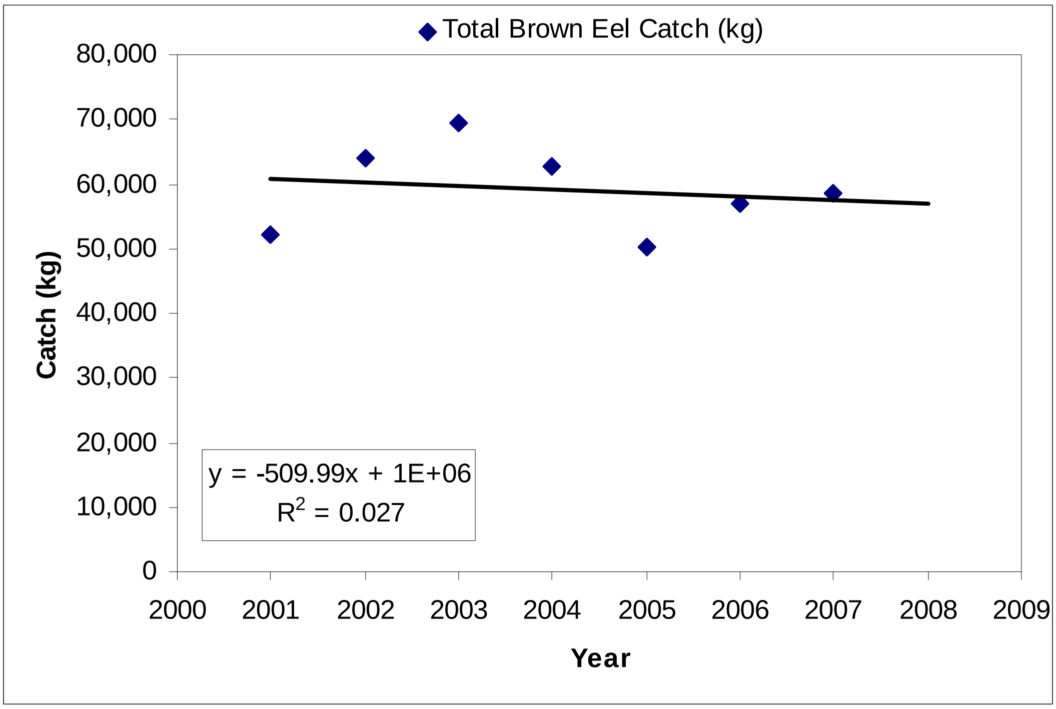


Figure E.2. Total (RoI) brown eel declared catch for the period 2001 to 2007. Trend not significant.

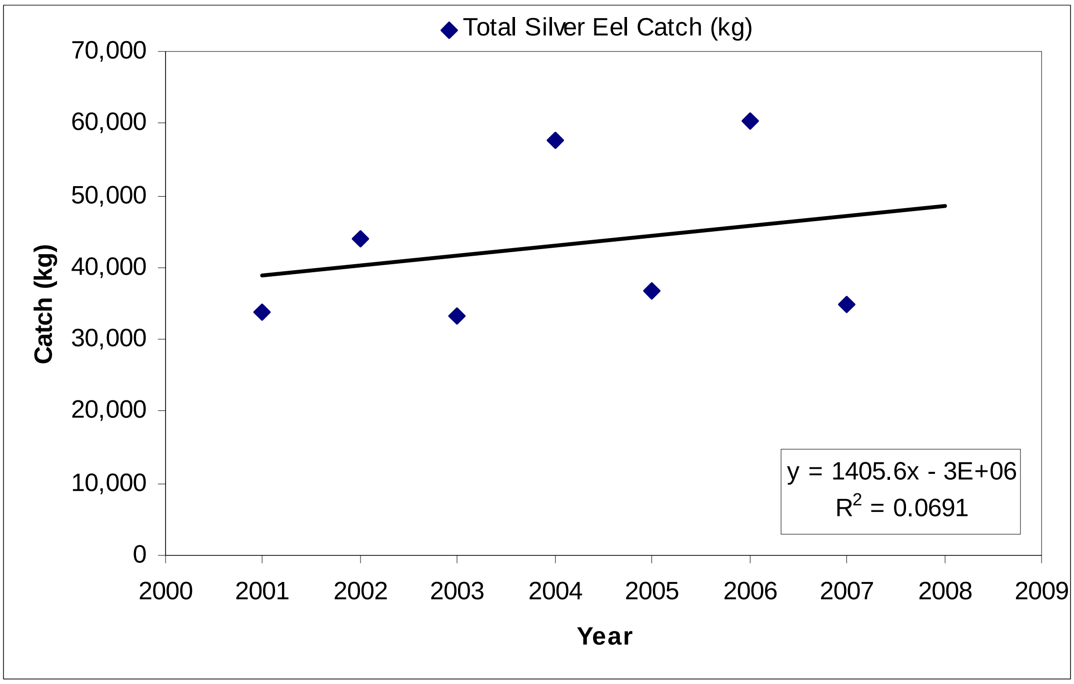


Figure E.3. Total (RoI) silver eel declared catch for the period 2001 to 2007. Trend not significant.

Table E.2. Declared regional catches (t) of brown eel for 2001–2006 OLD DATA.

Fishery Region	2001	2002	2003	2004	2005	2006
Eastern	14.0	16.0	10.7	9.0	1.3	1.0
Southern	8.5	4.8	4.7	3.6	5.3	2.7
South Western	0.6	1.0	0.1	0.1	0.1	0.5
Shannon	16.1	15.8	21.9	21.5	18.7	17.6
Western	8.9	3.9	12.4	9.8	7.9	13.3
North Western	13.9	11.0	12.5	12.1	10.5	6.7
Northern	4.7	8.9	-	4.5	6.6	18.1
Total	66.7	61.4	62.3	60.6	50.4	59.9

Table E.3. Declared regional catches (t) of brown eel for 2001–2007 NEW DATA. Changes are *high-lighted*.

Fishery Region	2001	2002	2003	2004	2005	2006	2007
Eastern	14.0	16.0	***11.3***	***9.6***	***1.1***	1.0	2.0
Southern	8.6	4.8	4.6	3.6	5.3	***3.1***	3.9
South Western	0.6	1.0	0.1	0.1	0.1	0.5	0.0
Shannon	***15.9***	***18.1***	***22.2***	21.5	18.7	17.6	24.6
Western	8.9	***4.1***	12.4	9.8	***8.1***	***11.9***	8.0

North Western	***13.2***	11.0	***11.0***	***11.3***	***9.7***	***6.3***	9.9
Northern	4.7	8.9	-	***6.8***	***7.3***	***16.9***	9.9
Total	***66.0***	***63.9***	***61.5***	***62.7***	50.4	***57.3***	58.4

Table E.4. Declared regional catches (t) of silver eel for 2001–2006. * total catch including a proportion released below hydroelectric dam, ** amount released and (% of catch). OLD DATA

Fishery Region	2001	2002	2003	2004	2005	2006
Eastern	2.5	4.3	3.2	2.7	0.6	0.9
Southern	-	0.1	-	0.2	0.0	0.3
South Western	0.0	0.0	0.0	0.0	0.0	0.0
Shannon Region					21.5	
Shannon System *	24.1	25.3	17.1	37.1	20.8	34.5
Shannon Released **	1.3 (5%)	3.9 (15%)	1.6 (9%)	2.9 (8%)	1.5 (7.3%)	7.7 (22.3%)
Western	9.4	13.0	10.6	13.9	13.4	22.4
North Western	1.4	1.2	2.0	4.0	1.5	2.4
Northern	0.1	0.1	-	-	0.0	0.0
Total	37.5	44.0	32.9	57.9	37.1	60.5

Table E.5. Declared regional catches (t) of silver eel for 2001–2007. * total catch including a proportion released below hydroelectric dam, ** amount released and (% of catch). NEW DATA. Changes are *highlighted*.

Fishery Region	2001	2002	2003	2004	2005	2006	2007
Eastern	2.5	4.3	***3.6***	***2.5***	***0.7***	0.9	0.1
Southern	0.0	0.1	***0.1***	0.2	0.0	0.3	0.0
South Western	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shannon Region					21.5		

Sh'n System *	24.1	25.3	17.1	37.1	20.8	34.5	18.1
Sh'n Released **	1.3 (5%)	3.9 (15%)	1.6 (9%)	2.9 (8%)	1.5 (7.3%)	7.7 (22.3 %)	3.7 (20.4 %)
Western	9.4	***13.2***	10.6	13.9	***13.2***	***21.6***	13.4
North Western	1.4	1.2	2.0	4.0	1.4	2.4	3.1
Northern	0.1	0.1	-	-	0.0	***0.6***	1.0
Total	37.5	44.0	***33.3***	***57.6***	***37.7***	***60.3***	35.7

Shannon Catchment

The annual downriver migrations of silver eels have traditionally been exploited in the River Shannon and the three commercial eel weirs, owned by ESB since 1937, have continued this practice with varying success (Figure E.4). In many respects the overall pattern of change, with steadily declining silver eel catches at Killaloe/Clonlara, but relatively steady catches at Athlone, mirrors the results obtained by monitoring the Lough Derg fykenet cpue brown eel catches vs. those in upper catchment lakes.

The silver eel catch in 2004/05 in Killaloe was 5.02 t and upstream of Killaloe it was 32.09 t, giving a total silver eel catch for the river of 37.12 t. This was more than double the catch recorded in 2003/04.

The silver eel catch in 2005/06 in Killaloe was 1.53 t and upstream of Killaloe it was 19.27 t, giving a total silver eel catch for the river of 20.80 t.

The silver eel catch in 2006/07 in Killaloe was 7.87 t and upstream of Killaloe it was 26.61 t, giving a total silver eel catch for the river of 34.48 t. This was almost as high as the catch recorded in 2004/05 and may have been helped by relatively high water levels throughout the early winter period.

The silver eel catch in 2007/08 in Killaloe was 4.1 t, upstream of Killaloe it was 14.0 t, giving a total silver eel catch for the river of 18.1 t. 3.7 t were released downstream of the turbine.

Corrib Catchment

The Galway Fishery comprises a weir with 14 coghill nets. These are fished throughout the dark moon phases and may be lifted during periods of very high water. The fishery was purchased by the state in 1978 and has been fished consistently since then. Fishing effort may have increased in later years. The downward trend in silver eel catch (Figure E.5) therefore probably reflects the decreasing stock in the greater Corrib catchment and falling silver eel escapement. The catch in 2004 was 5.83 t, in 2005 it was 7.2 t and in 2006 it was 9.2 t-the highest catch since 1990. The catch in 2007 was 9.3 t.

Burrishoole Catchment

The Burrishoole System in the West of Ireland is a relatively oligotrophic river and lake system with a catchment area of 8,949 ha. The eel population is unexploited and the total fresh-water silver eel production is trapped in downstream Wolf type traps. The silver eel catch is not included in the National commercial catch as the entire catch is released downstream. The Burrishoole silver eel migration is equivalent to approximately 1% of the National silver catch, by weight, but is indicative of eel production from a considerable number of low productivity Irish river systems where eel densities are relatively low and growth rates are slow, often <2 cm.yr^{-1}.

Total catches of silver eel in the trap between the years 1971 (when records began) and 1982 averaged 4400 individuals, fell to 2200 between 1983 and 1989 and increased again to above 3000 in the 1990s (Figure E.6). There was an above average catch in 1995, possibly contributed to by the exceptionally warm summer. The catch in 2001 of 3875 eel was the second highest recorded since 1982. The catch in 2005 was 2590 and in 2006 it was 2180 individual eels. Unusually high water levels in 2006 made trapping particularly difficult and some losses may have occurred.

Recreational eel

Recreational eel rod catches were not recorded in 2004, 2005, 2006 or 2007, but these were thought to be relatively low. Recreational net and trap eel catches were also low and were included in the commercial catch returns.

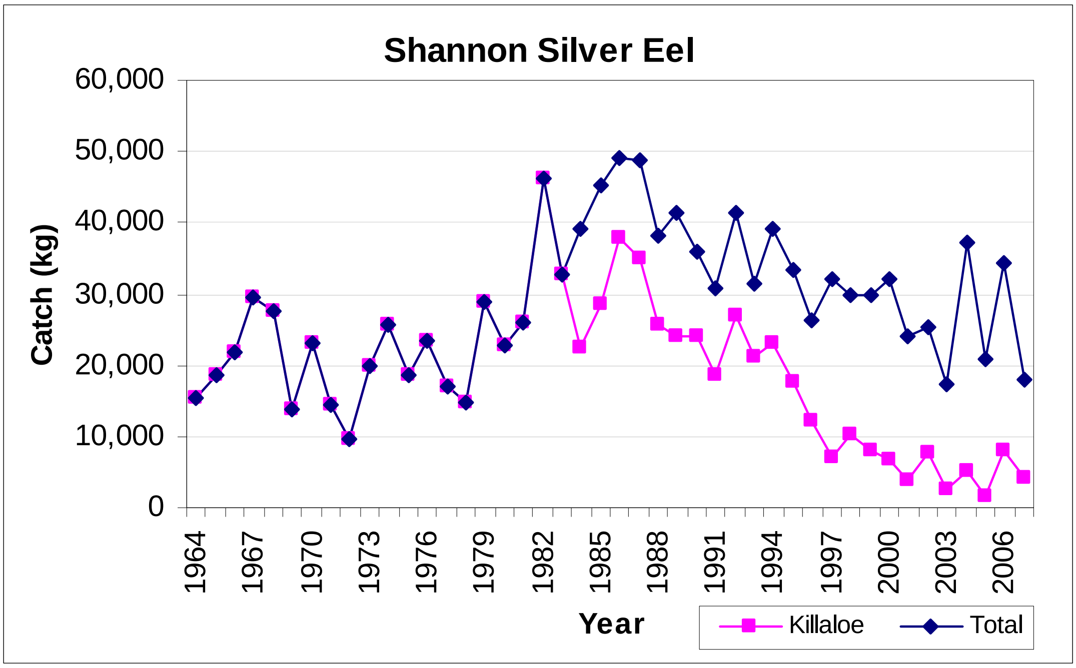


Figure E.4. Silver eel catches from the Killaloe eel weir and the Shannon system (1964 to 2007).

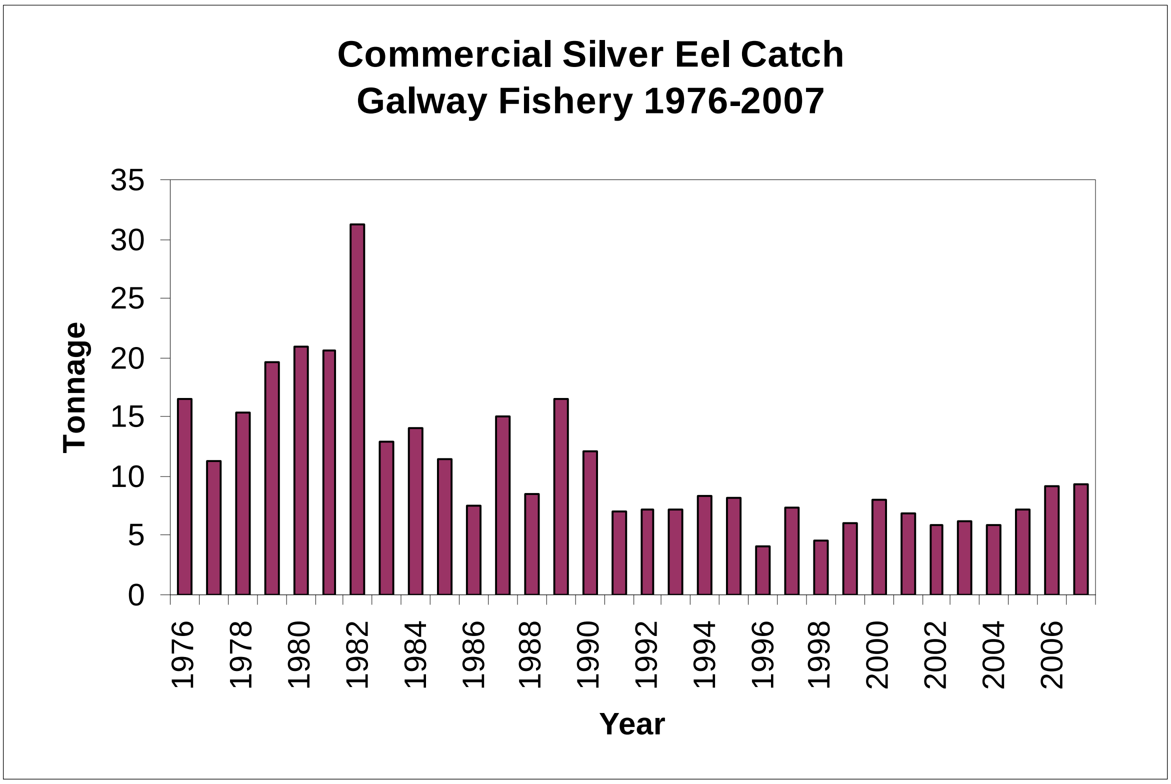


Figure E.5. Annual silver eel catch (t) in the commercial Galway Fishery, Corrib System, for 1976 to 2007.

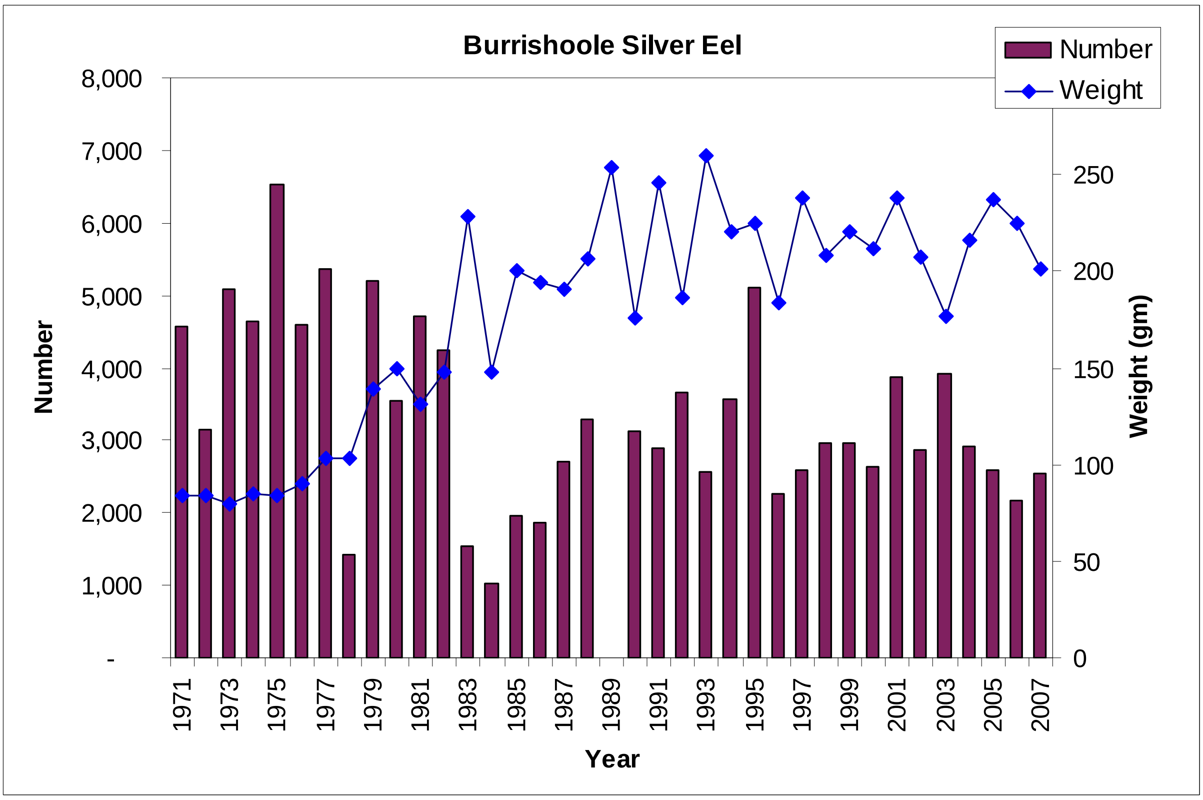


Figure E.6. Annual silver eel catch, and mean weight (gm) in the Burrishoole System for 1971 to 2007.

IR.F. Catch per unit of effort

IR.F.1 Trends in catch, effort and cpue

Trends in catch for a given fishing effort may be used to indicate changes to the stock. If fishing effort is precisely monitored, as in a scientific survey, the catch returns are a good proxy for stock. Such precise information is not available for the commercial eel fishery in Ireland. The best available information allows effort to be quantified as the number of licences actively fished and reported. This is a coarse proxy for effort, as catch returns for each licence ranged from a few kg to several tonnes (depending in large part on the number of nights and nets fished). This information is too coarse for examining trends in stock at the regional level. However, it is useful for examining national trends in stock because of the large number of licences involved. Catch per active licence is indicative of a declining stock of brown eels over the last 7 years at least (Figure F.1). Previous data were not available to allow this analysis prior to 2001 when cpues were likely to be higher.

Given the lack of logbooks or fishery register there is little cpue information available for Irish eel fisheries. Some data are available from selected individuals, fisheries or research teams and these are summarized here. Cpue depends on the amount of gear, such as the number of fykenets or the number of hooks per length of longline, and the number of nights that these are fished. Assumptions made here are that the number of nets or hooks fished remained constant. Figure F.2 cpue for different gear types for each river basin district, 2001–2007.

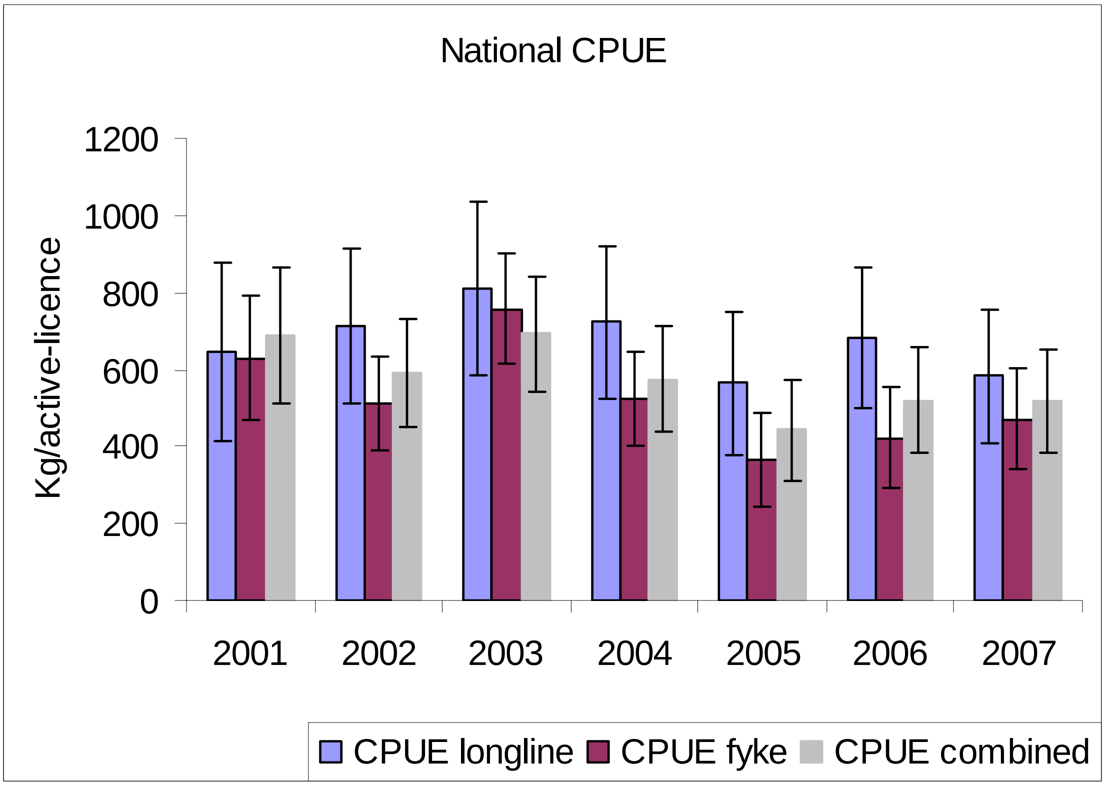


Figure F.1. Brown eel catch per unit of effort for longline, fykenet and combined gear types for the using the national reported catch based on reported actively fished licences.

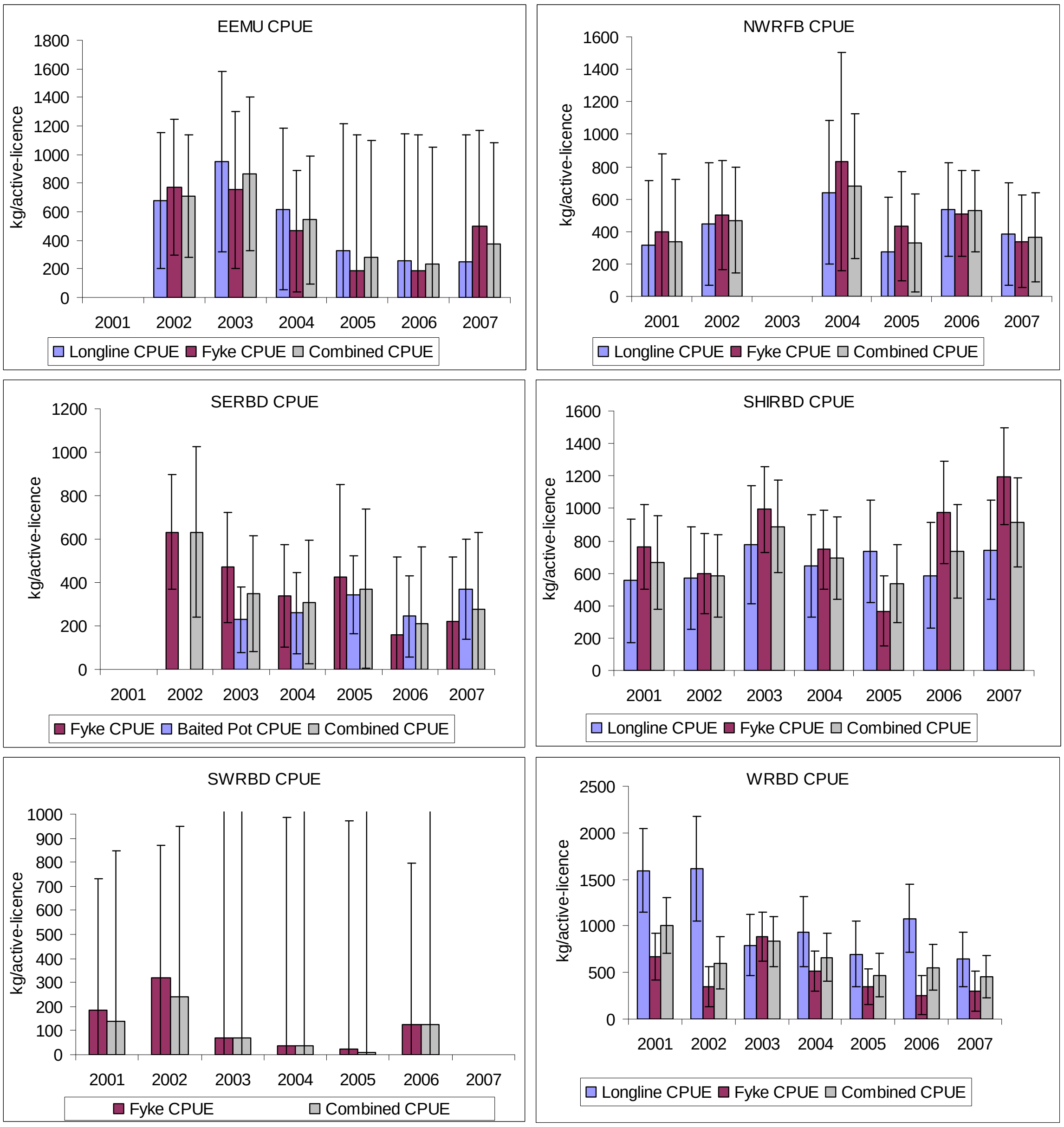


Figure F.2. Cpue for different gear types for each river basin district, 2001–2007. Bars are 95% CI.

IR.G. Scientific surveys of the stock

IR.G.1 National synopsis

There are no national surveys of eel currently taking place-these are not specifically required for eel by the DCR. A small number of research programmes are ongoing and data have been incorporated into the relevant sections of this report. Probably the most important datasets are the recruitment index data for the Shannon and Erne and the long-term silver eel datasets for the Shannon, Corrib and Burrishoole (presented elsewhere in this report).

Since 1992 there has been a comprehensive series of stock assessment surveys and sampling of the River Shannon eel fishery. This Shannon Eel Management Programme has included an extension of the brown and silver eel fishing, the experimental development of glass eel fishing and the improvement of the elver trapping. The focus of the River Shannon study undertaken by NUIG was changed in 2005 and much effort has been devoted to evaluation of alternative sampling protocols. This was done with a view to getting more accurate estimations of brown eel densities in lakes and to establishing the quantity, and quality, of silver eels migrating from selected lakes and through the lower section of the river system.

IR.G.2 Recruitment surveys-glass eel

Monitoring of elver migrating at Ardnacrusha (Shannon), Cathleens Falls (Erne) and for the Feale, Inagh and Maigue Rivers and monitoring of bootlace eel migrating at Parteen Dam (Shannon). Monitoring is carried out at six fixed stations by the ESB and fishing is also undertaken by the ESB/Shannon Regional Fisheries Board in the Shannon Estuary for glass eels (Table G.1). Indications are that recruitment remains low. Catches in 2004 for both Erne and Shannon were the second lowest recorded and although there is no effort data available, the total catch for all stations in 2004 was the lowest yet recorded (Table G.1). Elver and bootlace catches in 2005 were much more unpredictable, with good catches of elvers recorded in the Erne (45% of the 1979–1984 mean) and a poor catch in Ardnacrusha (1.4% of the 1979–1984 mean). The bootlace catch in Parteen was relatively good, almost equal to the mean (641 kg) for the last 20 years. Figure E.1 presents the historical elver monitoring for the Erne and the Shannon (Ardnacrusha).

Elver numbers reported to date for 2008 have been particularly poor and the bootlace numbers for Parteen were the highest since 1988.

All catches reported in Table G.1 are transported upstream and used in restocking.

IR.G.3 Adult eel surveys

There were no coordinated national surveys carried out in 2004, 2005 or 2006. A number of surveys were undertaken by the National University of Ireland Galway and the Electricity Supply Board, the Marine Institute and Trinity College Dublin and the Central Fisheries Board in the NSSHARE project- INTERREG IIIA Programme for Ireland/Northern Ireland. The majority of these are projects in progress, but will yield data compatible with Eel Management Plans and the DCR. See 2007 Country Report for details of the locations sampled.

Table G.1. Glass eel, elver and bootlace (Parteen) catches (kg), 1985 to 2006 (nf = not fished).

		Erne	Moy	Shannon	Shannon				Sh. Estuary
Year	Erne	Estuary	Estuary	Ardnacrusha	Parteen	R Feale	R Maigue	Inagh R	Glass Eels
1985	400			1093	984	503			
1986	700			948	1555				
1987	2300			1610	984				
1988	3000			145	1265				
1989	1800			27	581				
1990	2400			467	970				
1991	500			90	372				
1992	1400			32	464				
1993	1700			24	602				
1994	4400			287	125	70	14		
1995	2100			398	799	0	194		
1996	647			332	95	0	34	140	

		Erne	Moy	Shannon	Shannon				Sh. Estuary
Year	Erne	Estuary	Estuary	Ardnacrusha	Parteen	R Feale	R Maigue	Inagh R	Glass Eels
1997	1087			2120	906	407	467	188	616
1998	723	46		275	255	81	8	11	484
1999	1246	441		18	701	135	0	0	416
2000	1074	188		39	389	174	0	120	43
2001	699		13	27	3	58	2	18	1
2002	113		21	178	677	116	5		37
2003	580		36	378	873	36	72	111	147
2004	269		0	58	320	0	0	24	1
2005	836		13.5	41.4	612	0	1	0	41
2006	118		0	41.5	467	1	0	4	3.1
2007	182		0	45.4	789	0	0	38.5	11.5
*2008	38.7		0	5.80	1256	0	0	82.5	2.31

*** data provisional**

IR.H. Catch composition by age and length

IR.H.1 National synopsis

There is no national sampling programme for age and length of commercial eel catch in Ireland.

IR.H.2 ShRFB Shannon Catchment Programme (Shannon IRBD)

Length measurements are taken annually.

Shannon-Brown eel

Annual surveys undertaken by National University of Ireland, Galway, (1992 to date) involve measurement of subsampled catches of authorized fishing crews, representative of all major lakes in the catchment, and the length frequency distributions are statistically analysed at lake and total fishery levels. Total length data typically involve over 2000 eels per year, and further data are available from fishery-independent and research sampling. Weight and age data, which vary s from year to year, are available for selected zones. Changes in population demography have been recorded. These are mostly as a consequence of poor recruitment but the overall size frequencies are mostly determined by fishing gear selectivity (i.e. fykenet mesh size, longline bait/hook size).

Shannon-Silver eel

Annual surveys, by NUIG (1992 to date), at ESB fishing weirs and of authorized fishing crew catches provide length data for a series of sites located through out the river system. Annual length measurements involve 1500–2000 eels. Sub-samples are used for calculation of length/weight relationships and 200–250 are used for age determinations. Sex ratio changes, reflected in length, weight and age data have been detected. A recent increase in the percentage of males at Killaloe, representing a reversal of a trend noted since around 1985, seems to be as a consequence of changes in fishing intensities in upper vs. lower catchment and selective stocking of the lower part of the catchment.

IR.H.3 NWRFB Burrishoole Catchment (Western RBD)-Silver eel

Monitoring of length of silver eel in the Burrishoole has taken place since 1958, with total trapping since 1970 (Poole *et al*., 1990). Table H.1 gives the length and weight data since 1987 for both the total annual run, and where available for the separate sexes. Age data are presented in Table H.2. The silver eel lengths clearly fit into a bi-modal distribution consistent with males and females (Figures H.1 and H.2). There is a normal distribution of females between 40 and 60 cm with a small proportion of longer females up to 100 cm. Burrishoole eels are generally considered relatively old and slow growing, typical of oligotrophic Irish waters. Growth rates in the more productive waters in Ireland are generally faster than in Burrishoole.

Table H.1. Length and weight for migrating silver eel, Burrishoole. St Er given in brackets.

Year	Sample Type	Sample Size (Lt)	Mean Length (cm)	Min/Max Length	Sample Size (Wt)	Mean Weight (g)	Min/Max Weight (g)
1987	Total	849	44.5 (0.26)	29.7–98.8	849	190.5 (4.6)	48–2523
1988	Total	3003	45.6 (0.14)	28.9–92.9	2996	205.9 (2.3)	37–2240
	Male	1120	37.3 (0.10)	28.9–46.0	1116	97.7 (0.93)	37–210
	Female	1883	50.5 (0.11)	40.5–92.9	1880	270.2 (2.7)	90–2240
1995	Total	1547	46.4 (0.22)	29.1–100.0	263	225.3 (18.1)	45–2700
1997	Total	1022	48.9 (0.27)	25.3–95.0	-	-	-
2001	Total	850	48.9 (0.31)	24.4–95.6	72	208.6 (20.8)	60–1295
2002	Total	732	46.2 (0.35)	24.2–86.1	60	191.1 (16.3)	57–671
2003	Total	649	45.1 (0.37)	29.2–93.9	60	190.4 (15.1)	46–393
2004	Total	382	48.2 (0.45)	31.1–81.7	144	248.0 (11.2)	57–1399
2005	Total	587	48.8 (0.40)	27.3–99.6	581	237.0 (9.1)	35–2545
2006	Total	493	48.0 (0.39)	29.5–87.6	158	242.8 (13.6)	45–1770
2007	Total	571	45.7 (0.39)	27.6–95.2	571	201.4 (13.6)	35–2260

Table H.2. Length and age for migrating silver eel, Burrishoole. St Er given in brackets.

Year	Sample Type	Sample Size (lt)	Mean Length	Sample Size (age)	Mean Age	Age Range Min/Max
1987	Total	80	48.6 (1.0)	58	28.6 (1.1)	12–57
	Male	21	38.9 (0.7)	14	21.5 (1.9)	12–33
	Female	59	52.0 (1.0)	44	30.9 (1.2)	21–57
1988	Total	128	49.2 (1.0)	97	29.0 (0.98)	8–55
	Male	37	39.2 (0.6)	31	21.8 (1.3)	10–41
	Female	91	53.3 (1.2)	66	32.4 (1.1)	8–55
2001	Total	72	45.5 (1.3)	61	23.4 (1.1)	9–45
	Male	36	36.1 (0.4)	28	17.7 (1.4)	9–45
	Female	36	54.9 (1.1)	33	29.1 (1.1)	12–44

2002	Total	60	45.2 (1.4)	54	24.4 (1.2)	7–41
	Male	30	36.1 (0.4)	25	18.0 (1.5)	7–41
	Female	30	54.3 (1.3)	29	30.0 (1.1)	21–41
2003	Total	60	46.1 (1.4)	56	27.5 (1.0)	11–46
	Male	27	35.0 (0.4)	24	22.9 (1.4)	11–33
	Female	33	55.3 (0.5)	32	30.9 (1.1)	20–46
2005	Total	122	48.4 (1.0)	116	27.6 (0.8)	8–58
	Male	44	36.5 (0.6)	42	22.4 (1.5)	8–58
	Female	78	55.0 (0.9)	74	30.5 (0.8)	16–45

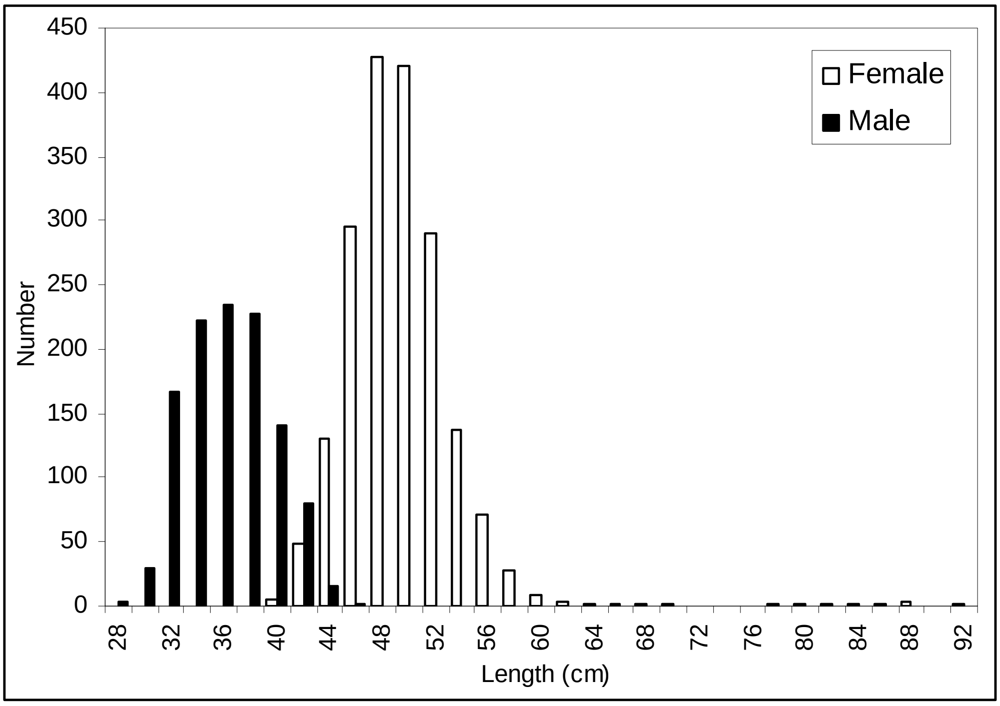


Figure H.1. Length frequency distribution for male and female silver eels in the Burrishoole system, 1988 (n = 3003).

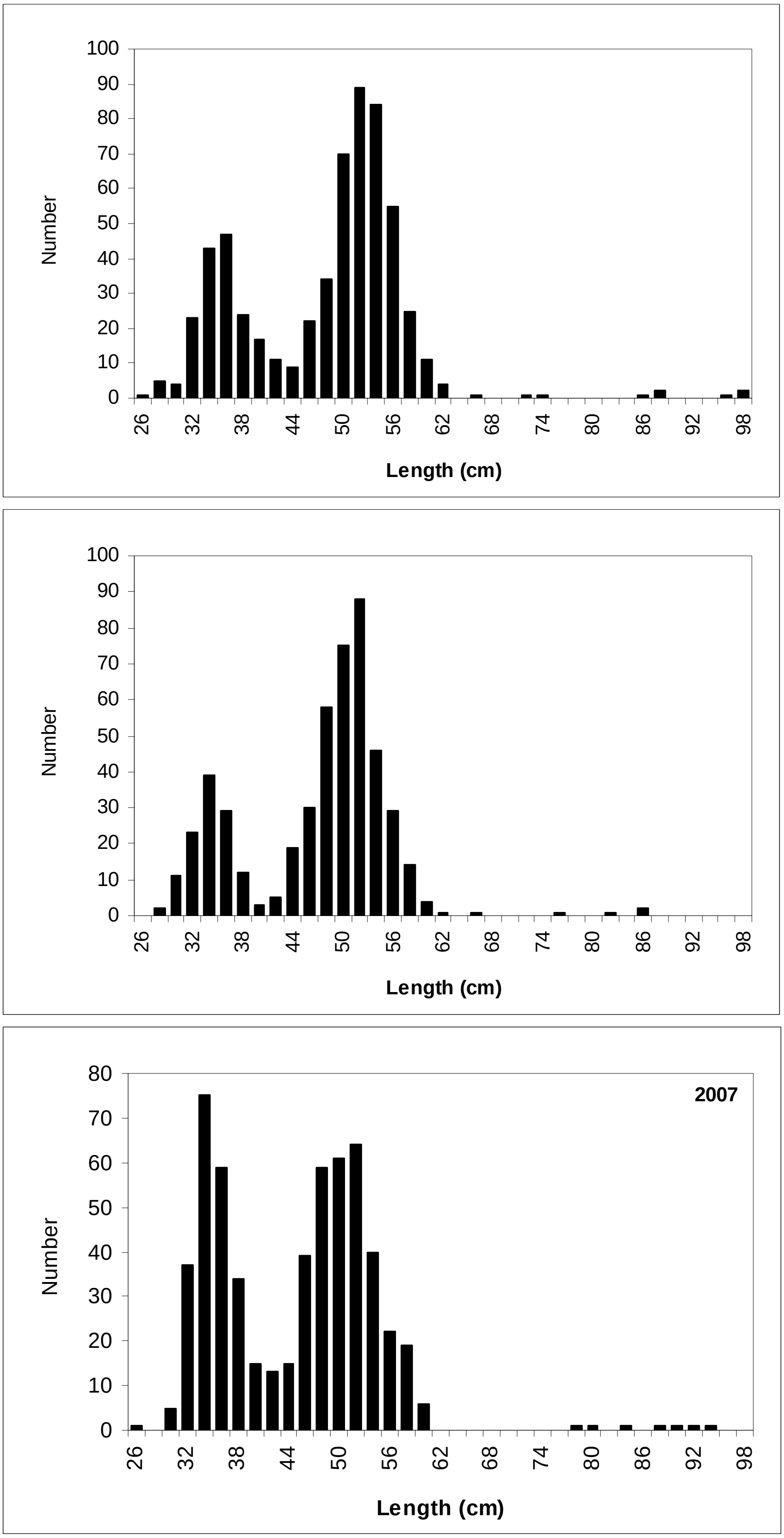


Figure H.2. Length frequency distribution for male and female silver eels in the Burrishoole system, 2005 (n = 587), 2006 (n = 493) and 2007 (n=571).

IR.I. Other biological sampling

IR.I.1 National synopsis

DCR requirement: Samples of length and weight are to be taken every three years for compliance with the DCR.

There is no national programme for sampling other biological aspects of eel in Ireland. A number of catchment based research programmes collect data which may be informative.

IR.I.2 Parasites

Anguillicola crassus was first recorded in Irish eels in the Waterford area in 1997. They were subsequently recorded in the Erne (see below) and this invasion probably occurred between 1997 and 1998, as they were apparently absent in 1996 (Copely and McCarthy, 2005). *Anguillicola* has now also spread to the R. Shannon (McCarthy and Cullen, 2000). A summary of the known distribution of *Anguillicola* in Ireland was compiled in 2003 (McCarthy *et al.*, in press) and the database is currently being updated, following discovery of the species in small and reputedly unexploited western Irish catchments. Current information would indicate that Anguillicola is now present in approximately 50% of the wetted area in Ireland, see map and Figure I.1.

Investigations of parasites assemblages of eels in marine, mixohaline and fresh-water habitats in the Shannon and other Irish rivers are being undertaken by the National University of Ireland, Galway, as part of a research project funded by the Higher Education Authority (HEA PRTLI- 3).

Annual surveys of brown and silver eels in the Shannon fisheries, undertaken since 1992, demonstrate that *Anguillicola* was first detected in 1998 at Killaloe and that since then it has become well established in the lower catchment and that it has more recently spread to lakes further up in the river system.

Eight parasitic endohelminth worm species (2 Cestoda, 3 Nematoda and 3 Acanthocephala) were found in the intestines of 1089 brown eel examined from throughout the Erne system, 1998–2001. Of greatest concern was the discovery of the pathogenic blood-sucking nematode *Anguillicola crassus* in the swimbladder of brown and silver eel from the Erne.

Initially detected in the R. Barrow in 1997, the parasite has since spread to the lower reaches of the R. Shannon and was first recorded from brown eel in southern Lower Lough Erne in 1998 (Evans and Matthews, 1999). By 1999 the parasite was detected as far upstream as L. Garadice with 90% of brown eel from the Narrows, Lower L. Erne infected.

Anguillicola has not been recorded to date in Burrishoole.

Preliminary analysis of information available on the presence of *Anguillicola* in different catchments would indicate that approximately 50% of the wetted area is now potentially infected by the parasite (Figure I.1). Catchments included are:

- Fane
- Slaney
- Barrow
- Nore
- Suir
- Shannon
- Corrib
- Screebe
- Moy
- Ballysadare
- Durnish L., Donegal
- Erne

Map supplied by NUIG

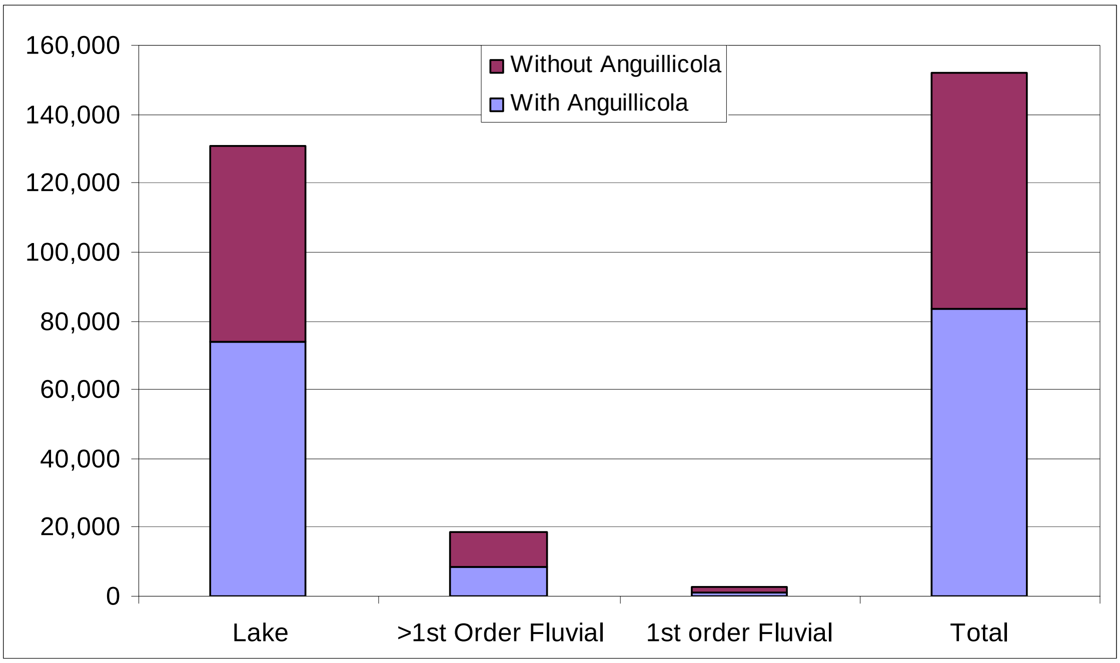


Figure I.1. Proportions of wetted area potentially infected by the *Anguillicola* parasite.

IR.I.3 Burrishoole catchment (Western RBD)-Silver eel

Length and weight are measured for Burrishoole silver eel on an annual basis (Table IR.10). The average weight of the silver eels in the catches has been steadily increasing from 95 g in the early 1970s to 215 g in the 1990s (Figure E.6). The increase in average weight has been caused, at least in part, by a change from a predominantly male sex ratio to more than 60% females in the more recent years (Poole *et al*., 1990).

IR.J. Other sampling

No other sampling for such issues pertinent to eel has taken place in Ireland up to 2004. Some samples have been taken in 2005 and 2007 and these have been analysed for contaminants (PCBs, dioxins, BFRs) and presence of *Anguillicola* (in the EEQD). Further samples have been taken in 2007 and 2008 and these will be analysed for length, weight, sex, age and *Anguillicola*.

IR.K. Stock assessment

There is no nationally coordinated eel stock assessment programme in Ireland and there is also no coordinated use of stock assessment data for the estimation of exploitation or % SPR.

Individual stock assessments are used to inform local fisheries management decisions, such as the R. Shannon Eel Fishery Programme run by the ESB and NUIG.

Waterframework directive surveys-Central Fisheries Board

Stock assessment surveys are being carried out by the CFB and Regional Boards at specified locations in a three year rolling cycle. Seventy-three lakes, 179 sites in rivers and 54 estuaries will be surveyed for fish. The surveys are being conducted using a suite of European standard methods; electric fishing is the main survey method used in rivers and various netting techniques are being used in lakes and estuaries. All fish species are being targeted during the survey and every effort is being made to release fish back to the water, however a subsample of fish is removed for laboratory analysis.

The sampling programme planned for 2008 is extensive and involves surveying 31 lakes, 120 river sites and 43 estuaries. To date 40 river sites and 11 lakes have been surveyed; 10 819 fish were recorded on rivers (732 of which were eels) and 5941 (172 of which were eels) on the lakes. All fish were counted, and a representative sample was measured, weighted and had scales removed for aging purposes. Some fish were retained for further analysis in the CFB laboratory.

The factual information compiled will be of value to the fisheries sector, as it will be used (with other data) to evaluate the effectiveness or otherwise of the pollution control measures in the River Basin Management Plans. The information will also be incorporated into a database and fish species distribution maps will be made available to the public through the WFD website (www.wfdfish.ie).

IR.L. Sampling intensity and precision

Data on sampling intensity, precision, catch composition, etc have not been analysed or compared. Any analysis would have been restricted to the research programme under which the data were collected.

IR.M. Standardisation and harmonization of methodology

IR.M.1 Survey techniques

Fyke Nets

Standard summer fykenets (Matthews *et al.*, 2001; McCarthy *et al.*, 1994; Moriarty, 1975; Poole, 1990, 1994; Poole and Reynolds, 1996a) have been widely used in eel surveys around Ireland since the early 1970s. The nets used have been generally similar in all the surveys, normally fished in chains of five or ten nets. A "typical" summer fykenet consists of two traps (each 3.3 m in length), facing each other, joined by a leader net (8m in length), mesh size 16–18 mm. Each trap consists of two chambers and a codend with knot to knot mesh sizes of 16, 12, and 10 mm respectively. The diameter of the trap entrance was 58 cm and the outer ring of each trap was 'D' shaped.

Catch per unit effort (cpue) data are normally reported in number of eels, or weight, per net (pair of traps) per night fished.

Longlines

Longlines have not been extensively used as a survey tool in Ireland. On the Shannon (McCarthy and Cullen, 2000) longlines have been standardized and the bait is restricted to earthworm allowing some comparisons to be made between fishing areas and years.

River Surveys

In deeper rivers and estuaries, fykenets have been the standard survey tool. In smaller rivers electrofishing is generally employed, despite being fraught with difficulties when applied to eel, with a variety of back-pack portable and bankside generator gear being used. Single pass and three fishing depletion methods are used, but often eel assessments are carried out as a "by-product" of other surveys, in particular salmonid surveys.

IR.M.2 Sampling commercial catches

There is no National programme for sampling commercial catches.

Erne

The survey of the Erne catchment 1998–2001 was carried out using a semi-commercial research team of crews (Matthews *et al.*, 2001). An observer was placed with each crew at least once a week to ensure standardization. Eels were stored in keep nets or boxes similar to those used by commercial fishers. Eels were graded and sold to eel dealers at the lake shore. The entire catch was sampled prior to grading and the fishers were paid full price for undersized eel, before their release.

Shannon

Commercial crews authorized by the ESB sell to eel dealers at lakeside locations on designated dates. ESB staff and NUIG researchers attend at sales points, to monitor catches and to obtain samples for length, weight, age and parasitology analyses. Dealers are required to provide advance notice of their collection schedules. Comparisons are made annually between sales statistics and cumulative catches, reported in logbooks, by the fishing crews. Dealers are required to disinfect truck tanks, monitored by ESB staff, before collections begin and to ensure that no water/potential pathogens are introduced to the river system.

IR.M.3 Sampling

Catch sampling is normally carried out on anaesthetized eel, although some samples may be taken from either freshly sacrificed or frozen samples.

IR.M.4 Age analysis

Age analysis of eel in Ireland has generally followed the methodology of burning and cracking (Christensen, 1964; Cullen and McCarthy, 2003; Hu and Todd, 1981; Moriarty, 1983; Poole and Reynolds, 1996b; Vollestad *et al*., 1988). Otoliths are extracted as described by Moriarty, 1973, stored dry and prepared by burning in either gas or spirit flame. There is no formal validation or quality control in Ireland. Some cross validation and double reading has been carried out between projects and this has ensured some degree of continuity between samples and surveys, (i.e. Moriarty, 1983; Poole *et al*., 1992; Matthews *et al*., 2001; Matthews *et al*., 2003; Maes, unpublished). Comparisons have also been made between age derived growth (back-calculations) and tag/mark recapture determined growth, thereby validating the use of burning and cracking otoliths for age and growth determinations in slow growing Irish eel (Poole and Reynolds, 1996a; Moriarty, 1983).

IR.M.5 Life stages

Glass eel/elver life stages are determined the pigmentation classification using that published by Elie *et al*., 1982.

Brown eel and silver eel are categorized by a combination of capture method and season, colouration and eye size. Silver eels are generally captured during their downstream migration, or can be recognized in the brown eel catch by the enlarged eyes and onset of coloration change.

IR.M.6 Sex determinations

Brown eel <25 cm are problematical to sex and >25 cm up to 45 cm are sexed by dissection. Silver eel are sexed by length and some studies have carried out dissections on eels between ~38 cm and 48 cm in order to determine the length overlap between the sexes.

Histological verification has not been used to any extent in Ireland.

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Report on the eel stock and fishery in Spain 2008

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ES.B. Introduction

In Spain, almost all the eels are fished in estuaries, lagoons, deltas, beaches and rivers. They all belong to different river basins. The river basins are the natural geographic and administrative units for water management. The autonomous regions of Spain (Figure ES.1) are in charge of the management of these water units when they extend only over one of them. The general administration of Spain on the other hand, manages through 8 hydrographical confederations, 8 inter-communitarian basins. Each one included inside various Autonomies (Figure ES. 2).

In this context, the Autonomies are allowed to establish its own regulation concerning eel fishery. Some of them have already developed a regulation in this sense but others not. This fact creates great differences among the Autonomies (Table ES.a.):

- The amplitude of the historical dataseries is variable among the autonomies. It depends on the date in which the regulation of each Autonomy was issued.

- In some Autonomies, the same regulation is applied to all the river basins although in others, each basin or even a particular zone within the same basin has its own regulation. Additionally, even in the same autonomy the fishery is regulated in some river basins but not in others.
- In some Autonomies, fishers are professional and have to sell the catches to the fish market, although in others they are non-professional. In this sense, the precision of the information of the catches and landings differs greatly among those Autonomies.
- Each Autonomy, has its own way of managing the stock: different fishing techniques are allowed and so, some of them use quotas, although others control the effort.
- In the same Autonomy, in many cases, the organizations that are involved in the management of the eel could differ depending on the eel development stages.

TableES.a. Eel fishery regulation of Spanish coastal Autonomies.

	GLASS EEL					YELLOW AND SILVER EEL					
	Control system	Fishing season	Allowed fishing gears	Effort or Catches control	Professional/ Recreational	Control system	Fishing season	Allowed fishing gears	Effort or Catches control	Professional/ Recreational	Observations
Basque Country	L. Only to be used in one river basin.	New moon October–New moon March.	Sieve and Hoe. Boat trawling allowed.	No.	R	L	March 18th–January 31st.	Rods.	From sunrise until sunset. Fishing forbiddden on Tuesdays. 2 rods per fishers. Eels >20 cm	R	Regulation for glass eel issued in 2003. It is obligatory to fill in the Daily Catches report with effort and catches.
Cantabría	L.	October 10th –March 31st.	Squared sieve (Max.:1. 2 m2)	Fishing forbi-dden between Saturday 14:00 and Sunday 18:00. At least 10 ms between fishers. Catches <250 gr in recreational.	R and P (Catches <250 gr).		March 17th–July 21st.	Rods.	Max: 20 eels/ fisher/day	R	
Asturias	L. Fishermen from the Nalón River can fish just in the Nalón River, and the rest of fisher-men can fish in all the rivers except from in the Nalón river.	Fishing season: November 2nd–March 31st. During last seasons it has been shortened.	Squared sieve (Max. : 200 x 60 cms). Boat trawling allowed only in Nalón river basin.	No fishing during week-end. In Nalón river number of licences: 70 from land and 50 from boat.	P	L	End of summer and autumn.	Eel traps.	From sunrise until 1 hour after sunset. Not allowed during the weekend.	P	Glass eel and eel recreational fishery forbidden since 2000 and 2006 respectively.

	GLASS EEL					YELLOW AND SILVER EEL					
	Control system	Fishing season	Allowed fishing gears	Effort or Catches control	Professional/ Recreational	Control system	Fishing season	Allowed fishing gears	Effort or Catches control	Professional/ Recreational	Observations
Galicia	L	Five days before and after the new moon from November until March.	Boat fishing is forbidden and the only allowed gear is a Max. 70 cm opening sieve.	No.	R and P	L	March 19th–August 21st.	Creels. Fixed gears are forbidden.	During all the day. Max. Of 10 creels.	R and P	The glass eel fishing normative can change during the fishing season depending on the evolution of the fishing season.
Galicia Miño*	Land-L from the country where the land is. Land. Boat-L rom eiher Spain or Portugal	Revised three yearly	Wire sieve of 1 to 1.5 m diam. joined to a stick. 2 to 5 mm mesh. conic fishing tackle. 8 m heightx 2,5 m mouth, x10 m length>2 mm mesh. until 2010.	Fishing boats a least 25 m apart from each other to draw the tackle	R and P	L	Revised three yearly	Anchored net with>30 mm mesh, 2 m length x 80 cm width.	Professional from o to 24 h of Sundays forbidden. >20 cm.	R and P	
Andalucía	L	All the year.	Squared sieve (Max. : 0. 80 x 0. 80 m²)	No.	Catches sale allowed.	L	All the year.	Rods and 5 ring creel. First, second and third mesh size of creel 12, 8, and 6 mm respectively.	From 1 hour before sunrise until 1 hour after sunset. 2 rods/fishers. Eels >35 cm.	Catches sale allowed.	
Murcia	No specific legislation					L	All the year	2 rods per fishers.	From 1 hour before sunrise until 1 hour after sunset. Eels >20 cm.	R	

	GLASS EEL					YELLOW AND SILVER EEL					
	Control system	Fishing season	Allowed fishing gears	Effort or Catches control	Professional/ Recreational	Control system	Fishing season	Allowed fishing gears	Effort or Catches control	Professional/ Recreational	Observations
Autonomous region of Valencia	L	October (variable depending on the year) March 31st.	Fyke nets (Mouth max 1. 5 m² and mesh size 1 mm).	From sunset to sunrise of Sunday, Monday, Wednesday and Thursdays. Tuesdays are reserved to take glass eels for restocking and experimentation. The Fyke net can not take up more than a third of the river width.	P*		In waters with trouts from March 21st to August 31st. In waters without trouts all the year.	Rod, with and without hook in recreational and fykenet in professional. Albufera lacuna: fixed place fishing and travelling fixing.	Rod with hook: from 1 hour before sunrise until 1 hour after sunset. Rod without hook: all the day. 1 rod /fishers. Eels >25 cm in recreational.	R and P*	Very dynamic, fishing season changes every year.
Catalonia	L	October 20th–March 10th.	Fyke nets.	Max. 340 Fyke nets and at least 50 m between them.	P	L	Changes every year.	Rods.	During all the day. No light sources allowed. 2 rods per fishers. Eels >35 cm.	R	

L: Licence; L*: Fishermen must be member of a fishers guilt to obtain the professional fishing licence; P: Professional; R: Recreational.

*** International stretch of Miño River between Spain and Portugal.**

Figure ES.1. Autonomies of Spain and their territorial area.

The River Basin Demarcations (RBDs) of Spain are not definitively defined yet. However, the Environmental Ministry of Spain made a proposal, publicized in the Official Bulletin of Spain as the Royal Decree 125/2007 that will be used in the present report (Figure ES.2). Some characteristics of these RBDs are listed in the Table ES.b.

Figure ES.2. Spanish RBDs. The RBDs of Norte, Duero, Ebro, Tajo, Júcar, Guadina, Guadalquivir and Segura are inter-communitarian. Galicia Costa, Basque Country, Catalonia Inner basins, Canary Islands Basins, Balear Islands Basins and South river basin are responsibility of the Autonomies where they flow.

In Spain the glass eel fishery exists in all the RBDs. In the Atlantic, the most important glass eel fishery river basins are the Miño (North I RBD), the Asturian basins (North II), the Basque river basins (Basque inner rivers), and the Guadalquivir. In the Mediterranean, the most important glass eel fishing points are the Delta of the Ebro River (Ebro RBD) and the Valencian Albufera (Jucar RBD). Besides, in Galicia, Valencia and Cataluña, there is an important yellow and silver eel fishery.

For the reasons explained above, the available information from each Autonomy is variable. There is not a national fish stock management plan for eel. Therefore, the compilation of all the data from the different Autonomies, in order to give a national overview of the eel fisheries in Spain, is a very complicated task. For the present report, eel fishery information has been obtained from the following Autonomies:

Basque country

There is not a professional yellow or silver eel fishery, and the catches of recreational fishery are insignificant. On the contrary, the glass eel fishery is a very traditional fishery in the Basque Country and affects to zones associated to river mouths, including beaches, estuaries and river banks. Glass eel fishery is located in most of the river basins of Bizkaia (Artibai, Lea, Oka, Butrón and Nervión-Ibaizabal) and Gipuzkoa (Bidasoa, Oiarzun, Urumea, Oria, Urola, and Deba). Although the glass eel fishery was very traditional, there was not any managing plan for the glass eels until 2001, when the Basque Government, with the advice of AZTI, launched a fisheries monitoring plan. In 2003, a new regulation for glass eel fisheries was issued. It stated that there must be only a license per person and fishing basin and that it is obligatory to fill in the Daily Catches report with data regarding catches and effort. Basque fishers can not sell the catches and therefore should be classified as non professional. The Basque Government collects the information regarding catches, and charges AZTI to analyse this information. In the Basque Country, there is a discrepancy between the issued licenses and the received catches reports. Besides, some of the received catches reports are empty. This is probably because until the 2006–2007 season, the license was free and some people obtained it, although they were not really interested in the glass ell fishing. Besides, there was not a requirement to deliver the old license to obtain the new one, and probably some fishers fish although they did not deliver the catches report. For the 2007–2008 season onwards, the Basque Government has started to charge the license, to avoid that people that are not interested in the glass eel fishing get the license. On the other hand, the government has required the old license and catches report to obtain the new one. In this way, the quality of the data will improve from now on. Finally, some fishers have delivered the catches report after the deadline, and these data have been updated in the present report, and this fact explains the discrepancies between that and the 2007 WGEEL report in data before the 2006–2007 season (ICES, 2007). In the Basque Country there are a lot of little river basins. The river mouths of those basins are included in the Basque Inner river basins RBD, but the upper parts of some of these rivers are included in North II and North III RBDs (Figure ES.2).

Asturias

There is not a professional yellow or silver eel fishery in Asturias, and the recreational fishery was forbidden in 2007. As glass eel is concern, the glass eel fishery is a very traditional fishery in Asturias and affects to zones associated to river mouths, including beaches, estuaries and river banks. The Fisheries General Direction of the Rural and Fishery Department of the Principality of Asturias has provided the data concerning the number of issued licenses and the glass eel sales data in Asturias using fish auctions. There are 18 fishers' guilds in Asturias; in the San Juan de la Arena fishers guild data are available since 1952 and for the other 17, data are available since 1983. In the report from 2006 (ICES, 2006), all the catches from Ribadesella fishers guild were attributed to the Sella River which is the closest one. However, fishers from other eastern rivers of Asturias sell their catches in Ribadesella also, and therefore it is not correct to attribute all the sales of Ribadesella to the Catches of the Sella. In fact, until now, the origin of the sold glass eel must be identified only in the fishers' guilds corresponding to the Nalón River (San Juan de la Arena and Cudillero). Besides, the catches of the Nalón are sold only in the San Juan de la Arena and Cudillero fish markets. So, it is perfectly possible to identify the glass eel from the Nalón. For that reason, from the 2007 report on, the fishery data are split into the Nalón and the "Other Rivers" from Asturias. Moreover, in the Nalón River, there is a specific exploitation plan for glass eel since 2004 that limits the number of licenses to 70 for land fishing and 50 for boat fishing.

Additionally, there is a specific control in this basin, and thanks to this control, information regarding fishing days is available since the exploitation plan started. The rest of fishers guilds are asked to record the glass eel catches of the free zone. It will allow comparing catches and sales as in the exploitation plan. In Asturias there are many little river basins and all of them are included in the North II RBD (Figure ES.2).

Galicia

Both, the glass eel and the yellow and silver fisheries, exist in Galicia. Both are either recreational or professional. The recreational fishery has not been evaluated, neither for eels (angling in fresh water and coastal waters) nor for glass eel (in the estuaries of Lugo province: Masma-Landro-Ouro, and in some rivers of Coruña province: Anllóns). The Miño River is the most important fishing point. The lower part of the Miño River delimits the border of Spain and Portugal and for that reason the permanent International Commission of the Miño is responsible for the management of this part of the river. In the present report, the information collected by the Galician Autonomy is included together with the data from the Miño River. The catches are established using auctions data from the different fishers' guilds, which are assigned to a determined river basin. In this way, the rivers listed below contain catches data from the following fishers' guilds:

- Arousa River: Cambados, Carril, O grove and Rianxo fishers guilds.
- Eo River: Coruña and Ribadeo fishers' guilds.
- Landro River: Barallobre, Celeiro, and Ferrol fishers' guilds.
- Lérez River: Pontevedra and Marín fishers' guilds.
- Verduxo River: Arcade and Vigo fishers' guilds.

On the other hand, the catches from the Ulla River and Miño River are collected by Ximode centre for fishing preserve and Miño River command respectively.

In the Galician fishers' guilds, yellow and silver eel catches are not split up. The information belongs to the Galician Coast RBD and it is obtained from the web of the Galician Government (www.pescagalicia.com) and UTPB (Unidade Técnica Pesca Baixura). The web service is free, and offers statistical and commercial information of several fisheries.

The other river basin mentioned in this report is Miño Basin (Figure ES.2). Almost half of the river basin drainage area is located inside the autonomous region of Galicia. The rest of the area is located among Asturias and Castilla-León Autonomies of Spain, while a little part of the lower basin belongs to Portugal. Eel fishing is regulated according to the autonomous region where fishing is realized. There is an international stretch of Miño between Spain and Portugal. There, the eel fishing is professional and can not be done from land, with exception of those professional fishers that using sieves, fish the glass eel from land (of the country they belong to). The conic tackle is allowed only for 2 years after the publication of the regulation of the international stretch of Miño and until the sand barrier of the Miño estuary is dredged that will facilitate the entry of the migratory species.

Autonomous region of Valencia

The glass eel fishing is only professional although the yellow and silver fishing is either processional or recreational. There are six professional associations of glass eel fishing distributed between the province of Valencia and Castellón; 2 of them are fishers' guilds (El Perellonet and El Molinell). There are two types of professional yellow/silver fishing depending on the province. In the province of Valencia, there are 4 fishing associations: Palmar, Silla, Catarroja and Molinell. First three associations exercise their rights to exploit the yellow and silver eel around the Albufera which is a 738 km^2 costal lacuna between Turia and Jucar rivers. Molinell association fish in Pego-Oliva fen which constitutes an agrarian landscape with a traditional economic activity that supports the surrounding population. It is conceded one license per association. On the other hand, in the province of Alicante, professional fishing is realized in 7 fishing preserves for commercial exploitation. These preserves are located between the wetlands El Hondo (Elche) and the salt flats of Santa Pola, both inside the Natural Park of Albufera.

The eel fishery in the Albufera has its own regulation and it considers both types of fishing, the fixed place fishing (named "redolins") and the traveling fishing. The fishers' community of El Palmar is the fishing organization with the mayor tradition and number of members, and the only one that is allowed to fish in fixed places in the lacuna.

In each fishing preserve of Alicante, a maximum number of fishing tackles (named "mornells") are allowed to those to own a fishing license.

These fishers' guilds gave their catch data to the territorial service of each province, responsible for the continental fishing. Then, Ricardo Garcia, from the Government of the Autonomous region of Valencia, provided this information for the report.

Catalonia

In Catalonia there are two RBDs; the Catalonia Inner river basins, which include small and medium rivers and the Ebro RBD, which is the second large river basin in Spain. Particularly, the delta of the Ebro River is the most important eel fishing point in Catalonia regarding the number of active fishers with license and eel catches.

The data presented in this report was obtained from the fishers guilds belonging to the delta of the Ebro River (province of Tarragona) in one hand, and Muga, Fluviá and Ter Rivers (province of Gerona) on the other. Although the fishery of glass eel is a professional activity, yellow and silver eel fishery are recreational nowadays.

Although the information given in each year report has increased thanks to the contribution of some Autonomies, data from many Autonomies is still missing. Therefore, the total catch of eel in Spain is not given in this report.

Table ES.b. Coordinates of the river basins included in the present report.

Autonomy	RBD	River Basin	Latitude (N°)*	Longitude *	Drainage area (km2)	River length (km)
Basque	B. Inner basins	Bidasoa	43º19'	1º58'W	700	69
	B. Inner basins	Oria	43º16'	2º06'W	882	77
	B. Inner basins	Urola	43º17'	2º14'W	342	65
	B. Inner basins	Deba	43º19'	2º26'W	530	60
	B. Inner basins	Artibai	43º21'	2º29'W	104	26
	B. Inner basins	Lea	43º22'	2º35'W	99	26
	B. Inner basins	Oka	43º21'	2º40'W	183	27
	B. Inner basins	Butrón	43º23'	2º56'W	172	44
	B. Inner basins	Nervion-Ibaizabal	43º19'	3º00'W	1798	72
	B. Inner basins	Barbadun	43º17'	3º07'W	128	27
Asturias	North II	Nalón	48º17'	5º23'W	2692	142
Galicia	G. Coast	Landro	43º4'	7º04'W	268	42
	G. Coast	Eo	43º4'	7º05'W	819	78
	G. Coast	Verduxo	43º2'	8º04'W	176	40
	G. Coast	Lérez	43º2'	8º04'W	594	57
	G. Coast	Arousa	43º4'	8º05'W	2964	132
	Miño	Miño	41º5'	8º52'W	9775	308
Valencia	Jucar	Albufera	39º22'	0º18' E	738	497
Catalonia	Ebro	Delta	40ª41′	0º44′E	85362	910

***The coordinates correspond to the river mouth**

N.D.: No data available.

ES.C Fishing capacity

See Table ES.a. for information regarding fishing gears.

As aforementioned, in the **Basque Country,** there is a discrepancy between the issued licenses and the received catches reports. For that reason, only those licenses that have been received by the Basque Government with the full catches reported are included. It is assumed that the fishers, who have not delivered the catches report, have not gone fishing. Probably, this will underestimate the results. However, if all the issued licenses are included, the error of the overestimation will be bigger than of the underestimation. Most of the licenses in the Basque Country are for land fishing. Boat fishing is concentrated in a few rivers.

The number of fishers has varied from season to season since the glass eel regulation was established. In the 2005–2006 and 2006–2007 seasons 474 and 446 licenses were granted respectively. There is not data available for 2007–2008 yet, because the catches books from the fishers are still arriving. Hence, it cannot be concluded neither an increasing nor a decreasing trend in the number of licenses since 2005.

However, the oldest fishers assert that there has been an important decline in the number of fishers since 1970s to nowadays. This decline has conditioned fishers' activity; some fishers have given up their activity. Other still keep fishing but have reduced the fishing nights.

In the Basque Country, in Aginaga (Oria river basin) there are 6 companies dedicated to the commercialization. One among them is dedicated to the growth of glass eels. The glass eels are bought to the local fishers, then they are transported to the hatcheries in Aginaga. These companies also have hatcheries in Asturias, Valencia, Catalonia, and the Atlantic coast of France where they maintain the glass eels.

The number of licenses in **Asturias** in lower than in the Basque County, but it must be kept in mind that the fishery in Asturias is professional while in the Basque Country is recreational. In Asturias boat fishing is only allowed in the Nalón River, and a maximum of 50 licenses can be issued according to the Nalón exploitation Plan. In this way, the boat licenses are around 50 during last three fishing season (Table ES. c). Although the number of land licenses demonstrated an increase during the previous season, it decreases significantly during the present season.

Table ES.c. Number of glass eel fishing licences per basin and fishing gear in the last three fishing seasons.

			2005–2006				2006–2007				2007–2008			
	RBD	RB	Boat	Land	Ns	Total	Boat	Land	Ns	Total	Boat	Land	Ns	Total
Basque C.	B. Inner	Barbadun	-	6	1	7	-	14	2	16	SC	SC	SC	SC
		Nervion Ibaizabal	-	77	7	84	1	63	4	68	SC	SC	SC	SC
		Butron	5	55	6	66	2	52	10	64	SC	SC	SC	SC
		Oka	-	8	-	8	-	6	-	6	SC	SC	SC	SC
		Lea	-	13	2	15	-	9	3	12	SC	SC	SC	SC
		Artibai	-	5	-	5	-	2	-	2	SC	SC	SC	SC
		Deba	1	111	21	133	4	119	16	139	SC	SC	SC	SC
		Urola	20	9	5	34	16	12	1	29	SC	SC	SC	SC
		Oria	28	77	15	120	27	70	10	107	SC	SC	SC	SC
		Bidasoa	-	2	-	2	-	-	2	2	SC	SC	SC	SC
		Total	54	363	57	474	50	347	48	445				
Asturias	North II	Nalón	50	67	-	117	47	70	-	117	45	49	-	94
		Others	0	204	-	204	0	164	-	164	0	156	-	56
		Total	50	271	-	321	47	234	-	281	45	205	-	250
Valencia	Jucar	L' Albufera	-	-	-	-	-	-	-	-	-	-	-	N.D.
		Total	-	-	-	-	-	-	-	-	-	-	-	168
Catalonia	Ebro	Delta	-	-	-	-	-	-	-	-	-	-	-	N.D.
	C. Inner	Muga, Fluvia, Ter	-	-	-	-	-	-	-	-	-	-	-	N.D.

SC: Still collecting data from fishers for the season 2007–2008.

N.D.: No data available

Ns: Non specified

In the Autonomous region of Valencia, there are approximately 140 fishers fishing glass eel in the Albufera. The number of licenses is higher than the number of fishers. This is because some fishers associations are collaborating partners.

In **Catalonia**, the total catches of glass eel in the inner river basins were collected by 15 fishers.

ES.D Fishing effort

In the Basque Country, the number of fishing hours per fishing season has decreased slightly from 2005–2006 to the 2006–2007 season (Table ES. d). There is not data available yet for 2007–2008 season for a comparative analysis between the last three seasons.

Table ES.d. Number of hours (Basque Country) and days (Asturias and Valencia) dedicated to glass eels fishing during the last three fishing season.

			2005–2006				2006–2007				2007–2008			
	RBD	RB	Boat	Land	Ns	Total	Boat	Land	Ns	Total	Boat	Land	Ns	Total
Basque C. *	B. Inner	Barbadun	-	78	6	84	-	334	22	356	SC	SC	SC	SC
		Nervion Ibaizabal	-	1808	190	1998	16	1318	168	1501	SC	SC	SC	SC
		Butron	290	987	24	1302	67	946	212	1225	SC	SC	SC	SC
		Oka	-	157	-	157	-	97		97	SC	SC	SC	SC
		Lea	-	278	31	308	-	143	40	183	SC	SC	SC	SC
		Artibai	-	117	-	117	-	39		39	SC	SC	SC	SC
		Deba	4	2720	176	2900	22	2919	126	3068	SC	SC	SC	SC
		Urola	1208	186	75	1468	996	325	62	1382	SC	SC	SC	SC
		Oria	1727	1778	225	3730	1576	1400	98	3073	SC	SC	SC	SC
		Bidasoa		24	-	24	-	-	18	18	SC	SC	SC	SC
		Total	3229	8132	727	12 088	2677	7551	745	10 973				
Asturias**	North II	Nalón	1317	1968	-	3285	952	458	-	1410	891	376	-	1267
Valencia**	Jucar	L' Albufera	-	-	-	-	-	-	-	-	-	206	-	-

***: Fishing hours**

****: Fishing days**

SC: Still collecting data from fishers for the season 2007-2008.

Ns: Non specified

In **Asturias**, both the total days dedicated to fish and the days each fisher dedicates to fish have decreased since the preceding two seasons. In the latter season, the time each boat fishers dedicated to fishing have maintained. However, the time each land fisher dedicated to fish increased slightly from the previous season 2006–2007.

In the Autonomous region of **Valencia**, the mean value of the number of days dedicated to fish has been 161.1 days/year in the last 10 years However, the value obtained for the 2007–2008 season is slightly above this mean value.

Table ES.e. Number of fishing hours (Basque County) and fishing days (Asturias and Valencia) per fishers.

			2005–2006			2006–2007			2007–2008		
	RBD	RB	BOAT	LAND	NS	BOAT	LAND	NS	BOAT	LAND	NS
Basque C. *	B. Inner	Barbadun	-	13.0	5.8	-	23.8	11.1	SC	SC	SC
		Nervion Ibaizabal	-	23.5	27.2	16.0	20.9	41.9	SC	SC	SC
		Butron	58.1	17.9	4.0	33.6	18.2	21.2	SC	SC	SC
		Oka	-	19.6	-	-	16.1	-	SC	SC	SC
		Lea	-	21.4	15.3	-	15.9	13.3	SC	SC	SC
		Artibai	-	23.5	-	-	19.3	-	SC	SC	SC
		Deba	4.2	24.5	8.4	5.5	24.5	7.9	SC	SC	SC
		Urola	60.4	20.6	15.0	62.2	27.1	61.7	SC	SC	SC
		Oria	61.7	23.1	15.0	58.4	20.0	9.8	SC	SC	SC
		Bidasoa	-	12.0	-	-	-	9.0	SC	SC	SC
		Average	46.1	19.9	12.9	35.1	20.6	22.0			
Asturias**	North II	Nalón	26	7	-	20	5	-	19.8	7.7	-
Valencia**	Jucar	L' Albufera	-	-	-	-	-	-	-	1.5	-

***: Fishing hours/fisher**

****: Fishing days/fisher**

SC: Still collecting data from fishers

Ns: Non specified

In the Autonomous region of **Valencia,** data of glass eel fishing days from the Albufera between 1981 and 2007 is available although some years are missing. The number of days that the fishers have dedicated to glass eel fishing has ranged from less than 100 days to 200 days. The fishers reached the largest number of fishing days during the 2007–2008 season.

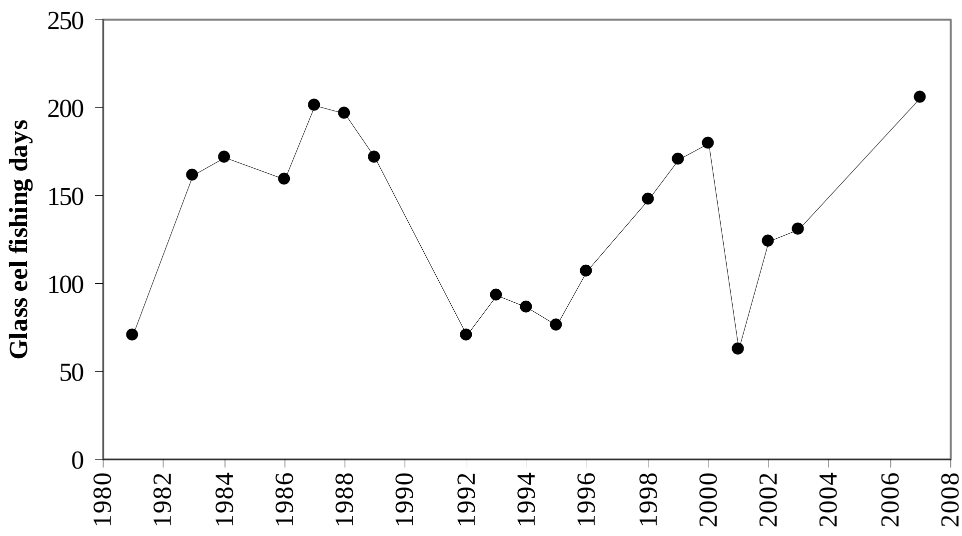


Figure ES.3. Glass eel fishing days in The Albufera.

In **Catalonia**, data regarding the time dedicated to glass eel fishery is not available for the 2007–2008 season.

ES.E Catches and landings

During the short time-series in the **Basque Country,** glass eel catches have been the lowest during the 2006–2007 season. This is because the number of licenses, the hours per license, and the cpues have all decreased (Tables ES.c., ES.d. and ES.h.).

In **Asturias**, there is an important historical dataseries of glass eel catches in the Nalón (see annex) from 50 years ago. The Nalón is the region with more important catches and hence, it could be an adequate indicator of the fishery tendency. However, for the rest of Asturias the data ranges from 1990s to nowadays.

The glass eel catches were stable the first years, then they increased significantly from the 1970s to 1980. From then on the catches were in general regressive. Regarding the last three seasons, the glass eel catches were similar but slightly increasing, from 2005–2006 to 2007–2008.

Table ES.f. Glass eel catches during the last three fishing seasons.

			2005 2006				2006 2007				2007 2008			
	RBD	RB	Boat	Land	Ns	Total	Boat	Land	Ns	Total	Boat	Land	Ns	Total
Basque C.	B. Inner	Barbadun	-	1.6	0.1	1.8	-	5.0	0.4	5.5	SC	SC	SC	SC
		Nervion Ibaizabal	-	127.9	12.6	140.5	0.0	90.9	6.0	96.9	SC	SC	SC	SC
		Butron	15.6	48.9	1.8	66.2	4.9	57.6	8.1	70.6	SC	SC	SC	SC
		Oka	-	11.9	-	11.9	-	7.4	-	7.4	SC	SC	SC	SC
		Lea	-	23.8	3.7	27.5	-	6.4	0.8	7.2	SC	SC	SC	SC
		Artibai	-	2.9	-	2.9	-	0.0	-	0.0	SC	SC	SC	SC
		Deba	0.1	312.3	20.3	332.7	1.0	207.2	7.9	216.0	SC	SC	SC	SC
		Urola	137.6	5.6	6.6	149.9	75.6	7.8	0.6	83.9	SC	SC	SC	SC
		Oria	401.9	129.6	16.3	547.7	239.8	67.7	1.9	309.4	SC	SC	SC	SC
		Bidasoa	-	1.0	-	1.0	-	-	0.1	0.1	SC	SC	SC	SC
		Total	555.2	665.5	61.3	12 82.1	321.2	452.2	25.9	799.3				
Asturias	North II	Nalón	-	-	-	1354. 5	-	-	-	1004. 6	1053.6	330.6	-	1384.2
		Others	-	-	-	820	-	-	-	1261	-	-	-	994.8
		Total	-	-	-	2175	-	-	-	2266	-	-		2379
Valencia	Jucar	L' Albufera	209	-	-	209	-	-	-	N.D.	-	-	-	164.6
Cataluña	Ebro	Ebro	-	-	-	-	-	-	-	-	-	-	-	1170.4
	C. inner	Muga, Fluviá, Ter	-	-	-	-	-	-	-	-	-	-	-	79.1

SC: Still collecting data from fishers.

N.D.: No data available.

Ns: Non specified.

Regarding the yellow and silver eel, the catches of Verduxo (Galicia**)** increased significantly in 2006 in relation to 2005. However, they decreased again in 2007 to a similar level of 2005. In the other Galician rivers, catches of yellow and silver eel decreased in general from the previous seasons to the last 2007–2008 season. Although there is not catches data available for 2006 in the Albufera, the catches in the last season exceed those obtained in 2005 for the same river basin.

Table ES.g. Yellow and silver eel catches (tons) during the last three fishing seasons

			YELLOW			SILVER			TOTAL			
Area	RBD	River Basin	2005	2006	2007	2005	2006	2007	2005	2006	2007	Data source
Galicia	G. Coast	Landro							5. 8	8. 0	2.7	Auctions
	G. Coast	Eo							2. 5	2. 3	2.9	Auctions
	G. Coast	Verduxo							14. 5	43. 0	18.5	Auctions
	G. Coast	Lérez								0. 1	0.01	Auctions
	G. Coast	Arousa							8. 9	9. 7	3.8	Auctions
		Total							30. 1	63 1	28.3	Auctions
A.R. Valencia	Jucar	Albufera	6. 0			1. 5			7. 5		10.67	xxx

The yellow and silver eel historical catches dataseries from the Albufera demonstrates a clear decline that started in the late 1960s. The decline is observed both in yellow and silver eel catches (Figure ES.5). The decline in total eel catches was particularly influenced by the decline in yellow catches.

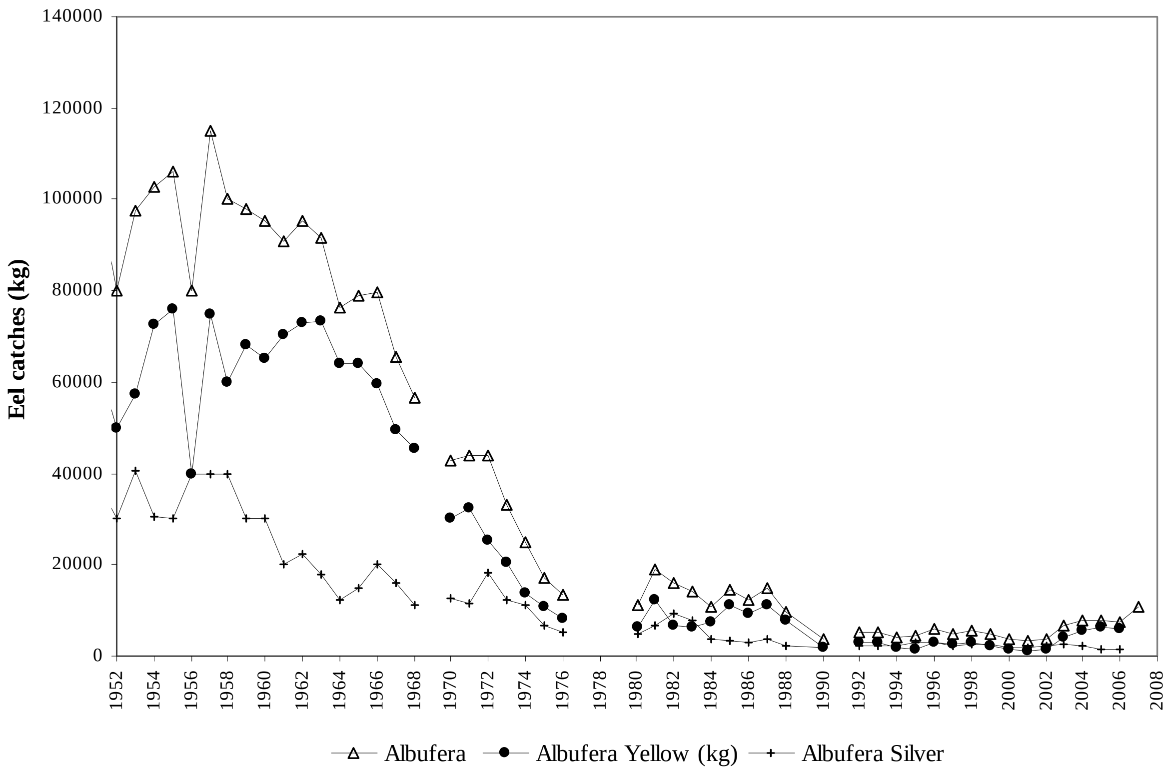


Figure ES.5. Time trends in yellow and silver eel catches in Albufera.

Albufera has been historically an important fishing point for eel in Spain, but nowadays, the catches in Verduxo (Galicia) are higher than in the Albufera. They reached almost half the maximum historical catches of 115 000 kg obtained in the 1950s. However, the catches obtained in Verduxo the last season. 2007–2008 decreased from the previous season but maintain at the same level of the 2005–2006 season (Figure ES.6).

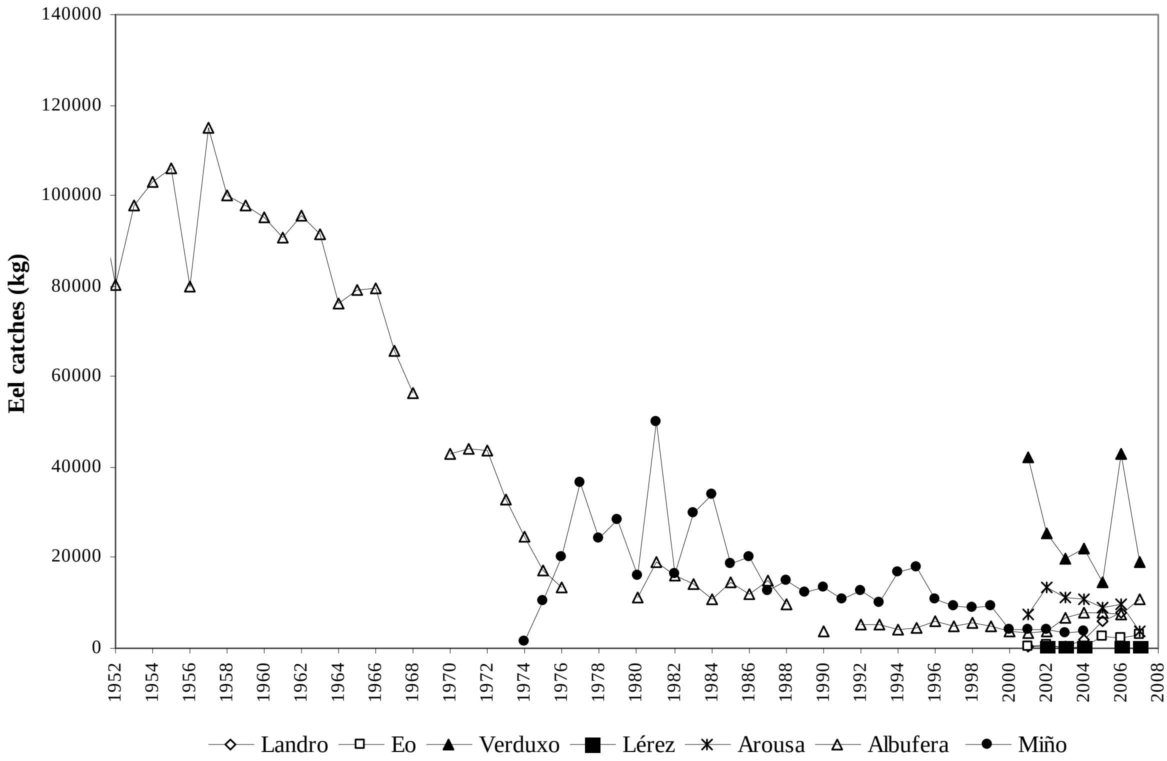


Figure ES.6. Time trends in eel (yellow and silver eels together) catches in some rivers belonging to Galicia river basin, Jucar river basin (Albufera) and Miño Basin.

The catches from Miño experienced an increase in early 1980s. However, they have regressed steadily since late 1980s to 2004. There is no data available for the last four years.

ES.F Catch per unit of effort

The available dataseries of cpues in the **Basque Country** and **Asturias** are not wide enough to detect any trend. However, in **Asturias** glass eel total cpues have slightly increased from the last three seasons (Table ES.h).

In the Albufera the value of the last season cpues of glass eel is 1.25 (Table ES.h). This value is 0.103 of the mean value of the last fishing seasons.

Table ES.h. Glass eel cpues during the last three fishing seasons.

	RBD	RB	2005 2006 BOAT	LAND	NS	TOTAL	2006 2007 BOAT	LAND	NS	TOTAL	2007 2008 BOAT	LAND	NS	TOTAL
Basque C. *	B. Inner	Barbadun	-	0.021	0.019	0.040	-	0.015	0.019	0.034	SC	SC	SC	SC
		Nervion Ibaizabal	-	0.071	0.066	0.137	0.000	0.069	0.036	0.105	SC	SC	SC	SC
		Butron	0.054	0.050	0.073	0.176	0.072	0.061	0.038	0.172	SC	SC	SC	SC
		Oka	-	0.076	-	0.076	-	0.000	-	0.000	SC	SC	SC	SC
		Lea	-	0.086	0.121	0.207	-	0.076	-	0.076	SC	SC	SC	SC
		Artibai	-	0.025	-	0.025	-	0.044	0.020	0.064	SC	SC	SC	SC
		Deba	0.029	0.115	0.116	0.259	-	0.001	-	0.001	SC	SC	SC	SC
		Urola	0.114	0.030	0.088	0.232	0.044	0.071	0.062	0.178	SC	SC	SC	SC
		Oria	0.233	0.073	0.072	0.378	0.076	0.024	0.010	0.110	SC	SC	SC	SC
		Bidasoa	-	0.043	-	0.043	0.152	0.048	0.020	0.220	SC	SC	SC	SC
		Total	0.429	0.588	0.555	1.572	-	-	0.006	0.006	-	-	-	-
Asturias**	North II	Nalón	0.75	0.72	-	1.47	0.74	0.73	-	1.47	1.18	0.88	-	1.98
Valencia**	Jucar	L' Albufera	-	-	-	N.D.	-	-	-	N.D.	-	-	-	1.25

***: Glass eel (Kg)/ Fishing hour**

****: Glass eel (Kg)/ Fishing days**

SC: Still collecting data from fishers

N.D.: No data available

Ns: Non specified

The historical records of the glass eel cpues in the Albufera, measured as glass eel catches per fishing day, demonstrate that the number of glass eel arriving to the Albufera has decreased since 1981 (Figure ES. 7).

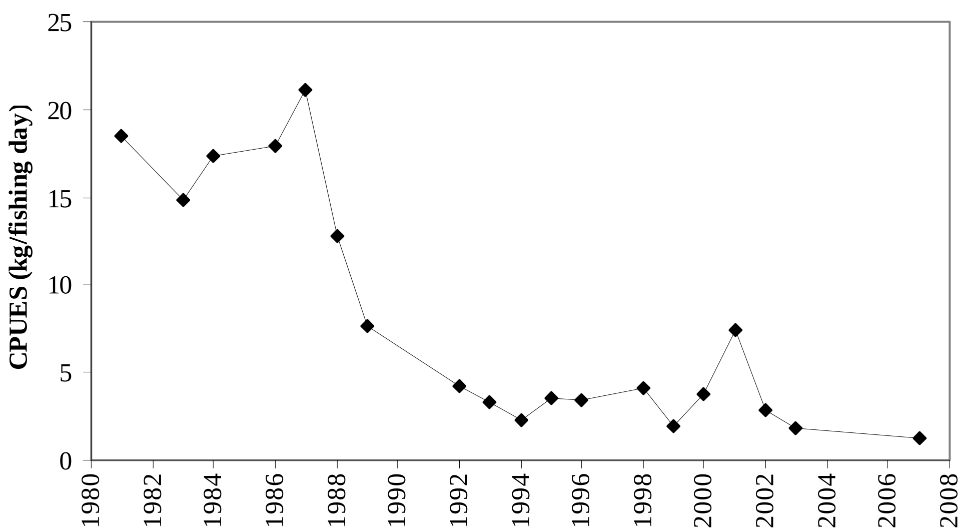


Figure ES.7. Time trends in cpues of glass eels in the Albufera.

ES.G Scientific surveys of the stock

In Spain there is not any national eel specific survey programme. However, there are some researches that have made some work in the subject. Besides, some Autonomies had promoted different studies regarding the eel.

ES. G.1 Recruitment surveys

In the **Basque Country**, during the fishing seasons of 2005–2006, 2006–2007 and 2007–2008 a series of experimental fishing have been made in order to determine the daily recruitment of glass eel in the Oria river basin (Castellanos *et al.*, 2008). Transects to obtain glass eel abundance have been carried out with two different sieves, one of them in the deepest layer and another one in water surface. Transects were performed in the left and right bank of the river as long as the high tide lasted. During these experimental fishing, data regarding filtered water volume and current speed were measured. To determine the recruitment corresponding to the experimental fishing days, the Adour model has been used (Bru *et al.*, 2004). This model is based in the extrapolation of the glass eel biomass obtained in the experimental fishing to the entire river using software designed in S+.

Using fishing notebooks the average daily catches and cpues per fishers are obtained. These two parameters are then related to the values of recruitment, estimated with the Adour model, using a polynomial function. Finally, this polynomial function is used to obtain recruitment data in those days in which only fishery data were available.

The data from 2007–2008 is still colleting and the recruitment is in consequence not yet available. Nonetheless, the recruitment in 2006–2007 was slightly higher than in 2005–2006 (Figure ES. 8).

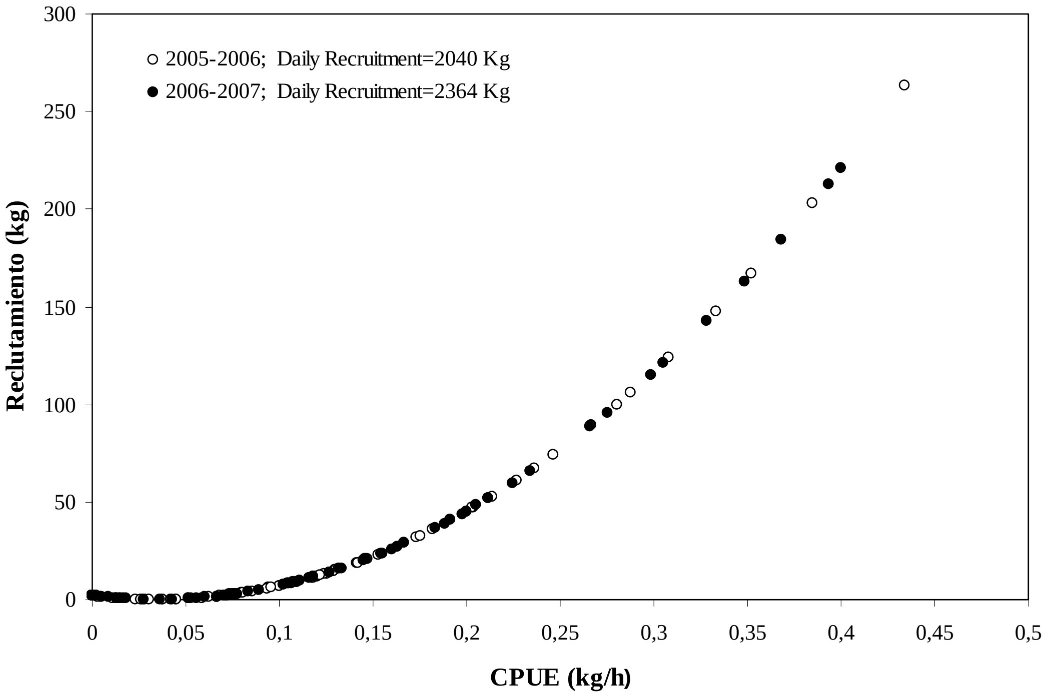


Figure ES. 8. The estimation of daily recruitment using polinomial function of Adour Model. This model correlates real recruitment with the cpues (y = 1656 x2 – 115.1 x + 2.0; r2 = 0.97; n = 10).

In this way, in order to analyse recruitment historical trends in Spain, it is necessary to use the glass eel catches. The oldest dataseries, the one form San Juan de la Arena (Atlantic Sea) and the other from the Albufera (Mediterranean Sea) confirms the decline in glass eel recruitment observed in the rest of Europe (Figure ES. 9). The glass eel data from the Miño go back to early 1980s. These catches were highest around middle 1990s. After then, they began to decline. The values of the latest years are nearly half of the values obtained in the 1990s.

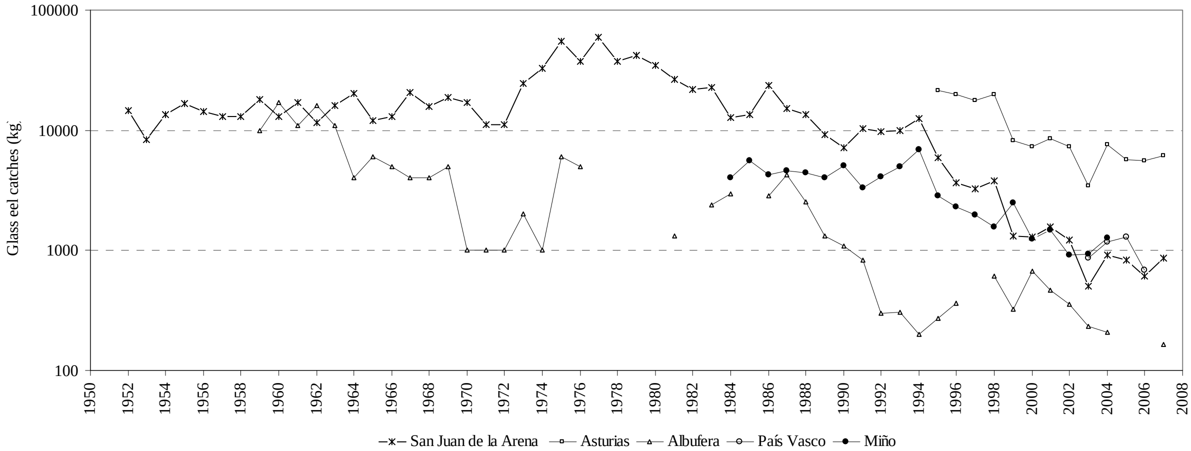


Figure ES.9. Time trends in glass eel sales or catches in different Spanish basins. Note that the scale is logarithmic.

There are no official statistics on commercial glass eel catches in the Guadalquivir river basins as the fishery in this river has not been regulated yet. In this sense, Sobrino *et al.*, 2005 made some samplings along the Guadalquivir River in order to analyse glass eel fishing activity during 1997–1998 and 1998–199 seasons. They then determined glass eel catches and cpues during this period.

Table ES.i. Glass eel catches and cpues (Catches per fishing day) in the Guadalquivir estuary.

	1997–1998					1998–1999				
	No. of boats	Fishing days	Fishing hours	Catch	cpue	No. of boats	Fishing days	Fishing hours	Catch	cpue
Zone I *	1.2	218		-	-	29.3	5333	42 661	1900	0.5
Zone II*	7.8	1420	1747	-	-	29.3	5333	42 661	1800	0.3
Zone III*	15.5	2821	11 357	-	-	15.7	2857	22 859	900	0.3
Total	24.5	4459	22 568	5000	1.1	74.3	13 532	108 181	4600	0.3

Source: Sobrino *et al.*, 2005.

*** : Zone I: upper zone of the river. Zone II: middle part of the river; Zone III: river mouth.**

There is not **restocking** in the **Basque Country** and **Asturias**. In **Catalonia**, a percentage of the glass eels catches should be conserved for restocking. In the A R. of **Valencia**, the old national service for the continental fishing in the early 1940s followed up the study of the eel catches realized in the channels of the Albufera. Regarding the regulation for the glass eel fishing, the glass eel fishers had to release the 10% of their catches over the sluice gates (named "golas" which regulate the level of the Albufera lagoon). This is not this way anymore. From 1989 on, the administration began a re-stocking programme for the eel in the continental waters of the Valencian Autonomy. The centre for the production and experimentation of warm-water fish was established then (Polinyà del Xúquer), where the fishers should give a percentage of the glass eels catches in Albufera and Bullent and Molinell rivers, to be farmed until they reach a weight of 8–10 g.

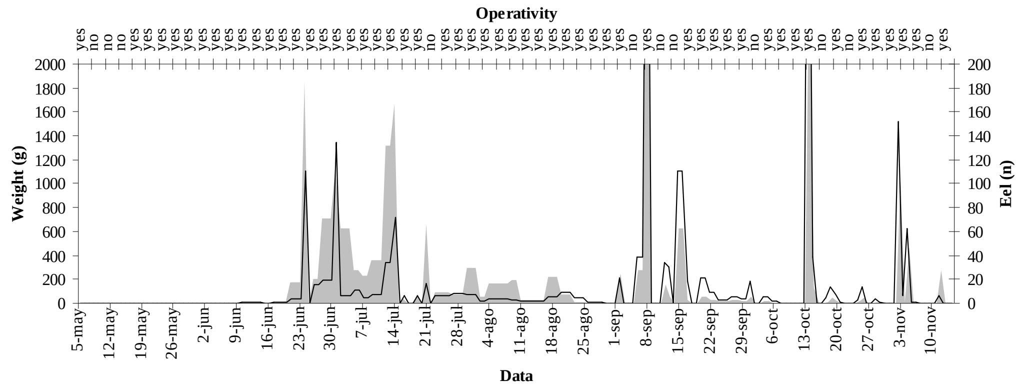
Then the eels are released up in the river waters and wetlands of the Valencia Autonomy and even in other Autonomies. The eel farms must give back to the city council 3000 eels of 8 gr for each Kg of glass eel they have received. There is not data available on the monitoring of the restocking that allows evaluating the success of it.

ES.G. 2 Yellow and silver eel surveys

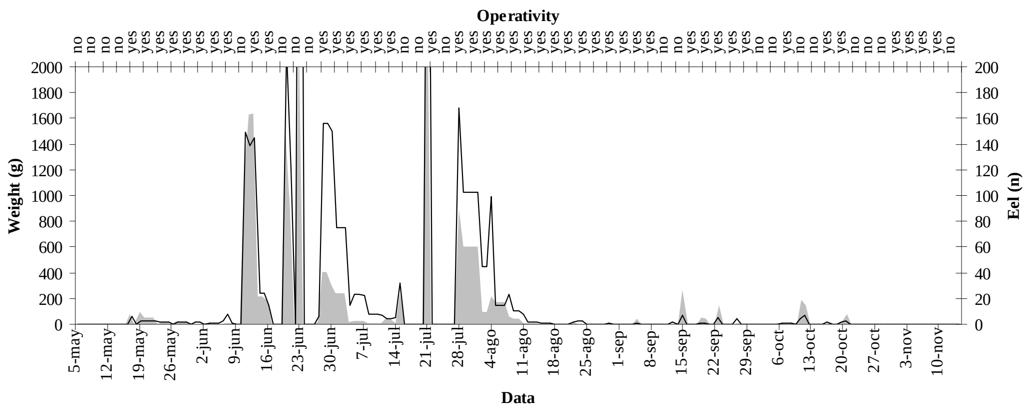
In the **Basque Country,** an ascendant young eel sampling station was installed in September 2004 in the Oria River which will give abundance and fluvial recruitment indices independent of fisheries. The trap was installed in a monitoring station for salmonids, located 11 km from the Oria River mouth in the tidal limit. Although the time-series is not wide enough to extract any conclusion (2005, 2006 and 2007), some general trends can be observed. The young eels start upstream migration in May and finish it in November. During this period, migration is constant but irregular. There are daily peaks of 10 462 g and 1989 individuals (29/08/2007; Figure ES. X).

The number of eels captured has increase since 2005, from 2656 to 3868 and 8960 approximately. But the biomass decreased in 2006 (from 32 106 g in 2005 to 20 939 g in 2006) to increase significantly later in 2007 (60 642 g; Figure ES. 9). This was probably as a result of the accumulation of bigger eels below the trap, caused by the impediment of migration by the dam until the trap was installed.

2005



2006



2007

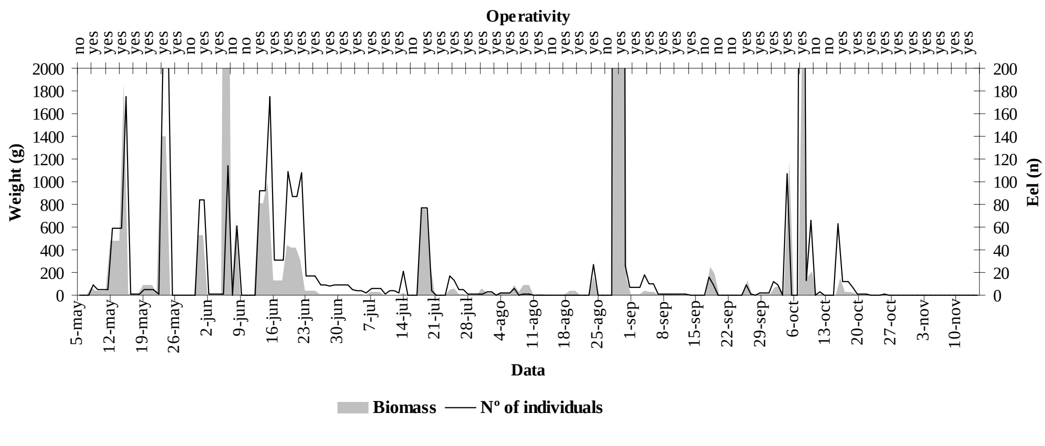
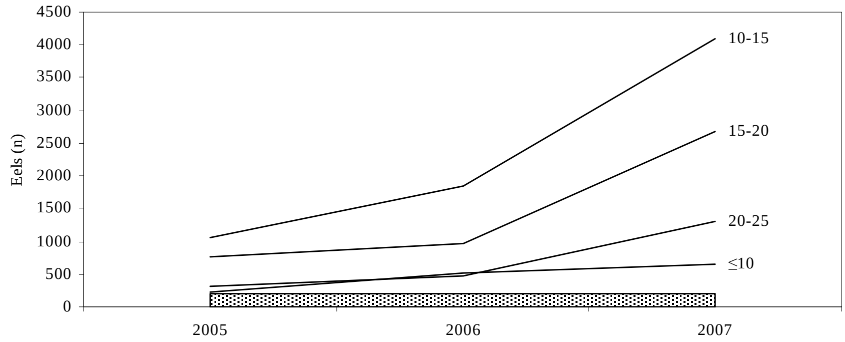


Figure ES. 10. Eel catches evolution in biomass and number of individuals during the migrations seasons of 2005, 2006 and 2007. The operativity indicates the state of the trap when sampling. Yes: active; No: inactive.

In general, there is a decrease in eel migrant size from May on. Eel length classes' frequencies demonstrated that a great proportion of captured individuals in every year belonged to length class of 10–15 cm (Figure ES. 11), which corresponds to individuals that stayed less than one year in the river before reaching the trap. Hence, the application of any restriction adopted to the glass eel fishery should be reflected in the data obtained in the trap the next year. On the other hand, the presence of the individuals belonging to the major length class was higher during 2005 than 2006 and 2007; probably as a consequence of the accumulation of individual below the dam before the pass was installed, as explained above.

(a)



(b)

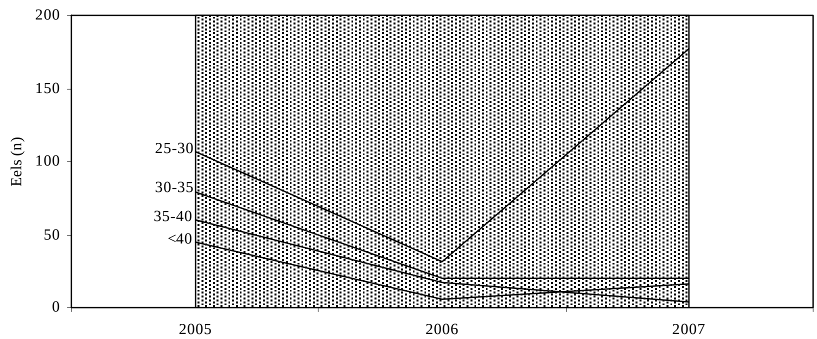


Figure ES.11. Temporal evolution of eel length classes captured in the tramp of the Oria River basin during 2005. 2006 and 2007. (a) ≤10; 10–15; 15–20; 20–25 and (b) 25–30; 35–40; ≥40. Note that the shadow area in (a) correspond to graphic area in (b).

In **Galicia**, the descendant eel length and weight data has been collected since 1993 from the trap located in Ximode preserve centre in the Ulla River, which flows into of the Arousa estuary. In general, the highest frequencies were obtained those yellow eels measuring 20–25cm and silver eels of 35–40 cm for almost every year, with a maximum number of individuals in 2001for both eel stages (Figure ES 12 a, b).

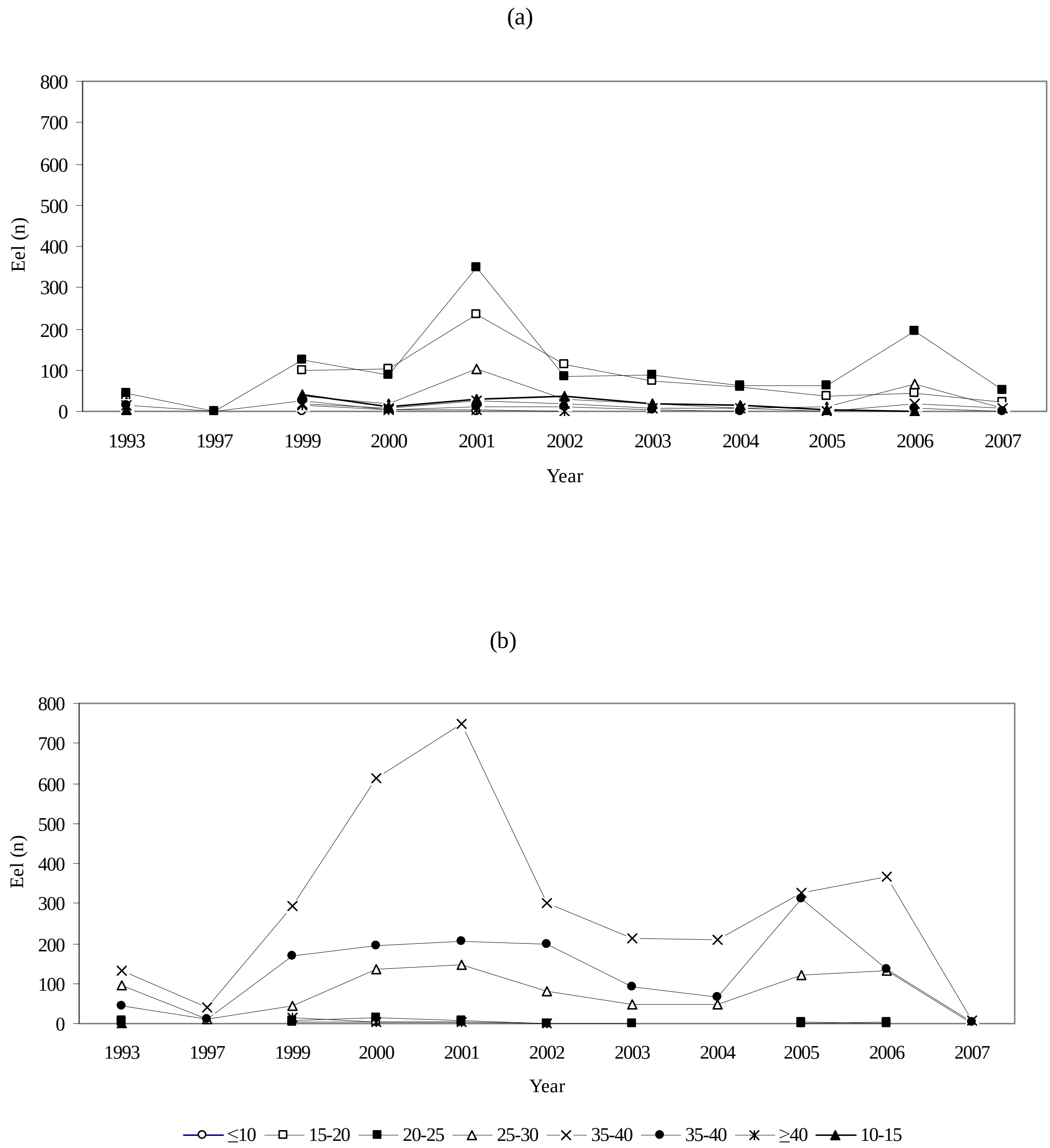


Figure ES.12. Temporal evolution of yellow (a) and silver eel (b) length classes (cm) captured in the trap of Ximode in the Ulla River.

The largest number of descending eels was reached in 2001 for almost all the size classes. On the contrary, the smallest number was obtained in 2007.

In **Asturias,** Javier Lobón has been monitoring the yellow and silver eel in the Esva basin since 1986 (Lobon-Cervia, *et al*., 1990; Lobon-Cervia and Carrascal, 1992; Lobon-Cervia *et al*., 1995; Lobon-Cervia, 1999).

In **Castilla la Mancha**, the Historical Evolution of the eel has been studied by Marin *et al*., 1994**.**

ES.H Catch composition by age and length

No information available.

ES.I Other biological sampling

ES.I.1 Length and weight and growth (DCR)

As mentioned above, in Spain there is not any national eel specific surveys programme. In the Spanish National Programme proposal for 2007 (http://datacollection. jrc. cec. eu. int/nationalprog. php?y=2007) Spain has asked for an exemption to sample eel based on the low discards. However, the bulk of the eel catches are monitored by the autonomous governments of the different Spanish regions as mentioned above, but these data are not centralized, and therefore, in Spain total eel catches are unknown.

ES.I.2 Parasites

Some studies have been carried out regarding the presence of *Anguillicola crassus* in rivers form Spain (Table. ES.j). These studies have demonstrated that the parasite is widespread in Spain. However, there are still some rivers **in Asturias** and **Galicia** that have not been colonized yet; therefore special measures should be taken to avoid the infection of these basins. It is difficult to follow the sequence of A. crassus introduction in Spain since the first data we have is from 2000 and probably the nematode arrived before that data. However, it looks like in the Mediterranean the presence of the parasite is lower than in the Atlantic (lower prevalence, intensity and abundance). In the **Basque Country**, comparing the results of Gallastegi *et al*., 2002 in the Butron in year 2000, with those of Díaz *et al*., 2007 in the Basque rivers in 2006, we can see that there is an increase in the prevalence of the parasite, but that the infection intensity has decreased.

ES.I.3 Contaminants

Although there is not any specific survey to analyse the presence of contaminants on eel, eel is sometimes among the species included in the biomonitoring of water masses made by the public administrations. Additionally, in some studies that evaluate the contamination in the biota, the eel is among the studied species. In this way, information regarding PCBs, pesticides and heavy metals bioaccumulation in eels from rivers of the Basque Country (Sanchez *et al*., 1997), from the river Ebro (Santillo *et al*., 2006), river Miño (Santillo *et al*., 2006), river Jucar (Bordajandi *et al*., 2003) and river Guadalquivir (Usero *et al*., 2003) is available. Few studies represent a specific survey to analyse the presence of contaminants in eel, as heavy metals determination in eels from the Albufera lacuna (Alcaide and Esteve, 2007). These authors concluded that among the tested HM. bioaccumulation of Cd, Hg, Zn, and Cu in liver tissue is related to the age/length of individuals [W and B values; $p \leq 0.01$] and so recommendations are remarked on standardization on length and/on age of the eels used in such studies (Alcaide and Esteve, 2007). On the other hand, Ureña *et al*., 2007 concluded for the same location of the latter study that the eels with similar length demonstrate different pattern of metal distribution among tissue depending on there are from the wild or farmed.

ES.I.4 Predators

In 1996 there were 35 000 great cormorants (*Phalacrocorax carbo sinensis*) ovewintering in Spain, by 2003 the population increased by 96% (DelMoral and DeSouza, 2004).

Regarding the impact of this species in eels, the Cantabrian Goverment carried out a study in which they analysed the gut content of cormorants (Serdio, 2005). In that study, it was concluded that salmonids were the most consumed prey by cormorants, and that they had a high impact in trout population. However, the presence of eel in the cormorant diet was not very important (Table ES.k.). The same happened in the Mediterranean Santa Pola Lagoon, where eel constituted the 1% of the diet of the cormorants about numbers and the 0.4% about biomass. In fact, the diet of cormorants was mainly composes of mugilids (Olmos *et al.*, 2000).

Table ES.j. Prevalence, infection intensity and abundance of *Anguillicola crassus* in different basins from Spain.

	River/Lake	Lat	Long	Year	N eels	Mean Size(cm)	N sites	N sites infected	Prevalence	Infection intensity	Abundance	Reference
Jucar	**Albufera**	**39º20' N**	**0º20' O**	**2003/04/05**	**45**	**29. 6**	**-**	**-**	**6**	**0.33**	**0. 18**	**Esteve and Alcaide, 2007**
Jucar	**Albufera**	**39º20' N**	**0º20' O**	**2003/04/05**	**46**	**39. 7**	**-**	**-**	**15**	**2. 4**	**0. 58**	**Esteve and Alcaide, 2007**
Jucar	**Albufera**	**39º20' N**	**0º20' O**	**2003/04/05**	**31**	**56. 7**	**-**	**-**	**13**	**1**	**0. 32**	**Esteve and Alcaide, 2007**
B. inner	**Urumea**	**43º19'N**	**1º58' O**	**2006**	**10**	**28. 9**	**1**	**1**	**70**	**4.3**	**3. 0**	**Díaz *et al.*, 2006**
B. inner	**Oria**	**43º16' N**	**2º06' O**	**2006**	**24**	**34. 7**	**4**	**3**	**25**	**3.8**	**1. 0**	**Díaz *et al.*, 2006**
B. inner	**Urola**	**43º17'N**	**2º14' O**	**2006**	**1**	**59. 5**	**1**	**0**	**0**	**0**	**0. 0**	**Díaz *et al.*, 2006**
B. inner	**Artibai**	**43º19' N**	**2º26' O**	**2006**	**34**	**25. 0**	**1**	**1**	**64. 7**	**2.8**	**1. 8**	**Díaz *et al.*, 2006**
B. inner	**Lea**	**43º21' N**	**2º29' O**	**2006**	**13**	**19. 9**	**1**	**1**	**15. 4**	**2**	**0. 3**	**Díaz *et al.*, 2006**
B. inner	**Ea**	**43º22' N**	**2º35' O**	**2006**	**28**	**23. 6**	**1**	**1**	**42. 9**	**2.7**	**1. 1**	**Díaz *et al.*, 2006**
B. inner	**Oka**	**43º21' N**	**2º40' O**	**2006**	**54**	**28. 3**	**3**	**3**	**44. 4**	**2.3**	**1. 0**	**Díaz *et al.*, 2006**
B. inner	**Estepona**	**43º25' N**	**2º48' O**	**2006**	**29**	**32. 4**	**1**	**1**	**48. 3**	**3.3**	**1. 6**	**Díaz *et al.*, 2006**
B. inner	**Butrón**	**43º23' N**	**2º56' O**	**2006**	**5**	**31. 7**	**1**	**1**	**60**	**1.7**	**1. 0**	**Díaz *et al.*, 2006**
B. inner	**Butrón**	**43º23' N**	**2º56' O**	**2000**	**90**	**32. 1**	**1**	**1**	**7. 8**	**9**	**0. 7**	**Gallastegi, *et al.*, 2002**
B. inner	**Nervión**	**43º19' N**	**3º00' O**	**2006**	**63**	**32. 6**	**4**	**4**	**44. 4**	**2.6**	**1. 2**	**Díaz *et al.*, 2006**
B. inner	**Barbadun**	**43º17' N**	**3º07' O**	**2006**	**28**	**27. 3**	**1**	**1**	**28. 6**	**1.9**	**0. 5**	**Díaz *et al.*, 2006**
North II	**Cares**	**43º19' N**	**4º36' O**	**2006**	**46**	**29. 6**	**-**	**-**	**0**	**0**	**0**	**Aguilar *et al*. 2005**

	River/Lake	Lat	Long	Year	N eels	Mean Size(cm)	N sites	N sites infected	Prevalence	Infection intensity	Abundance	Reference
North II	Bedón	43º26' N	4º52' O	2006	25	28. 0	-	-	0	0	0	García pers. Comm., 2006
North II	Sella	43º27' N	5º 03' O	2006	204	27. 6	-	-	51. 2	3.8	1. 9	García pers. Comm., 2006
North II	Sella	43º27' N	5º 03' O	2006	23	32. 8	-	-	34. 8	4.6	1. 6	García pers. Comm., 2006
North II	Villaviciosa	43º31'N	5º23' O	2006	20	17. 4	-	-	60	1.7	1	García pers. Comm., 2006
North II	Nalón	43º33' N	6º04' O	2006	75	28. 8	-	-	50. 7	1.9	1	García pers. Comm., 2006
North II	Esva	43º32' N	6º27' O	2006	20	25. 5	-	-	0	0	0	García pers. Comm., 2006
North II	Porcía	43º33' N	6º52' O	2006	15	20. 1	-	-	0	0	0	García pers. Comm., 2006
North II	Eo	43º31' N	7º02' O	2006	45	38. 3	-	-	0	0	0	García pers. Comm., 2006
G. coast	R. Tea	42º05' N	8º21' O	1999/2000	200	-	-	-	55. 5	5. 5	3. 05	Aguilar *et al.*, 2005
G. coast	R. Ulla	42º39' N	8º44' O	1999/2000	323	-	-	-	0	0	0	Aguilar *et al.*, 2005

Table ES.k. Presence of eel in the diet of eel in Cormorants from Cantabria.

			N	Full gut	Ingested preys/ day	Ingested biomass/ day	Trophic diversity	F (%)	P (%)	BM (%)
Ason	**43º20' N**	**3º25' O**	**14**	**13**	**5.1**	**327.2**	**1.3**	**7.7**	**3**	**6.9**
Pas-Pisueña	**43º23' N**	**3º58' O**	**6**	**3**	**7**	**176.5**	**0.9**			
Besaya	**43º20' N**	**4º04 O**	**14**	**14**	**15.1**	**262.8**	**1**	**7.1**	**0.5**	**6.6**
Saja	**43º21' N**	**4º07 O**	**12**	**8**	**3.7**	**670.9**	**0.8**			
Deva	**43º06' N**	**3º12' O**	**5**	**5**	**4.2**	**398.3**	**1.1**	**20**	**4.8**	**1.5**
Ebro	**42º55' N**	**4º01' O**	**37**	**31**	**15.5**	**205**	**0.9**			

Trophic diversity according to Shannon-Weaver

F: Frequency of presence of eel in the diet (%)

P: Percentage of eel in relation to the total consumed fish

BM: Percentage of the species in the total consumed biomass

ES.J Other samplings

Researchers of the University of Valencia have studied the incidence of infectious diseases in the Albufera´s eel population (Jucar basin, Valencia), through a 3-years period (from October 2003 to July 2005. They analysed 122 individuals of different growth stage (Durif *et al.*, 2005) and health condition and observed that eels suffer from acute diseases such as those produced by highly virulent bacteria belonging to *Edwardsiella tarda* and *Vibrio vulnificus* species (Alcaide *et al.*, 2006; Esteve *et al.*, 2007; Esteve and Alcaide, 2007). *Edwardsiella tarda* disease was present along the study period with a prevalence ranging from 5.6 to 27.8% in the nine surveys performed (Esteve and Alcaide, 2007). *Vibrio vulnificus* disease had a sporadic incidence during the study; it was detected in November 2003 with a very high prevalence of 77.2% (Esteve *et al*., 2007). In addition, chronic and mixed infections caused by weakly virulent bacteria (*Aeromonas* sp. and *Pseudomonas* sp.) and fungi (*Saprolegnia* sp.) were observed along the study period with a prevalence ranging from 10.5 to 22.2% in the nine surveys performed (Esteve and Alcaide, 2007). In fact, authors remarked that pathogenic bacteria may play a leading role in the decline of Albufera´s eel population as the prevalence of each bacterial disease was at the same level than that observed for the swimbladder parasitic disease (Esteve and Alcaide, 2007).

Interestingly, the correlation between the sanitary status of an eel [Healthy; Acute bacterial disease; and Chronic disease] and its growth stage [Young Yellow; Sexually differentiated Yellow; and Mature Silver] was statistically significant: observed number of both "young yellow eels which present acute bacterial disease" and "silver eels which present chronic illness" notably exceed those expected [Pearson X^2= 10.812; *P*(4 d.f.)= 0.029] (Esteve and Alcaide, 2007). Thus, authors suggested that youngest eels could suffer high mortality rates in the natural habitat (Albufera lacuna), and that low quality of mature adults could reduce their survival along the downstream migration to the sea.

ES.K Stock assessment

There is no general advice on eel management in Spain. Each Autonomy has his own regulation regarding eel fisheries, and some Autonomies don't have any regulation. For the Basque Country, a group coordinated by AZTI-Tecnalia has been created including the Deputations of the three provinces (Gipuzkoa, Araba and Bizkaia), and The Basque Government, that has already started to work in the design of an eel management plan. Besides, some meetings have been held with technicians from the Northern Coastal Autonomies of Spain (Basque Country, Cantabria, Asturias, and Galicia) regarding eel management plans.

ES.L Sampling intensity and precision

No works has been done in this subject until now.

ES.M Standardisation and harmonization of methodology

No work has been done in this subject until now.

ES.N Overview, conclusions and recommendations

As mentioned above, in Spain, each autonomous government is in charge of the control, regulation and management of the eel fishery and population. Apart from the present report, there is not any global study or sampling programme for compiling information (fishery data, biological information etc.) from each the Spanish region, in order to give a Spanish national overview of the eel situation.

For that reason, and considering the new EC regulation proposal for eel, it is proposed the inclusion of eel in the Spanish National Data Collection Programme. Besides, it is considered that a special effort should be carried out in order to compile information regarding eel population in the whole of Spain; then, develop a national management plan for eel in base of it.

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Table ES.l. Glass eel catches (kg) in Spain from 1952 on.

Year	B. Country*	San Juan de la Arena**	Nalón**●	Rest of Asturias**	Asturias**	Miño***	Guadalquivir†	Albufera**	Delta Ebro*	Rest of Catalonia*
1952		**14 529**								
1953		**8318**								
1954		**13 576**								
1955		**16 649**								
1956		**14 351**								
1957		**12 911**								
1958		**13 071**								
1959		**17 975**						**10 000**		
1960		**13 060**						**17 000**		
1961		**17 177**						**11 000**		
1962		**11 507**						**16 000**		
1963		**16 139**						**11 000**		
1964		**20 364**						**4000**		
1965		**11 974**						**6000**		
1966		**12 977**						**5000**		
1967		**20 556**						**4000**		

Year	B. Country*	San Juan de la Arena**	Nalón**●	Rest of Asturias**	Asturias**	Miño***	Guadalquivir†	Albufera**	Delta Ebro*	Rest of Catalonia*
1968		15 628						4000		
1969		18 753						5000		
1970		17 032						1000		
1971		11 219						1000		
1972		11 056						1000		
1973		24 481						2000		
1974		32 611						1000		
1975		55 514						6000		
1976		37 661						5000		
1977		59 918								
1978		37 468								
1979		42 110								
1980		34 645								
1981		26 295						1309		
1982		21 837								
1983		22 541			30 804			2387		
1984		12 839			15 911	4027		2980		
1985		13 544			14 229	5534				
1986		23 536			22 219	4282		2845		
1987		15 211			27 417	4627		4255		
1988		13 574			13 500	4468		2513		
1989		9216			14 309	4037		1322		
1990		7117			7515	5075		1079		
1991		10 259			7660	3313		831		
1992		9673			12 990	4126		300		
1993		9900			10 109	4960		303		
1994		12 500			14 307	6866		199		
1995		5900	6117	1850,8	7751	2843		271		
1996		3656	5302	3673,4	7329	2296	5000	366		

Year	B. Country*	San Juan de la Arena**	Nalón**●	Rest of Asturias**	Asturias**	Miño***	Guadalquivir†	Albufera**	Delta Ebro*	Rest of Catalonia*
1997		**3273**	**4723**	**3241,3**	**6514**	**1980**	**4600**		**3125**	
1998		**3815**	**5572**	**3297,9**	**7113**	**1580**		**616**	**2905**	
1999		**1330**	**2039**	**1728,5**	**3058**	**2503**		**323**	**1518**	**401**
2000		**1285**	**1839**	**1446,3**	**2732**	**1254**		**678**	**4644**	**368**
2001		**1569**	**2305**	**1535,7**	**3105**	**1474**		**466**	**6964**	
2002		**1231**	**1793**	**1538,6**	**2770**	**918**		**357**	**3850**	**357**
2003	**858**	**506**	**764**	**845,6**	**1351**	**935**		**233**	**3577**	**283**
2004	**1181**	**914**	**1835**	**1961,0**	**2875**	**1277**		**209**	**1238**	
2005	**1282**	**836**	**1355**	**1339,3**	**2175**				**2065**	**147**
2006	**799**	**615**	**1005**	**1650,2**	**2266**				**1313**	**148**
2007	**SC**	**871**	**1423**	**1508,0**	**2379**			**165**	**1170**	**86**

***Data from catches report; ** Data from auctions; † Sobrino *et al.*, 2005; ***Data from river command corresponding to Spain and Portugal.**

● In the Nalón River, data from San Juan de la Arena and Cudillero guilds is included.

SC: Still collecting data from fishers.

Table ES.1 Yellow and silver eel catches in Spain from 1950 on

Table ES.1. Yellow and silver eel catches (kg) in Spain from 1950 on.

	Landro*	Eo*	Verduxo*	Lérez*	Arousa*	Miño**	Albufera*		
Year	Yellow + silver						Yellow	Silver	Yellow + silver
1950							60 000	30 000	90 000
1951							64 200	38 000	102 200
1952							50 000	30 200	80 200
1953							57 300	40 400	97 700
1954							72 500	30 400	102 900
1955							75 860	30 260	106 120
1956							40 000	40 000	80 000
1957							75 000	40 000	115 000
1958							60 000	40 000	100 000
1959							68 000	30 000	98 000
1960							65 300	30 040	95 340
1961							70 500	20 200	90 700
1962							73 000	22 400	95 400
1963							73 500	18 000	91 500
1964							64 000	12 300	76 300
1965							64 000	15 000	79 000
1966							59 500	20 000	79 500
1967							49 600	16 000	65 600
1968							45 300	11 200	56 500
1969									
1970							30 250	12 600	42 850
1971							32 400	11 612	44 012
1972							25 500	18 300	43 800
1973							20 600	12 428	33 028
1974						1650	13 612	11 210	24 822
1975						10 600	10 620	6570	17 190
1976						20 000	8260	5300	13 560

	LANDRO*	EO*	VERDUXO*	LÉREZ*	AROUSA*	MIÑO**	ALBUFERA*		
1977						36 600			
1978						24 300			
1979						28 400			
1980						16 000	6352	4668	11 020
1981						50 000	12 269	6848	19 117
1982						16 400	6845	9126	15 971
1983						30 000	6397	7697	14 094
1984						34 127	7395	3577	10 972
1985						18 534	11 013	3464	14 477
1986						20 321	9243	2871	12 114
1987						12 827	11 228	3611	14 839
1988						14 827	7698	2098	9796
1990						12 499	2000	1843	3843
1991						13 318			
1992						10 648	3000	2330	5330
1993						12 619	3000	2349	5349
1994						9928	2000	2155	4155
1995						16 867	1600	2897	4497
1996						18 066	2960	3105	6065
1997						10 979	2784	2123	4907
1998						9358	3100	2563	5663
1999						8992	2400	2503	4903
2000						9315	1537	2047	3584
2001	479	467	42 159	0	7439	3973	1284	1995	3279
2002	213	643	25 252	30	13 563	4001	1432	2126	3558
2003	266	180	19 708	16	11 171	4073	4042	2598	6640
2004	1887	460	22 014	14	10 997	3297	5591	2138	7729
2005	5849	2480	14 512	0	8861		6493	1472	7965
2006	7993	2344	42 994	73	9707		5974	1479	7453
2007	2721	2900	18 860	10	3788				10 675

*** Data from auctions; ** Data from river command corresponding to Spain and Portugal.**

Report on the eel stock and fisheries in Italy

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Reporting Period: This report was completed in August 2008, and contains data up to 2006.

IT.B. Introduction

Eel (*Anguilla anguilla* L.) exploitation in Italy has a long standing tradition, and still concerns all continental stages, i.e. glass eel, yellow and migratory silver eel.

A most distinctive exploitation pattern for eel in Italy has been in the past coastal lagoon fishery, that yielded most of yellow and silver eel extensive culture and fishery production (Ciccotti, 1997; Ciccotti *et al*., 2000; Ciccotti, 2005). Quite important was also eel intensive aquaculture, that played a major role within the national and European context up to a few years ago, but has strongly reduced today (Ciccotti *et al*., 2000; Ciccotti and Fontenelle, 2001).

Lagoons cover around 1500 km^2, 610 of which are exploited at the present moment. Of the exploited area, about 300 km^2 are located in the upper Adriatic and 120 in the Po delta, the rest being scattered in Apulia, Campania, Latium, Tuscany, Sicily and Sardinia (Ardizzone *et al*., 1988).

In the upper Adriatic lagoons the typical form of management was the *vallicoltura* that slightly differed from other lagoon management and fisheries because relying on artificial fry stocking and active hydraulic management.

Inland eel fisheries are found in main rivers and lakes. Most of the eel catches are from the great Alpine lakes in the northern regions, but the eel is also an important target species for professional fisheries in some volcanic lakes of Central Italy. Professional eel fisheries in rivers are confined today to residual activities, although professional glass eel fisheries still take place in some estuaries, and in many channel mouths as well. At the moment, most of the glass eel yield comes from the Central and Southern Thyrrenhian area. The main sites of glass eel catches are the estuaries of rivers such as the Arno and Ombrone in Tuscany, the Tiber and the Garigliano in Latium, and the Volturno and Sele in the Campania region. Those sites are frequented not only by local fishers but occasionally also by fry fishers from other regions, who reach those sites with trucks equipped with oxygenated tanks to collect mullet, sea bass, sea bream and eel fry. Local fishers are usually single or Co-operative fishers that are equipped with boats and structures to store the product alive. Fishing instruments vary depending on the characteristics of the site.

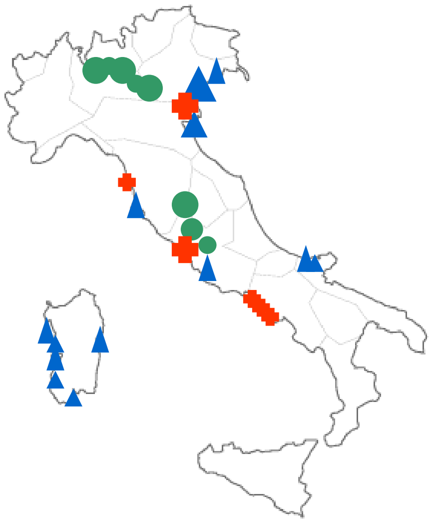

Figure IT.1 Distribution of main eel fisheries in Italy (O Lakes, Δ Coastal lagoons, ✣ Rivers).

Governmental management framework for eel results disjointed, because in Italy the Ministry of Agriculture and Forestry Politics controls salt and brackish waters, although inland waters are under the control of local Administrations, i.e. Regions or Provinces. Therefore the only eel fisheries under a central Administration are the glass eel fisheries practised in estuaries, as no marine adult eel fishery exists in Italy. In most cases, anyway, central and regional regulations are in agreement, glass eel fishery regulation being joined always to the regulation of fishery of finfish and bivalve fry for aquaculture. In both departments, a license is necessary, which has to be renewed annually, in which quantities to be fished have to be declared. Fishermen must notify their catches and sales. Destination of glass eels ought to be restricted to aquaculture and restocking purposes. However, poaching and black market in some regions remain a problem. In absence of counterchecks, collection of data can prove to be partial, and their reliability doubtful.

With regards to inland fisheries, each Region has its own regulations, none specific for eel. At the present moment, an agreement between National Administration and Regions is being discussed regarding fisheries, but not yet in force. Up to now, as a rule individual professional fishing licenses are issued, which are valid for six years, by each Region, and are enlisted in registers kept by the Provinces. The permitted gears vary from region to region, also in relation to local traditions, and are specified by each Administration, together with authorized times and places. For the nets, mesh sizes and minimum and maximum dimensions of gears are listed.

In the present report an overview on the eel stock and fisheries in Italy is presented, based on information gathered for previous meetings (Workshop on National Data Collection for the European eel held in Sweden in 2005, Eel WG 2006 and 2007), and updated to 2008. At the present moment, Italy has not established yet its Data Collection Framework for eel, nor has developed a final proposal for a National Management Plan as foreseen by the Regulation 1100. Nevertheless some actions are being undertaken, in particular in November 2007 a programme has started targeted to the setting up of the knowledge base for the preparation of a National Management Plan [title: “Investigation to gather the knoledge base for the drafting of a National Management Plan for the sustainable management of the eel, *Anguilla anguilla*"-Ministero per le Risorse Agricole Alimentari e Forestali, Consorzio Unimar e Università di Roma "Tor Vergata"].

Aim of the project is the development of a data collection framework specific for eel, and the identification of the key elements for eel management and restoration at the national level. This programme is in course at the present moment, and its preliminary results shall constitute the basis for the drafting of the Eel National Management Plan to be presented at the end of the year to the European Commission.

IT.C, D, E and F Fishing capacity, fishing effort, catches and landings, catch per unit of effort

Notwithstanding the above mentioned Programme, that is providing for a mapping and census of all eel fishing activities at the national level, at the present moment no estimates of fishing capacity can be given. A central registration is not available of fishing companies per fishing typology nor per region, apart the Province Registers, and the census of fishing licenses is at the moment still far from complete. For adult eel, there is no possibility of evaluating the number of companies dedicated to eel fishing at the present moment. For glass eel fisheries in marine waters, the number of licenses issued annually by the Ministry for coastal waters demonstrates a sharp drop in the course of the 1990s, also as a consequence of the fact that from 1998 a pecuniary charge is due by the fry fishing companies, but it must be borne in mind that the license is not restricted to glass eel. A rough estimate of fishing companies dedicated to glass eel amounts to less than ten.

Fishing equipment for eel catching in lagoons, lakes and rivers includes a variety of instruments ranging from single fykenets to groups of fykenets, traps, baskets and fish hooks. Systems consisting of arrangements of nets and fykenets, constituting barriers that close the lagoon from one shore to the other, are used in some lagoons, such as the "paranze" from the lagoon of Lesina in the Southern Adriatic, Italy. Most of silver eel captures take place at fish barriers (*lavoriero*), devices based on the principle of V-shaped traps that intercept the fish when moving to reach the sea: for silver eel, most captures take place in winter in coincidence with seaward migration. Fishing efficiency by these devices can be considered to attain 100%.

For glass eel fishing, dipnets are used often in Tuscany, but usually glass eel fishing is carried out with fykenets of varying dimensions, which are often provided with wings.

There are no logbook systems to record type and number of nets, neither obligatory nor voluntary, at any level, neither central nor local. Considering the large heterogeneity of the fishing devices, no other measure of fishing effort, fuel consumption or other, seems applicable at the present moment.

No obligatory registration of landings exists, at any level, at the present moment, for eel, apart the catch declarations required by the Ministry or by the local Administrations for issuing annual glass eel fishing licenses that seem purely indicative. Within the actions foreseen by the programme, a thorough investigation of actual productions is being performed, by direct interviews with the fishers' cooperatives, but no data are available up to now.

Official statistics to which it is possible to make reference for eel are, at the present moment, still those gathered by the Istituto Nazionale di Statistica, Servizio Statistiche sull'Agricoltura. Statistics are grouped on an annual basis, by region and by species or species group. Data are given separately for marine and brackish waters (lagoon and sea fisheries) and for inland (lakes and artificial basin fisheries). Riverine catches are not considered, being probably worthless. It must be borne in mind that statistics referring to eel consider only adult eel, yellow and silver cumulated, deriving only by professional fisheries. However, catches from anglers are possibly quite significant.

Eel total landings from lagoon fisheries in Italy from 1969 to 2004 are reported in Figure IT.2. Data refer to coastal lagoons only, no marine fisheries existing, although extensive culture productions such as the *vallicoltura* yields ought not to be considered, falling within the aquaculture productions. It is possible, however, that a certain overlap has occurred in the past. Data from 2005 are not available for eel singled out from other species.

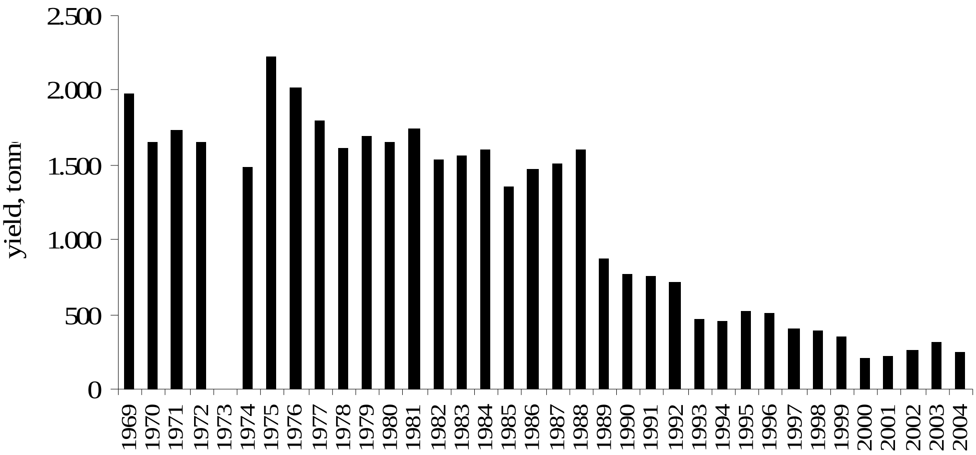

Figure IT.2 Eel landings (yellow and silver eel) in Italy, period 1969–2004, from lagoon fisheries (Istituto Nazionale di Statistica). From 2005 data are cumulated to other minor species, and therefore not available.

Inland waters eel landings from 1969 to 2006 are reported in figure IT.3; statistics refer only to lakes and artificial basins.

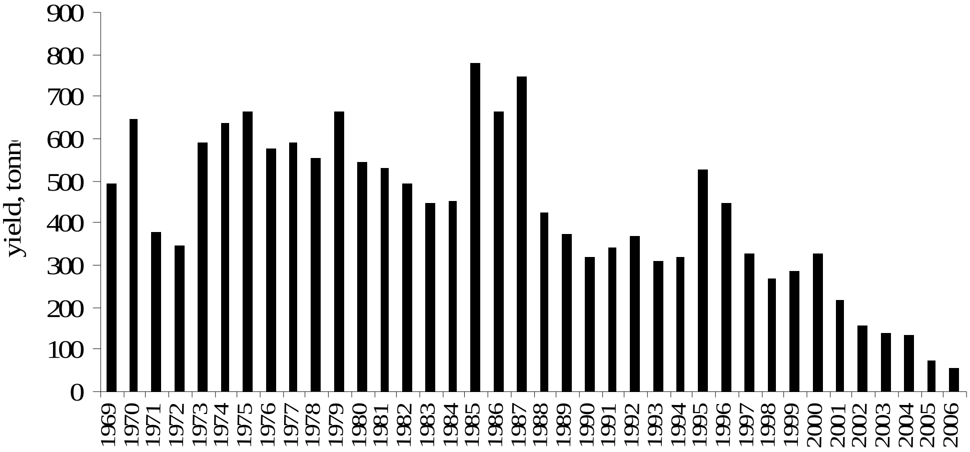

Figure IT.3 Eel landings (yellow and silver eel) in Italy, period 1969–2006, from lakes and artificial basins (Istituto Nazionale di Statistica).

The above statistics refer to yields cumulated for all Italy, but landing data split at the Regional level are also available, not given in the present report.

With regards to catch per unit of effort, considering that no estimate of fishing effort can be given, it is not possible to estimate cpue for eel, for any of the fishing tipologies.

IT.G. Scientific surveys of the stock

IT.G.1 Recruitment surveys, glass eel

The monitoring of glass eel recruitment in Italy has been carried out since the mid 1980s within research programmes supported by the Ministry of Agriculture and Forestry Politics, aimed at the assessment of euryhaline finfish fry used for aquaculture and restocking (Ciccotti, 2002; Ciccotti, 2004; Ciccotti 2006). Methodology has been extensively described in Ciccotti, 2002.

The monitoring method set up in the Tiber has allowed to describe glass eel recruitment trend at the river Tiber estuary during 16 years monitoring, as well has having allowed to draw a picture of the trend of glass eel fishery dating back as far as the mid 1970s, and appeared completely reliable in recording catches of the local fishery. Catch data from the Tiber, and the fishing indicators obtained within the monitoring, also allowed to figure out an overview of recruitment at a national scale, because of a general coherence of recruitment trends among sites, and evidenced a declining trend up to the season 2005–2006. Nevertheless, an assessment of total glass eel yield at the national level has never been possible because of gaps regarding regions where the glass eel fishery seems to continue with good results (such as in Campania and Toscana), and because of a general lack of information in relation to poaching and black markets.

The monitoring at the Tiber mouth has allowed to witness the ending of the glass eel professional fishery, as a consequence of the unquestionable drop in recruitment, but also of a local environmental situation (unpredictable floods, water quality), although the yellow eel fishery, practised by the same fishers, is still going on, even if it has progressively reduced.

The monitoring in this site, owing to the situation described above and to the ending of the specific monitoring programmes in 2006, has therefore ended. Similarly, also the monitoring at a second monitoring site, located on the river Marta estuary, also in Latium, on the Thyrrenian coast, has been discontinued in 2007. The fishery in this site is still going on, but no information is available at present.

At the present moment, a breakdown of the monitoring work, that involves also a weakening of the monitoring framework set up in the course of the years, appears a major problem in relation to the necessity of follow up of recruitment, and to the fact that the existing time-series have been discontinued. It is to be hoped that some recruitment monitoring can be resumed within the programme mentioned above.

IT.G.2 Stock surveys, yellow and silver eels

Scientific surveys of eel stock in Italy have been carried out on a continuative basis only for recruitment, and up to 2006. For yellow and silver eels, a number of researches on population dynamics were carried out between 1973 and 1985, for some northern Adriatic *valli* populations as well as for some other coastal lakes in the southern Adriatic (Lesina, Varano, Acquatina) and Thyrrhenian (Monaci, Orbetello, Sardinian ponds) as well as for the Tiber river. Most of those were published in scientific journals, although some remained as grey literature (see Ciccotti, 1997 for a review). Subsequently, as interest, also in research, shifted towards intensive aquaculture, investigations on wild stock were abandoned, apart from some modelling applications investigated more recently that focus on eel population structure and body growth, and its applications for the resource management (De Leo and Gatto, 1995; De Leo and Gatto, 1996; De Leo and Gatto, 2001).

Anyway, all these investigations rely on scattered, in space and time, samplings, and therefore cannot be defined scientific surveys. Nothing is actually being executed on a continuative basis. Recently (2007) a national research project regarding eel has started, financed by the Ministry of Research that involves five Universities, aimed at the widening of the knowledge base for the management of the European eel.

IT.H Catch composition by age and length

In Italy there is no sampling programme foreseen in any national or regional framework for adult eel, and therefore no samplings are taken from commercial catches, within any fishery tipology. It must be borne in mind that landing data are collected for statistical purposes, linked therefore to the characterization of social, economic and environmental conditions of the country, and only secondarily related to fishery management. A number of researches were carried out in the past (see above section), but no information is available at present for recent years.

IT.I. Other biological sampling (age and growth, weight, sex, maturity, fecundity)

As specified above, only incidental samplings within specific researches have been performed, and not recently, and this represents a major gap, because for many local stocks it may be that strong changes have occurred, regarding productivity, age structure, length composition, sex ratio. Unfortunately, no routine programme for any population parameter is executed.

Among the samplings and examinations performed within specific research projects, other features have been occasionally examined, such as parasitic infestations, in particular regarding *Anguillicola* sp. infection rates, contaminants loads and eel condition, fat levels, etc. Some recent data based on available information (published, grey) have been gathered, presented in the relative section of the present Report. Probably, occasionally some analyses for these features related to human health or to veterinary aspects have been monitored by official sanitary or veterinary services, but no information is ever made available and most probably also in this case only scattered sporadic samplings have been actuated.

IT.J Other sampling

For inland waters, most Regional laws in Italy contemplate the accomplishment of Fish Maps by the Provinces, instruments aimed at the planning and management of fish populations and of fishing activities. The reference unit for the Fish Maps is the catchment basin, investigation levels are actuated at different levels (environmental characteristics of water habitats, anthropogenic effects, structure and dynamics of fish populations, fisheries). Methodologies should follow in most cases standardized guidelines, and differ depending on the habitat. Therefore, Fish Maps could contribute with a useful amount of information. Up to now, only a certain number of Provinces, mostly in the northern regions, have compiled Fish Maps, and in most cases have been published by the Provinces and available. The main constraint at the present moment for the utilization of this source if information is the fact that no centralized work of coordination and synthesis is done for any fish species. Eel presence has been ascertained in most of the catchments where investigations have been carried out, but no data on density or biomass are available.

Other samplings in Italy concern environmental monitoring, that involves a network of Agencies at different levels. The APAT (Agenzia per la Protezione dell'Ambiente e per i Servizi Tecnici) is the technical organ of the Ministry of the Environment, whose function is to coordinate actions as well as to maintain the connection with the European network EIOnet, although the ARPA are Regional Agencies involved in environmental protection. An important section of the work of these Agencies involves water environments. Data from environmental monitoring are collected, elaborated and divulgated on a framework basis through the SINAnet, the National Environmental Informative System. In this way a great amount of information regarding different environmental aspects is made available.

IT.K Stock assessment

In Italy no routine assessment of eel stock is under any scheme neither at the central nor regional level. There is no formal advice on eel fishery management.

IT.L Sampling intensity and precision

Having stated beforehand that no samplings or investigations on catch composition and/or age and growth are carried out within official recordings, it is not possible to analyse variation in samplings, within and among sites, seasons, gears. Anyway, a discussion on this topic seems important for eel in Italian waters (and probably in other Mediterranean countries) in relation to the heterogeneity in eel habitats and fisheries organization, to the seasonal variation of eel catch and catch composition most pronounced in lagoons, etc.

IT.M Standardisation and harmonization of methodology

Having stated beforehand that only incidental samplings within specific researches have been performed, it is impossible to give an overview of methods with regards to the different items. In most research studies, sampling collection and sampling treatment (size measurements, age reading, sex determination, stage identification) as well as any other biological observation (parasites) or determination (contaminants) has been done by following the latest protocols as inferred from literature available at the moment the research was carried out.

The setting up of a standardized sampling methodology and of protocols for biological investigations on eel is therefore a priority.

IT.N. Overview, conclusions and recommendations

In the present report an overview of the European eel stock and fisheries is presented for Italy. From the presented information, it is possible to summarize the following points:

- Eel landings in Italy, in coastal waters as well as in inland water bodies, demonstrate a continued decrease. Glass eel monitoring, carried out up to 2006, confirms the current low trend in recruitment.
- Scientific surveys on a continuative basis have been carried out only for recruitment, along 16 years (1999–2006) within the Three-year Plan of Ministry of Agriculture and Forestry Politics, law 41/82, and contributed up to now to the understanding of the eel stock situation in Italy with respect to the rest of Europe. At the present moment, anyway, the monitoring has been discontinued.
- At the present moment, Italy has not established yet its Data Collection Framework for eel, nor has developed a proposal for a National Management Plan. Nevertheless, in the course of 2007 the Ministry of Agriculture and Forestry Politics has financed a Project, that followed a specific call, for a programme started in autumn 2007, targeted to the setting up of the knowledge base for the preparation of a National Management Plan, by developing a data collection framework specific for eel, and by identifying the key elements for eel management and restoration at the national level.
- Debate on the course of actions to be undertaken to comply with the European Commission dispositions is currently being held at different levels, administrative as well as scientific, in relation to the awareness of the necessity of urgent actions for the eel stock recovery. A group has been established to work at the drafting of an Eel Management Plan for Italy. Therefore the next months shall prove to be extremely important for the development of these actions.

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Report on the eel stock and fishery in Norway 2008

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NO.B Introduction

Eel fishing is performed with fykenets from May–November in coastal areas of the sea. Eel fishing takes place in estuarine, brackish as well as saltwater areas. The data reported here consists of the only known eel dataset from brackish or salt water.

The European eel has been added to the Norwegian Red List of Species since May 2006.

NO.C Fishing capacity

Fishing for glasseel is prohibited in Norway.

There is a minimum legal size of between 37 (silver eels)–40 cm (yellow eels). The official catch data consists of annual totals by district.

The eel fisheries are located mainly along the south coast of Norway. No distinction is made between yellow and silver eels and they are both caught with eel pots. Fishermen operate in the estuarine area around coastal islands. Fykenets are set on soft and muddy bottom, with preference of areas with seagrass beds (eelgrass *Zostera marina*). Like seagrasses throughout the world the eelgrass in Nordic waters are under great pressure (Baden, 2003), and human-induced disturbances are among the main factors threatening these habitats. Alarming, Baden *et al*., 2003 demonstrated great loss of seagrass on the Swedish Skagerrak Coast (58% in 10–15 years), especially within areas with the highest nutrient loads.

NO.C.1 Reported by year

The table lists the number of eel fishing licenses delivered each year. These figures correspond approximately to the number of fishers although one boat (fisher) can change licences within a year.

Table 1. Number of eel fishing licenses in Norway between 1977–2007.

Year	Number of licenses
1977	326
1978	313
1979	374
1980	541
1981	501
1982	505
1983	478
1984	434
1985	399
1986	412
1987	425
1988	525
1989	479
1990	468
1991	449
1992	434
1993	404
1994	452
1995	423
1996	417
1997	445
1998	389
1999	429
2000	347
2001	336
2002	327
2003	284
2004	258
2005	241
2006	247
2007	

NO.C.2 Reported by district

The total number of licenses delivered in Norway since 1977 is 12 062. Trends are similar in all the districts (Figure 1). Highest numbers were in 1980 and 1988. The number of registrations is significantly decreasing since the year 2000.

Table 2. Number of eel fishing licenses in Norway between 1977–2006.

District	Number of licenses
A	89
BD	38
F	3
H	2930
M	463
N	20
NT	47
O	27
R	1733
SF	384
ST	42
T	10
TK	677
V	736
VA	1680
Ø	1980
AA	1203

NO.D Fishing effort

There is no registration of fishing effort (about number of eel pots or boat per license).

NO.E Catches and landings

Eel landings were highest in the 1930s and 1960s amounting to an annual total of 500 tons. Two important decreases in the landings were observed during both World Wars (1914–18 and 1939–45). Since 1969, landings have decreased with a few years of exception (for example in 1988). It is difficult say whether this trend reflects the number of eels because this number is correlated with the number of licenses (available between 1977 and 2006, R=0.60).

Institute of Marine Research has two resource monitoring programmes of importance for the Norwegian eel populations. a) a fykenet monitoring programme, and b) a beach-seine programme.

a) Since 1977 20–30 fishers have reported yearly information from their fykenet fishing.

Data on: 1) how many fykenets are used during eel fishing, 2) the exact period (days) eel fishing is performed and 3) the landings of eel are reported. These data demonstrate little variations in catch rates and landings over the latest 10–20 years.

Table 3. Official landings of yellow and silver eels reported by fishers in Norway. The number of registration is available since 1977 and cpue were calculated based on these numbers.

Year	Norway (tons)	Year	Norway (tons)	cpue
1908	268	1958	437	
1909	327	1959	409	
1910	303	1960	430	
1911	384	1961	449	
1912	187	1962	356	
1913	213	1963	503	
1914	282	1964	440	
1915	143	1965	523	
1916	117	1966	510	
1917	44	1967	491	
1918	35	1968	569	
1919	64	1969	522	
1920	80	1970	422	
1921	79	1971	415	
1922	94	1972	422	
1923	140	1973	409	
1924	290	1974	368	
1925	325	1975	407	
1926	341	1976	386	
1927	354	1977	352	1.0797546
1928	325	1978	347	1.1086262
1929	425	1979	374	1
1930	450	1980	387	0.71534196
1931	329	1981	369	0.73652695
1932	518	1982	385	0.76237624
1933	694	1983	324	0.67782427
1934	674	1984	310	0.71428571
1935	564	1985	352	0.88220551
1936	631	1986	272	0.66019417
1937	603	1987	282	0.66352941
1938	526	1988	513	0.97714286
1939	434	1989	313	0.65344468
1940	143	1990	336	0.71794872
1941	174	1991	323	0.71937639
1942	131	1992	372	0.85714286
1943	136	1993	340	0.84158416
1944	150	1994	472	1.04424779
1945	102	1995	454	1.07328605
1946	167	1996	353	0.84652278

Year	Norway (tons)	Year	Norway (tons)	cpue
1947	268	1997	467	1.0494382
1948	293	1998	331	0.85089974
1949	214	1999	447	1.04195804
1950	282	2000	281	0.80979827
1951	312	2001	304	0.9047619
1952	178	2002	311	0.95107034
1953	371	2003	240	0.84507042
1954	327	2004	237	0.91860465
1955	451	2005	249	1.03319502
1956	293	2006	293	1.18623482
1957	430	2007	194	0.8362069

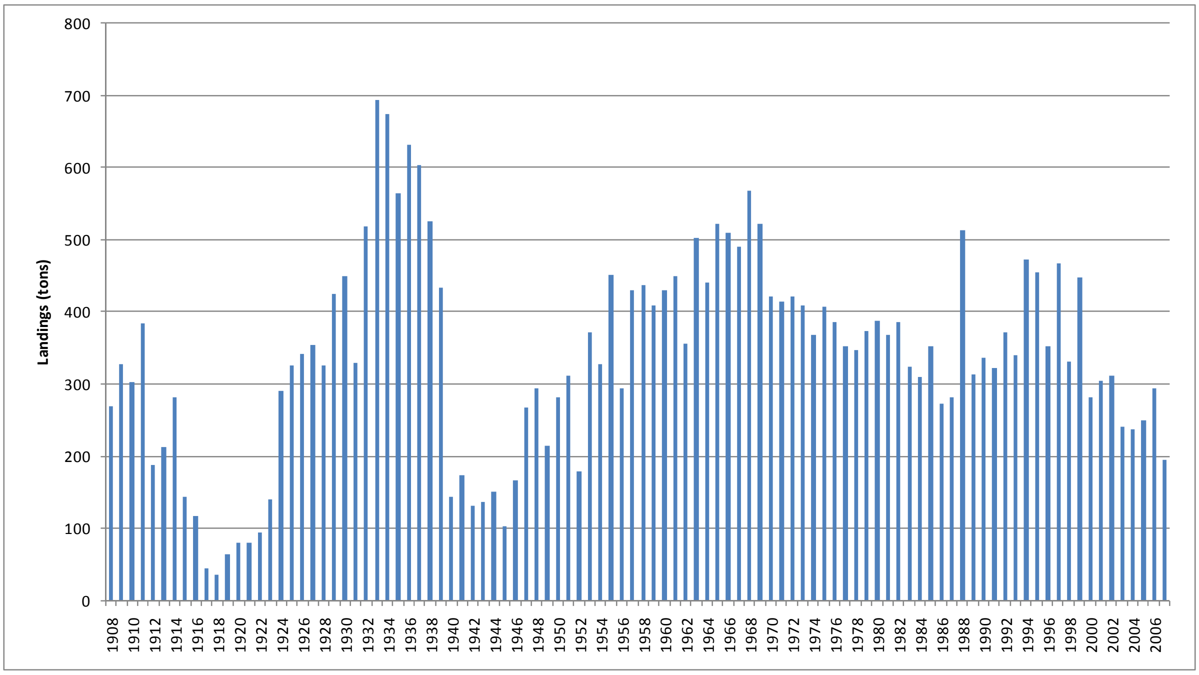

Figure 1 Landings (tons) of yellow and silver eels reported for Norway between 1908 and 2007.

NO.F Catch per unit of effort

Cpues were calculated as: cpue=landings/number of registration.

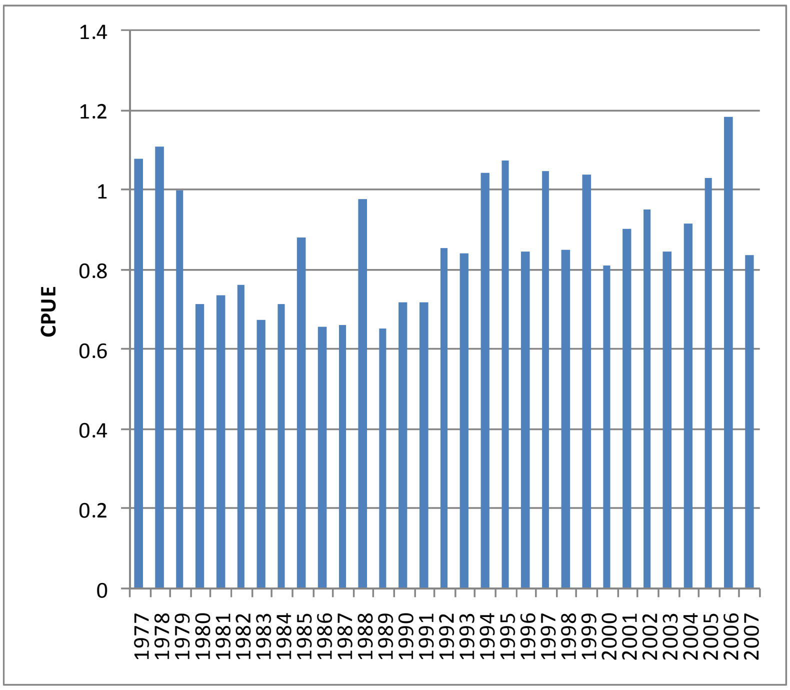

Figure 2 Cpues of eels calculated between 1977 and 2007.

IR.G. Scientific surveys of the stock

NO.G.1 Freshwater data

The only available time-series for eel abundance in fresh water in Norway is the one maintained by the Norwegian Institute for Nature Research at Ims (southwest Norway; since 1975). Silver eels are caught in a Wolf Trap at the river's mouth. Elvers and small yellow eels are also counted as they ascend the river. Data is missing between 1994 and 1999. This time-series was formally analysed by Hvidsten, 1985a and by Vøllestad and Jonsson, 1988. The later part of the time-series has not been analysed in detail. Further, during the 1980s detailed data on the population dynamic were collected and analysed (Vøllestad, 1990; Vøllestad and Jonsson, 1986, 1988). However, Vøllestad did sample more population dynamic data that has not been analysed in detail-these data include information about age, sex and size of subsamples of downstream migrating silver eels for a number of years. The downstream migration of the silver eels in Imsa has also been studied in detail (Haraldstad *et al*., 1985; Hvidsten, 1985b; Vøllestad *et al*., 1986, 1994).

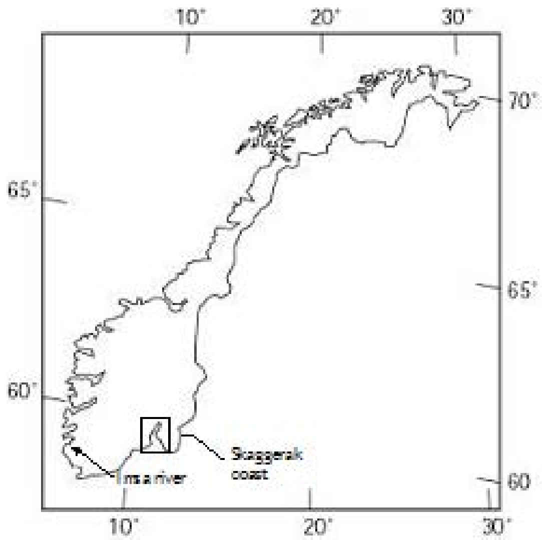

Figure 3. Locations of the sampling areas along the Skagerrak coast and of the Imsa River.

Table 3. Trap data from the river Imsa.

YEAR	NUMBER OF ELVERS	NUMBER OF SILVER EELS
1975	42 945	5201
1976	48 615	3824
1977	28 518	5435
1978	121 818	4986
1979	2457	2914
1980	34 776	3382
1981	15 477	2354
1982	45 750	3818
1983	14 500	3712
1984	6640	3377
1985	3412	4427
1986	5145	3733
1987	3434	1833
1988	17 500	4274
1989	10 000	2107
1990	32 500	2196
1991	6250	1347
1992	4450	1394
1993	8625	681
1994	525	
1995	1950	
1996	1000	
1997	5500	

YEAR	NUMBER OF ELVERS	NUMBER OF SILVER EELS
1998	1750	
1999	3750	
2000	1625	1749
2001	1875	4580
2002	1375	1850
2003	3575	2824
2004	375	2076
2005	1550	1894
2006	350	2827
2007	100	3067

The ascent of elvers has decreased strongly the last years (Figure 7), and on a log scale the trend is clearly linear. Before 1995 the number of elvers entering the elver trap in Imsa has varied between 5000 and 50 000, with large annual variation. In the last 10 years the number of ascending elvers has been extremely low, and decreasing. Earlier analyses of the data-the first 10–15 years of the time-series-did indicate a relationship between temperature and number of ascending elvers (Hvidsten, 1985a; Vøllestad and Jonsson, 1988). The suggestion was that more elvers ascended fresh water when water temperature during summer was high. To test if the temperature hypothesis could also help explain the long-term trends we collected data on mean June–July air temperatures from the Meteorological Institute. There was no relationship between the number of ascending elvers (ln-transformed) and temperature ($r = 0.007$, $P > 0.9$). The complete collapse in eel recruitment in the Imsa thus is very similar to what is happening all over Europe (ICES 2007).

The silver eels are intercepted at downstream migration during autumn. The numbers were high during the early part of the time-series before a reduction starting in the mid-1980s (Figure 6). What is striking, however, is that the silver eel numbers have remained relatively stable (but low) despite the recent strong reduction in recruitment. A simple model with log-transformed numbers of silver eels as response and time as predictor can explain 34.9% of the variation ($P < 0.001$). However, there is large year-to-year variability, a lot of which can be explained by variation in year-class strength (Vøllestad and Jonsson, 1988). The recruitment of some year classes was very weak originally (i.e. the 1979 year class and all year classes since 1994), whereas other year classes are very strong (i.e. 1976 and 1983). To add complexity, the 1985 year class was used in a growth experiment at the research station, and very few elvers were allowed to migrate upstream. In total this should lead to large variability in silver eel production.

NO.G.2 Skagerrak beach-seine survey

The Skagerrak beach-seine surveys data from Norway constitute the longest non-fishery dependent set of data. It is also the only potential time-series on the subpopulation of marine eels. This unique monitoring programme was initiated at the Norwegian Skagerrak coast as a result of a controversy between the founder of the Flødevigen Marine Research Station Gunder Mathiesen Dannevig (1841–1911) and the great pioneer in marine research Johan Hjort (1869–1948; Solemdal, 1997). Every year a series of beach-seine hauls are carried out in some selected fjords of the Norwegian Skagerrak coast. Here we analyse for the first time the time-series concerning eels.

More details on the methods used to analyse the data can be found in Durif *et al*., 2008.

The first hauls of the Skagerrak monitoring programme were conducted in 1904, and during the following years, new sampling stations were added, and a standard routine for the hauls was developed. Approximately 80 stations are sampled in 20 different areas (Figure 4). All hauls are taken at the same season (autumn) and always during daytime. Based on the initial results from these hauls, the monitoring programme was established and reached its present form in 1919 (Dahl and Dannevig, 1906; Fromentin *et al*., 1998; Johannessen and Sollie, 1994; Solemdal *et al*., 1984).

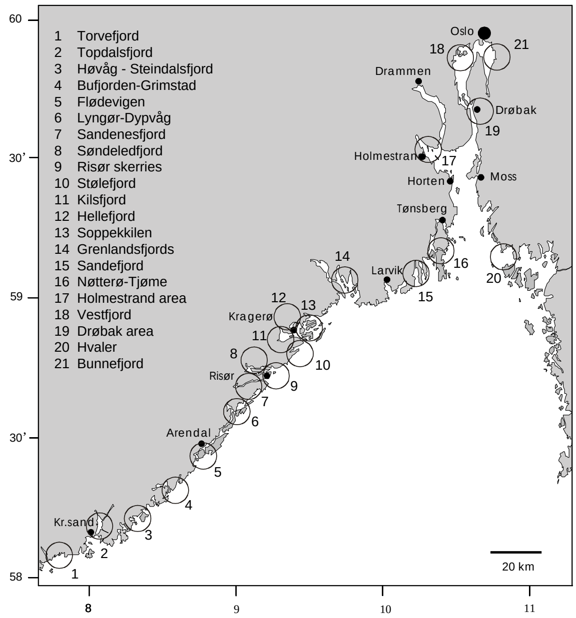

Figure 4 Sampling areas of the Skagerrak beach-seine survey.

Eel catch during the Skagerrak survey has fluctuated substantially since 1925, but with a substantial decline in catch the last 10 years. Eel catch was initially low (from 1925 to 1936) after which it increased to reach its highest level in 1996. The period between 1959 and 1979 was relatively stable. The collapse in eel catch began in 1997 (Figure 5), and last year's catch (in 2007) was null.

The time-series from Imsa (fresh-water recruitment and escapement) correlated with the Skagerrak data. Significant correlations between the elver and the Skagerrak series were found when lags of, either, 0, 1 or 3–6 years were applied (respectively $r = 0.41$; 0.36; 0.47; 0.40; 0.43 and 0.48; $P < 0.01$). Significant correlations were also found with the silver eel series at lags 5–6 and 8–11 years (respectively $r = 0.41$; 0.46; 0.57; 0.45; 0.51 and 0.59, $P < 0.01$). Decline in elvers and silver eels on the Imsa began respectively in 1982 and 1988 (Figure 6, Figure 7). This is consistent with the age structure of silver eels from this river which are approximately 6–8 years old (Figure 11). The decline in the Skagerrak is first observed in 1997, thus 9–15 years later. The fact that the series correlate at several lags is because of the fact that eels from the Skagerrak represent several cohorts (possibly from early yellow stage to silver stage). This is also seen through the body length distribution measured since 1993 (Figure 10). Because the Imsa series are much shorter (only since 1975) than the Skagerrak series, it is improbable that correlations with greater lags would be significant because of too few overlapping data points.

In order to compare with another longer time-series from Europe, a trend was calculated on the recruitment time-series (glass eels) at Den Oever, in the Netherlands (Figure 8). A very similar trend was obtained revealing a complete collapse starting in 1981. A significant correlation between the two original series was obtained when lags of either 17 or 18 years were applied (respectively r = 0.28; r = 0.34; P<0.01).

No significant correlations were found between the Skagerrak series and NAO. However, correlations with sea surface temperatures measured in the Sargasso Sea were significant (Figure 9). Standardized eel catch was negatively correlated with temperatures when lags of 7 or 11 years were applied (respectively r = -0.30 and -0.32; P<0.01). This indicates that eels caught during the Skagerrak survey are probably between 7 and 11 years old. This fits well with the age distribution of yellow eels caught with fykenets in the Drøbak area of the Oslo fjord (Vøllestad, 1985, 1986).

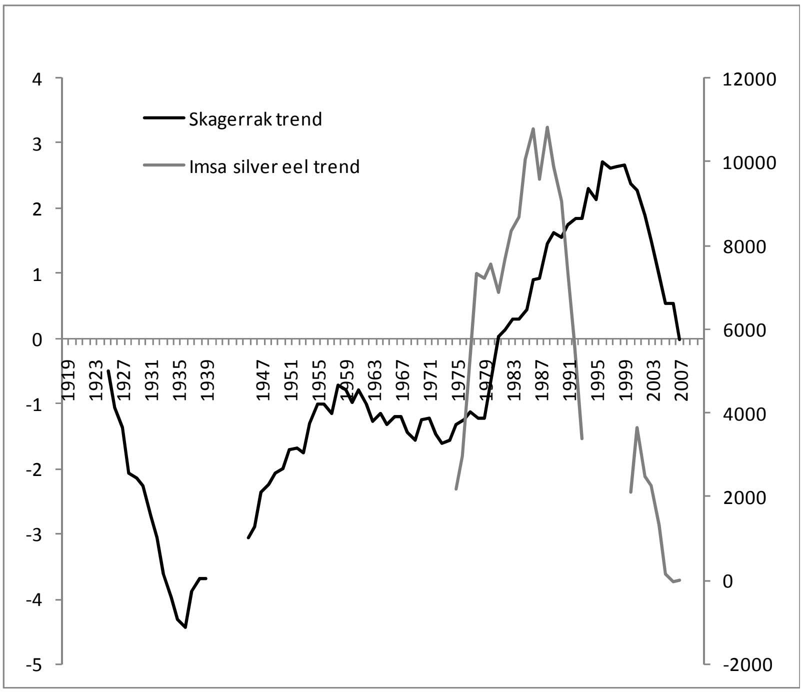

Figure 5. Time series from the Skagerrak coast. CUSUM were calculated on the standardized catch.

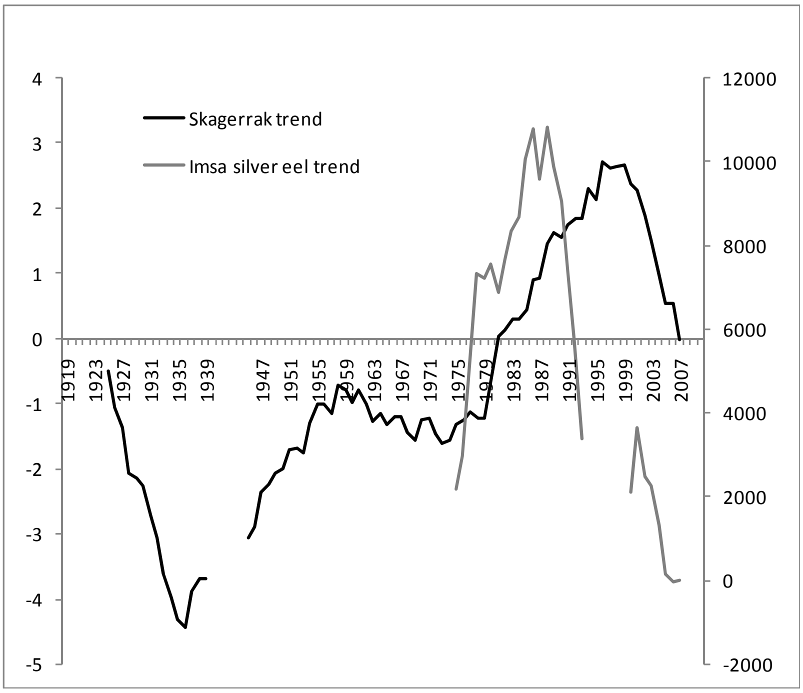

Figure 6. CUSUM trends of the Skagerrak time-series and silver eel monitoring on Imsa.

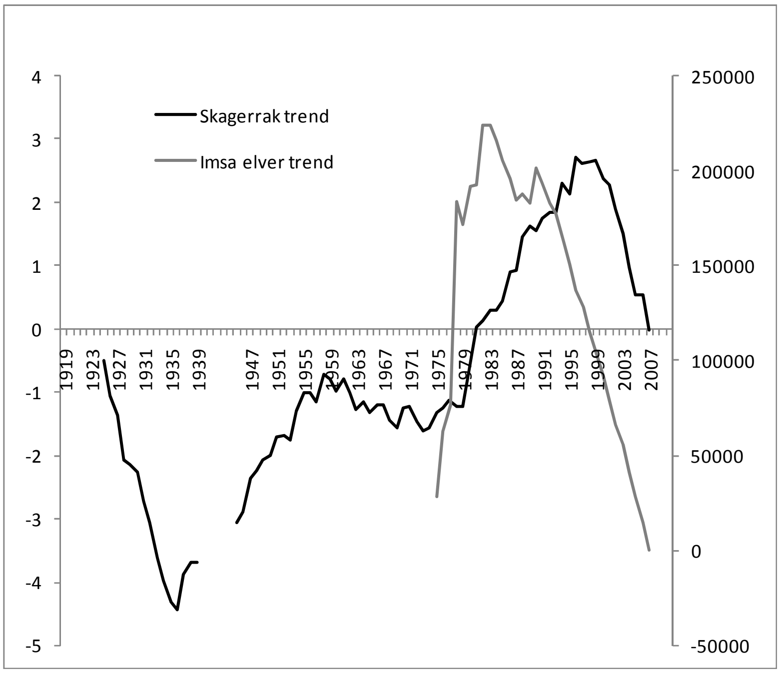

Figure 7. CUSUM trends of the Skagerrak time-series and elver monitoring on Imsa.

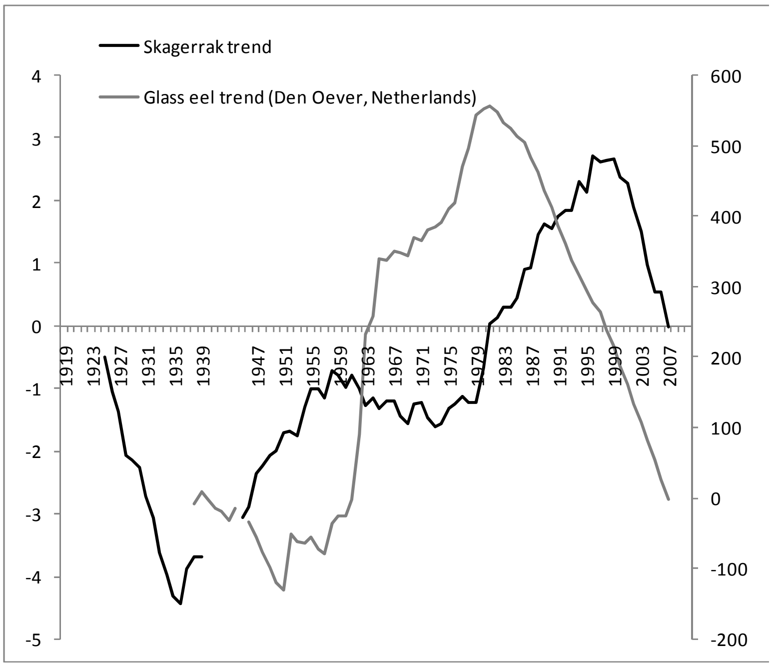

Figure 8. CUSUM trends of the Skagerrak time-series and of the Den Oever Index indicator for glass eel recruitment in the Netherlands.

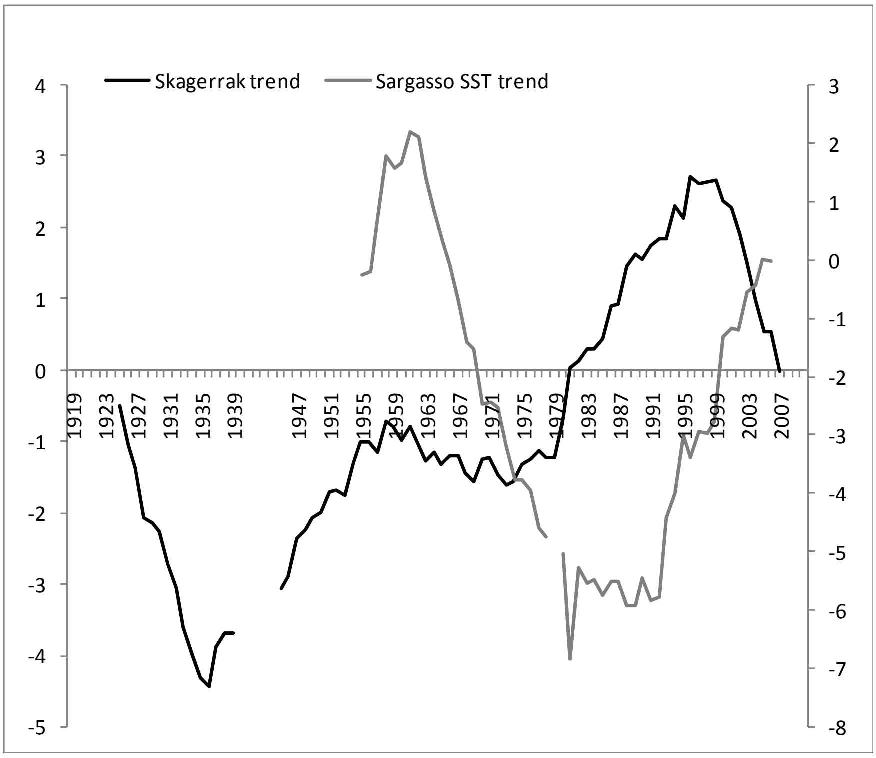

Figure 9. CUSUM trends of the Skagerrak time-series and Sargasso Sea surface temperature.

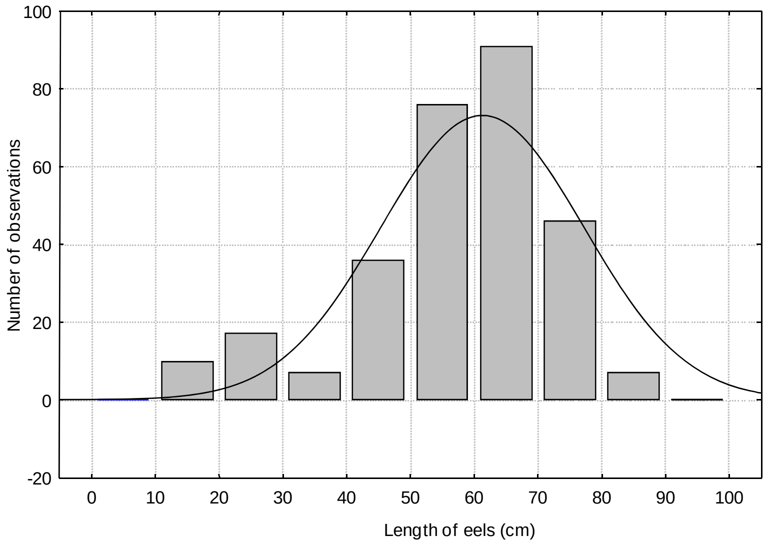

Figure 10. Size distribution of eels measured since 1993 during the Skagerrak beach-seine survey.

NO.H Catch composition by age and length

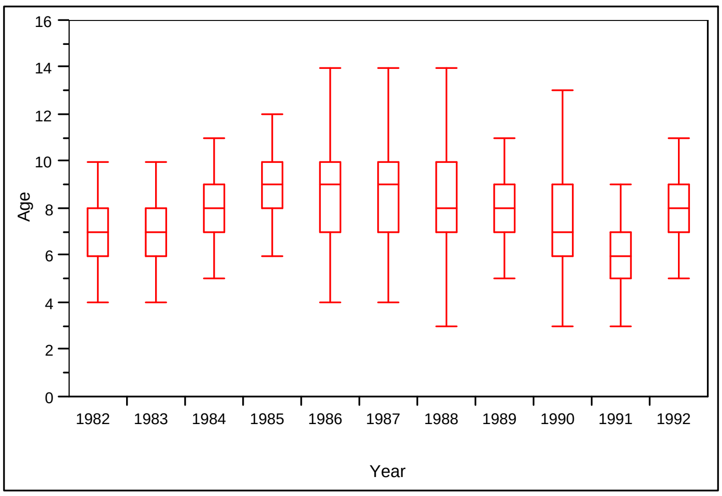

Figure 11. Age structure of eels in the river Imsa. The box plot demonstrates median, 25th and 75th quantile, and the 5th and 95th quantile.

NO.I. Other biological sampling

NO.I.1 Length and weight and growth (DCR)

NO.I.2 Parasites

Infection of eels from the river Imsa by *Anguillicola crassus* was first reported in July 2008. In total 7 out of 22 silver eels contained the parasitic nematode *Anguillicola crassus* in their swimbladder, therefore a prevalence of 32%.

All eels were female and at the silver migrating stage. Infected eels tended to be bigger in length and weight, but their condition factor was not significantly different (Mann-Whitney test, P=0.934). Two eels contained mature worms filled with eggs, in their swimbladder. Small and medium sized worms were also found.

NO.I.3 Contaminants

See excel file.

NO.J Other sampling

None

NO.K Stock assessment

None

NO.L Sampling intensity and precision

None

NO.M Standardisation and harmonization of methodology

None

NO.M.1 Survey techniques

NO.M.2 Sampling commercial catches

NO.M.3 Sampling

NO.M.4 Age analysis

NO.M.5 Life Stages

NO.M.6 Sex determinations

NO.N Overview, conclusions and recommendations

NO.O Literature references

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Report on the eel stock and fishery in Estonia

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EE.B. Introduction

Eel fisheries in Estonia occur in Lake Võrtsjärv (20–100 t) and in costal waters (10–30 t). Annual catch from small lakes and rivers mostly in L. Peipsi basin and L. Peipsi itself is 2–4 t. Eel catches by amateur fishers constitute about 1 t from brackish water and about 2 t from inland water bodies. According to the fishery statistics during the last decade the total annual catch of eel from Estonian waters was nearly 50 tons (in 2007 35 tons). During the first half of previous century eel was very abundant and one of the most important commercial fish in western costal waters of Estonia. At that time annual catch of eel exceeded hundreds of tons.

Natural eel stocks have never been very dense in Estonian large lakes. The annual catch of eel in 1939 was only 3.8 tons from L. Võrtsjärv and 9.2 tons from L. Peipsi. The construction of the Narva hydropower station in the early 1950s blocked almost totally the natural upstream migration of young eel from the Baltic Sea to the basins of lakes Peipsi and Võrtsjärv. As a result, eel almost disappeared from the fish fauna of Estonian large lakes. Today, thanks to the introduction of glass eels or farmed eels into L. Võrtsjärv, it has become one of the most important commercial fish in this lake. According to latest investigation the downstream migration of eel through the hydropower station is possible.

Management of eel stock (re-stocking and fishery) is under the governmental control. The Fishery Department of Ministry of Environment takes care of stocking and local services of the Ministry of Agriculture give out fishing licenses. There are gear and size restrictions.

Estonia has the state programme of reproduction and re-stocking of fish (2002–2010) including European eel. In connection with this programme we have ongoing special investigations and monitoring projects concerning eel in Estonia financed by the Ministry of Environment and ERDF:

Re-stocking results in small lakes.

Food resources of eel in water bodies suitable for stocking.

The distribution of eel and long-term re-stocking results in L. Peipsi and L. Võrtsjärv basin.

Downstream migration.

There are three main eel fishing areas in Estonia:

1) L. Võrtsjärv is a large but very shallow and turbid lake with a surface area of about 270 km^2 and mean and maximum depths of 2.8 m and 6.0 m, respectively. Its drainage basin (Figure EE 2; 3104 km^2, incl. 103 km^2 in Latvia) is situated in the Central Estonia. Eel *Anguilla anguilla* (L.), pikeperch *Sander lucioperca* (L.), northern pike *Esox lucius* L. and bream *Abramis brama* (L.) are the main commercial fish in the lake. Professional fishing gears are fykenets and longlines are used by recreational fishers. Every fisher has own individual licenses. The eel production of L. Võrtsjärv is entirely based on stocking with wild-caught elvers or farmed eels (4–20 g). During the half hundred years (1956–2008), 46 million eels were stocked. According to the official statistics in 1988, the maximum annual catch of eel exceeded 100 t. In the 1990s, the reported annual catch of eel (22–49 t) was much smaller than real catch (estimated catch was 80% higher). Nearly half of the income of fishers comes from eel, despite their annual investments to the state Foundation of Environmental Investments (>100000 € annually) in stocking material. Due to the changes in fishing law, the number of fishers has increased during the last 5 years. During 1970–1998, the number of professional fishers varied between 20–25, followed by an increase to 32 in 2003 and over 40 in 2004–2008. The total number of people involved in the fishery of L. Võrtsjärv is estimated to be two times higher.

2) In costal waters, the Gulf of Riga, the Väinameri, the Gulf of Finland, the catches of eel have increased (from 3–10 t in 1991–95 to 20–8 t in 1999–2003), but from 2004 decreased again up to 6 tonne in 2007. Along the shore of the Baltic eels are caught with bottengarns (poundnets) and fykenets; longlines are also used. As there are hundreds of fishers in that region, eel is not first-rate fishing object.

3) Small lakes in Peipsi basin, where eel has migrated from L. Võrtsjärv and was additionally stocked consistently during last 5 years: in Vooremaa district (Figure EE 1) L. Saadjärv (700 ha), L. Kuremaa (400 ha) and L. Kaiavere (250 ha) and L. Vagula (500 ha) in South Estonia. Fishing gears are dominated by fykenets.

The WFD subdivides the Estonia into 3 districts and 8 subdistricts, what are not connected only with one river. The Narva River District is the biggest (1/3 of territory of Estonia and shared with Russia (Figure EE 2). Other more important rivers are River Pärnu, River Kasari and River Gauja, shared with Latvia.

EE.C. D. E. Fishing capacity, fishing effort, catches and landings

No data available of fishing capacity.

The exact number of fykenets being used in costal waters is unknown. The number of fykenets in L. Võrtsjärv in 1970s and 1980s was 200–250, in 1990s 300 and from 1998 up to 2004 350. In 2005-2008 the total number of fykenets was reduced to 324 (1.2 fykenets per km^{-2}). Longlines (622 fishing nights of 100 hooks, catch 0,6–1,0 tons in 2004–2007) are used only for sport fishing. In Vooremaa lakes licensed fishers have 36 fykenets (2.6 fykenets per square kilometer) and 3 eel boxes. 20 licensed longlines (100 hooks) are not continuously in use.

The eel catches have two peaks in inland waters: May and August–September. Eel has a legal (minimum) size: 55 cm in lakes Võrtsjärv and Peipsi, 50 cm in other Estonian inland water bodies and 45 cm min. coastal waters.

Figure EE.1 Location of Estonia, Lake Võrtsjärv and the Vooremaa Lake District.

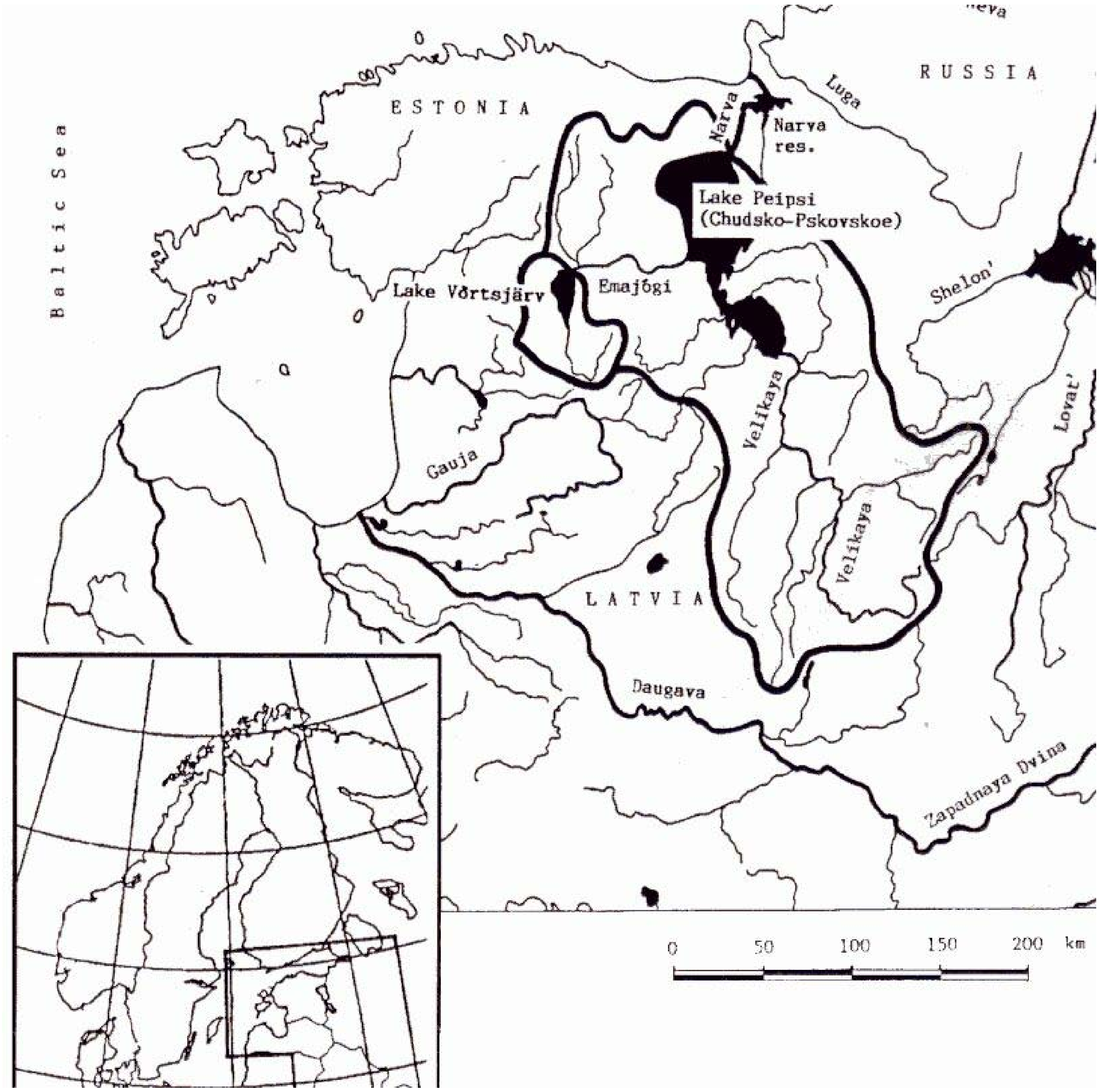

Figure EE.2 Location of watershed areas of L. Peipsi and L. Võrtsjärv.

More than half of the catch of eel in Estonia comes from L. Võrtsjärv (Table EE A). According to the information provided by fishers, the actual catches of eel in L. Peipsi are significantly higher. 80% from registered catch of eel from small lakes and rivers originated from the three lakes situated in Vooremaa district. The real total catch in Estonia should be 1.5 up to 2 times higher.

Table EE A Catches of eel in tons per year in different water bodies in 1993–2007.

Year	Baltic Sea	L. Võrtsjärv	L. Peipsi	Others	Total	Percentage of L.Võrtsjärv
1993	10,0	49,0	0,2	-	59,2	83
1994	10,0	36,9	-	-	46,9	79
1995	6,0	38,8	-	0,6	45,4	85
1996	20,0	34,1	0,1	1,2	55,4	62
1997	18,3	40,3	0,5	-	58,8	69
1998	22,2	21,8	0,2	-	44,2	49
1999	28,3	36,3	0,2	-	64,8	56
2000	26,7	38,9	0,2		67,0	58
2001	27,1	37,6	0.3	1,2	65,2	58
2002	27,3	20,4	0,2	2	50,3	41
2003	18,8	26,4	0,2	3,2	48,6	54
2004	15,6	20,1	0,3	3,2	38,9	52
2005	15,7	17,6	?	3	36,3	49
2006	9,6	19,9	0,1	3,1	32,7	61
2007	6,5	21,5	0,1	2,8	30,9	70

Table EE.B Landings per tons year from Lake Võrtsjärv.

Year	1933–39	1960	1970	1980	1990	2000
0	1,8	0	6,5	17,8	56,1	38,8
1		0	6,5	16,5	48,5	37,6
2		0	16,4	10,8	31	20,4
3		0	21,3	24,5	49	26,3
4		3	18,7	66,7	36,9	20,1
5		0,3	36,9	71,9	38,8	17,6
6		1,9	49,6	55,6	34,1	19,9
7		2,7	50	61,2	40,3	20,5
8		2,9	44,5	103,8	21,8	
9		5	45	47,6	35,2	

EE.E.2. Re-stocking

Estonia has re-stocking programme for years 2002–2010. 75–100% of re-stocking has been financed by local fishers, except Soviet time. Restocking quantities are listed in Table C. Estonia imported glass eel up to 1987 from France, thereafter from England. Young yellow eel (average weight approx. 5 g) was imported from Germany in 1988 and 1995, from Netherland in 2003 and 2005, from local fishfarm in 2002 and 2004.

Table EE.C Re-stocking of glass eel and young yellow eel in the Estonia, in millions re-stocked.

	1950		1960		1970		1980		1990		2000	
Year	Glass eel	Young yellow eel	Glass eel	Young yellow eel	Glass eel	Young yellow eel	Glass eel	Young yellow eel	Glass eel	Young yellow eel	glass eel	Young yellow eel
0	0,0	0,0	0,6	0,0	1,0	0,0	1,3	0,0	0,0	0,0	1,1	0,0
1	0,0	0,0	0,0	0,0	0,0	0,0	2,7	0,0	2,0	0,0	0,0	0,44
2	0,0	0,0	0,9	0,0	0,1	0,0	3,0	0,0	2,5	0,0	0,0	0,36
3	0,0	0,0	0,0	0,0	0,0	0,0	2,5	0,0	0,0	0,0	0,0	0,54
4	0,0	0,0	0,2	0,0	1,8	0,0	1,8	0,0	1,9	0,0	0,0	0,44
5	0,0	0,0	0,7	0,0	0,0	0,0	2,4	0,0	0,0	0,15	0,0	0,37
6	0,2	0,0	0,0	0,0	2,6	0,0	0,0	0,0	1,4	0,0	0,0	0,38
7	0,0	0,0	0,0	0,0	2,1	0,0	2,5	0,0	0,9	0,0	0,0	0,33
8	0,0	0,0	1,4	0,0	2,7	0,0	0,0	0,18	0,5	0,0	0,0	0,19
9	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,3	0,0		

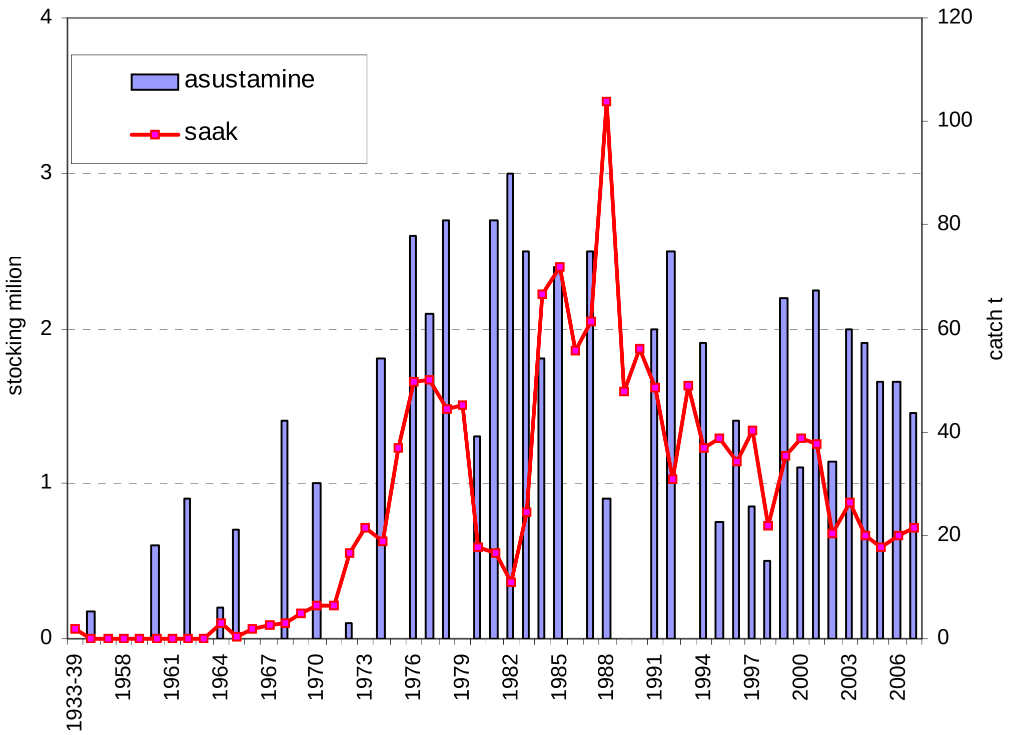

Figure EE.3 Re-stocking (blue columns) and catch (red line) of eel in L. Võrtsjärv. (1 young yellow eel = 5 glass eels).

In 1956 re-socking of glass eels into L. Võrtsjärv was restarted. However, re-stocking has been irregular (Figure EE.3**)**. In the years 1988, 1995 and 2001–2005 young eels reared previously min a fish farm, were stocked. The re-stocking rate with glass eels has been relatively low: annual average in 1956–2001 was about 35 ind. ha^{-1} with a maximum of 84 ind. ha^{-1} in 1980–1984. The peak of re-stoking with glass eels occurred in the early 1980s. As a result, during the following five-eight years the catches of eel were the highest, constituting 2.5 kg ha^{-1} y^{-1}. The maximum catch of this fish was recorded in 1988 (104 t or 3.7 kg ha^{-1}). From the end of 1980s the declared annual catch was decreased.

EE.E.4. Aquaculture

There is only one eel farm in Estonia. Aquaculture production was:

Year	2003	2004	2005–2007
Production (tons)	10	15	40–50

EE.E.5. Recreational fishery

Eel catches by amateur fishers, using mostly longlines, constitute about 2 t from brackish water and about 2 t from inland water bodies.

EE.F. Catch per unit effort

In logbook every professional fisher makes records daily, according to specific fishing gear (fykenets, longlines). According to the longline data the natural density of eel population in Estonian lakes outside of Peipsi watershed area was 2–3 times lower (Table EE B; Figure EE.2). In 2000–2004 the mean annual catch of eel per fykenet in L. Võrtsjärv was 80 kg, in 2005–2007 60 kg.

Real catch in 1,5 times higher.

Table EE B Cpue (catch in grammes per 100 hooks per night) of longlines in water bodies of different river basins (Figure EE.2) and in L. Võrtsjärv in 2000–2004.

River basin, lake	CPUE	
R. Emajõgi	2847	re-stocked
R. V.-Emajõgi	1393	re-stocked
L. Võrtsjärv	1316	re-stocked
R. Õhne	976	re-stocked
R. Gauja	700	natural
R. Pärnu	421	natural
R. Võhandu	397	re-stocked
R. Daugava	338	?
R. Salaca	0	natural

EE.G. Scientific surveys of the stock

EE.G.1 No data available

EE.G.2.

Until the end of 1990s Estonian investigations, based on commercial catches, were focused on stocking and fishing return of eel in L. Võrtsjärv. Since 2001 the catches of yellow and silver eel were investigated in many lakes and rivers all over Estonia. Main source of the information for the eel were official catch and special longline fykenet catches and electrofishing in rivers (multispecies survey in more than 300 stations every year, relative abundance). Special survey of eel in costal waters was not done in Estonia. During last five years investigations of eel were financed by the Ministry of Environment.

Investigations of downstream migration and influence of turbines and dam of Narva hydroelectric power station

Due to the re-stocking, eel is the most important commercial fish in Lake Võrtsjärv and in many small lakes in Estonia. The construction of the hydropower station on the Narva River in the early 1950s blocked the natural path of eel to the waterbodies of L. Peipsi basin. About 45 million glass and farmed eels have been stocked into the L. Võrtsjärv during 1956–2007. According to the European Council Regulation of establishing measures for recovery of the stock of eel, the principal element of the Regulation is the establishment of national eel management plan, by means of which each Member State will achieve the objective of a 40% escapement of adult silver eel from each river basin. One of the most crucial conservation measures in L. Peipsi basin to ensure eel survival and reproduction are modifications to dam and turbines to allow improved eel migration. The hydroelectric power station lies on the side of Russian Federation of Narva River. To investigate the downstream migration of silver eel from Lake Võrtsjärv and Peipsi and their possibility to go over or through the dam and turbines during the project period 557 eels was tagged in all. All specimens were tagged with Carlin-tags among them 7 specimens with radiotelemetric tags. Eels for tagging was brought from professional fishers Lake Võrtsjärv and caught from Lake Ülemiste. To evaluate migration behaviour of eels held before the stocking in non-native conditions, 200 of them were brought from special eel farm. First label-tagging and stocking of eel into Narva water reservoir and Lake Võrtsjärv took place from October 2006–August 2008. Recapture results in 2007 were rather successful. In spite of low intensity of catch with eel-type fishing gears in Narva River, there was recaptured 4 label-tagged eels downstream of the dam. One eel in Finnish Gulf near the River Purtse and one after 4 month in Koge Bay, close to Denmark. We observed also survival and behaviour of eels equipped with transmitters after coming through the turbines using manual and automatic registration of migration. Minimum 50% of radio-tagged eels came through the turbines alive. Two of them were caught back in Narva River after two month and one next year close to island Saremaa. The fixed evidence of possible downstream migration of eel is very important result for sustainable and reproductive management of European eel in Lake Peipsi basin during the last 50 years. According to the project results both partners made a proposal to construct new fish-ladder using old riverbed.

Figure EE.3 A. Places of re-capture.

Figure EE.3 B.Eel with radio-tag.

EE.H. Catch composition by age and length

There is a sampling programme including measuring of length, weight and age determination of eel in L. Võrtsjärv and small lakes (Figure EE4; Table EE C).

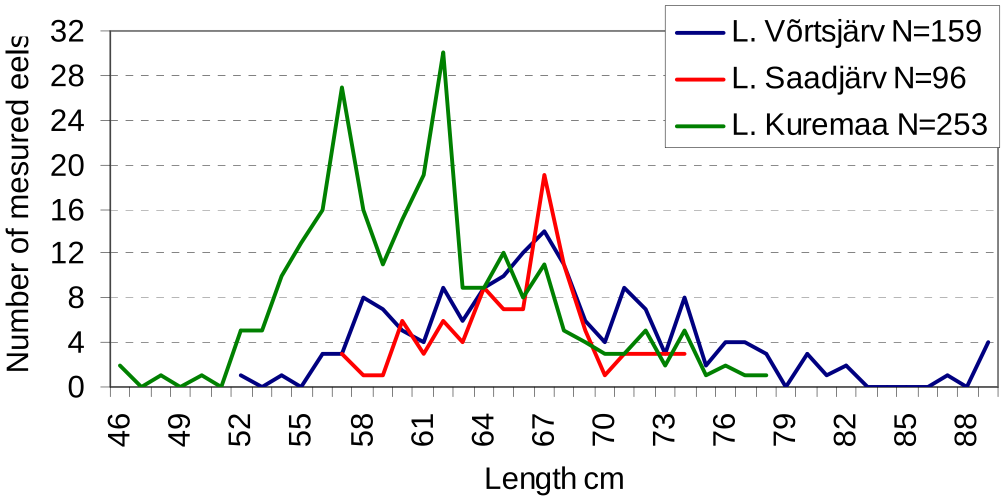

Figure EE.4 Number of measured eels and length distribution in fykenet catches in L. Võrtsjärv, L. Saadjärv and L. Kuremaa in May 2004.

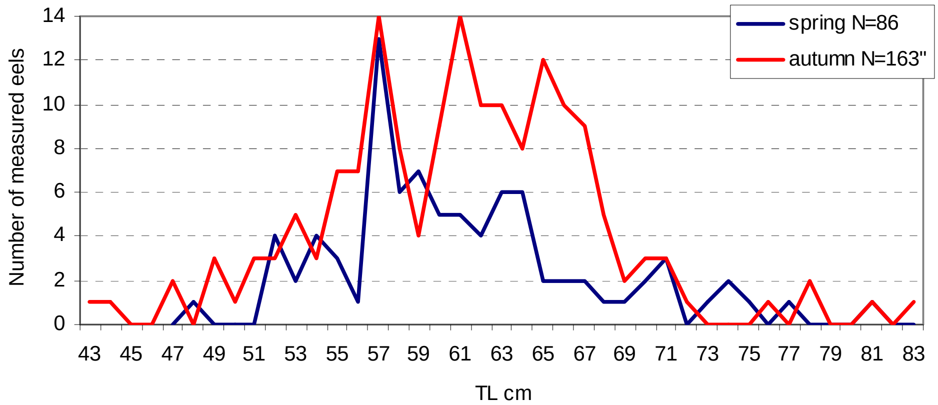

Figure EE.4 Number of measured eels and length distribution in fykenet catches in L. Võrtsjärv in Spring and Autumn 2007.

EE.I. Other biological sampling

Since 1992 the intensity of *Anguillicola* infection in the eel population of L. Võrtsjärv has studied. During last 20 years the feeding and the condition factor of eel in L. Võrtsjärv have studied.

EE.J. Other sampling

During 1999–2003 there was estimated food composition of cormorants in the costal waters including the proportion of eel.

In 2002–2006 feeding of pike in winter and the proposition of eel in it.

EE.K. Stock assessment

The fish stock assessment programme of the Fishery Department of the Ministry of Environment financed Environmental Investments Centre, includes special project of eel stock investigations (length, and age structure, recapture calculations, prognoses, limits) in L. Võrtsjärv and in other inland waters of Estonia. The results are reported to the Fishery Department.

EE.L. Sampling intensity and precision

Since 1973 measurements of eel in L. Võrtsjärv have been carried out. In all 11 000 specimens have been analysed. In 1990s and 2000s were measured 500–1000 eels annually mostly during two high seasons, in May and in August–September.

EE.M. Standardisation and harmonization of methodology

EE.N. Overview, conclusions and recommendations

- registration of fishing efforts is well organized in inland waters, but not so good in coastal waters.
- biological sampling almost absent.

- stock surveys are good in L. Võrtsjärv, in decent level in some small lakes but it is random on costal waters.

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Report on the American eel (*Anguilla rostrata*) stock and fisheries in Canada 2008

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CA.B. Introduction

The American eel (*Anguilla rostrata*) is widely distributed in the eastern part of Canada, from the Atlantic Ocean as far inland as Niagara Falls in the Great Lakes (Figure 1). Historically, the American eel had one of the largest distributions of any fish species in Canada but abundance has declined precipitously since the mid-1980s, in the upper reaches of the St. Lawrence River and Lake Ontario. This sharp decline prompted government agencies involved in stock and fisheries management (Québec, Ontario and Canada) to collate information in order to determine the status of the species throughout the distribution range. Information was summarized in a Status Report prepared for the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and can be found at http://dsp-psd.pwgsc.gc.ca/Collection/CW69-14-458-2006E.pdf.

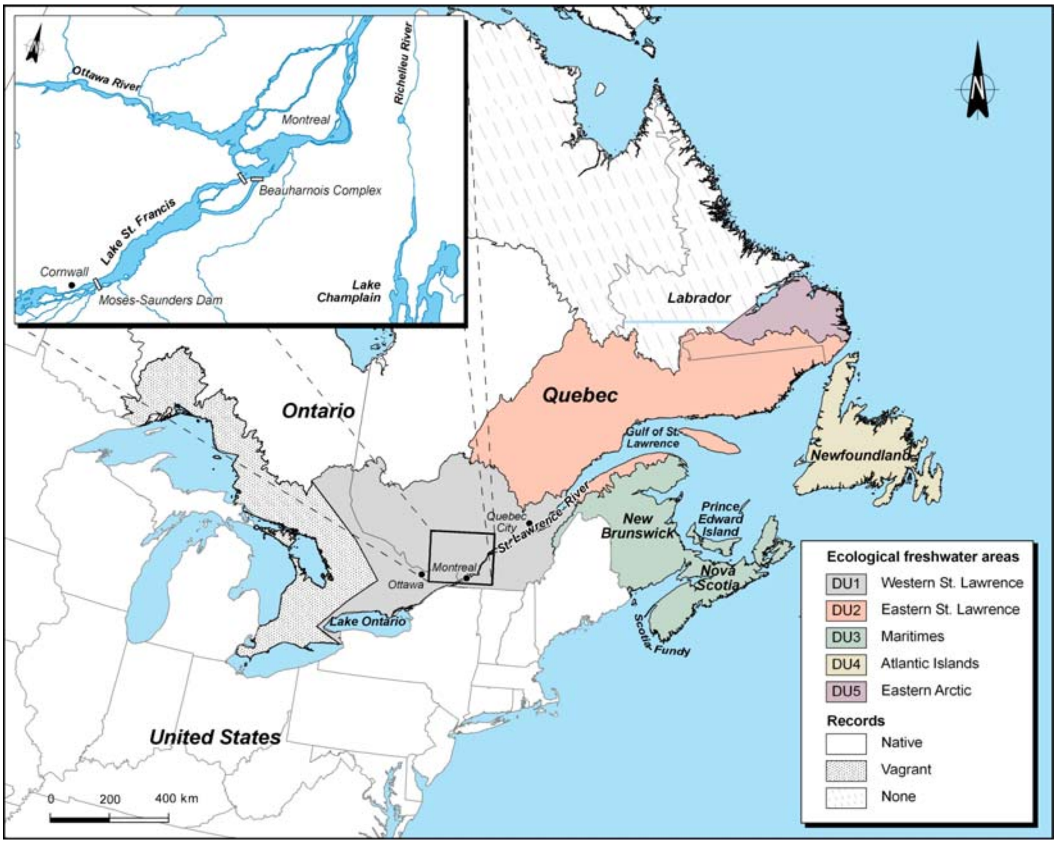

Figure 1. Distribution range of the American eel in Canada, by Ecological Freshwater Areas.

CA.B.1. Species status and management plan

In May 2006, COSEWIC assessed the American eel in Canada as Special Concern (a species that may become a threatened or an endangered species because a combination of biological characteristics and identified threats). A decision by the Government of Canada on whether or not to officially list the species is pending. A draft Management Plan has been developed to coordinate actions among Canadian jurisdictions. Public hearings on the Management Plan started in early 2007 and a final version will be completed based on input from the public and stakeholders by 2008. The next step will be the implementation of a more detailed plan to strengthen management, reverse abundance declines and foster conditions for rebuilding the population. In the Province of Ontario, American eel was listed as endangered under the new Ontario Endangered Species Act on July 1st. In this province and in Québec, action Plans were set up by Government agencies and public hydro companies (Ontario Power Generation and Hydro-Québec) to mitigate the impact of dams on the St. Lawrence River.

CA.C. Fishing capacity

Eels are subject to ongoing fisheries in parts of eastern Canada (Figure 2), although substantial areas have never been commercially fished (Figure 2). Fisheries in many areas have changed since the mid-1980s. Traditional fisheries were for yellow and silver eels but a recent (1989) fishery for elvers and glass eels began in Nova-Scotia and southern New Brunswick (DU 3). Restrictions in the number of licenses and on seasons for large eels, and on harvest for elvers, have been in place in all areas since the mid-nineties (Anon., 2007).

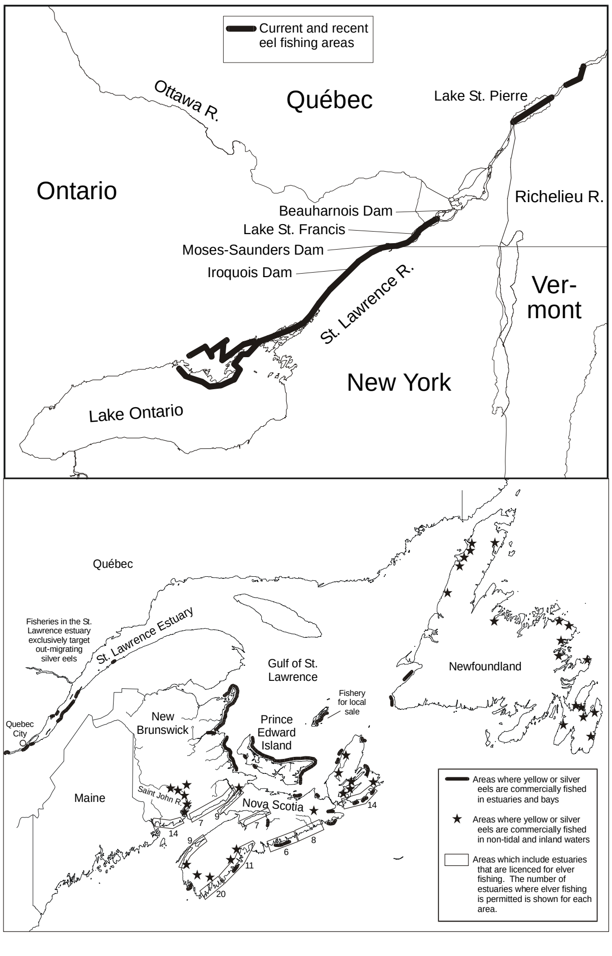

Figure 2. Approximate areas of current and recent commercial eel fisheries in Canada (Cairns *et al.*, 2008).

In response to the sharp decline in abundance, the Richelieu River eel fishery was shut down in 1998. Ontario closed all eel fisheries by setting the quotas on 95 commercial fishing licenses to zero in 2004 and closing the sport fishing season for eel in 2005. In Lake St. Pierre, fishing effort was reduced by 86% since 2002, compared to the historical number of fishing licenses and hoop-nets, as a consequence of a buy-out programme completed in 2008. In the St. Lawrence tidal estuary, a 60% decrease in fishing effort was observed during the last ten years and related to the decrease in silver eel abundance during autumn migration. In the Maritime Provinces, fishing licenses have been frozen for the elver fisheries and commercial elver quotas reduced by 10%. However this 10% can still be harvested provided that the elvers could be sold only for conservation (stocking) purposes.

CA.D. Fishing effort

Eel fishing effort is unevenly distributed within the Canadian range of the American eel. In some areas, there are intensive fisheries although in others, eels are unexploited. The stage targeted by fisheries (glass eel, elver, yellow eel, and silver eel) also varies geographically.

In Québec, there are major fisheries in the upper St. Lawrence River and estuary (DU1) which target mainly silver eels. Except for the Magdalen Islands, eels originating in DU2 are not exploited. In the southern Gulf of St. Lawrence (DU3), commercial fisheries target primarily yellow eels in tidal waters. Yellow eels are fished extensively in coastal waters and estuaries of New Brunswick and Prince Edward Island. There is relatively little eel fishing effort in Gulf Nova Scotia, and none in most fresh waters of the southern Gulf of St. Lawrence. Winter recreational spear fisheries also contribute to anthropogenic mortality of yellow eels in the Southern Gulf of St. Lawrence. In the Scotia-Fundy area, eel fishing occurs in both fresh and marine waters, but many rivers and coastal areas are not fished. The only elver fishery in Canada occurs in Scotia-Fundy. In Newfoundland (DU4) and Labrador (DU5), yellow and silver eels are fished principally in rivers, but many rivers are not exploited. Landings for Labrador were reported only in 1985 (4.3 tonnes) and in 1993 (0.1 tonne), and it is unknown whether this irregular pattern is related to abundance; however, landings are not large (COSEWIC 2006).

CA.E. Catches and landing

Total harvest for Canada between 1961 and 2007 fluctuated between 500 and 1200 tons per year and catches declined from approximately 1100 tons in late eighties to less than 500 tons today (Figure 3). Unreported catches are not thought to be significant.

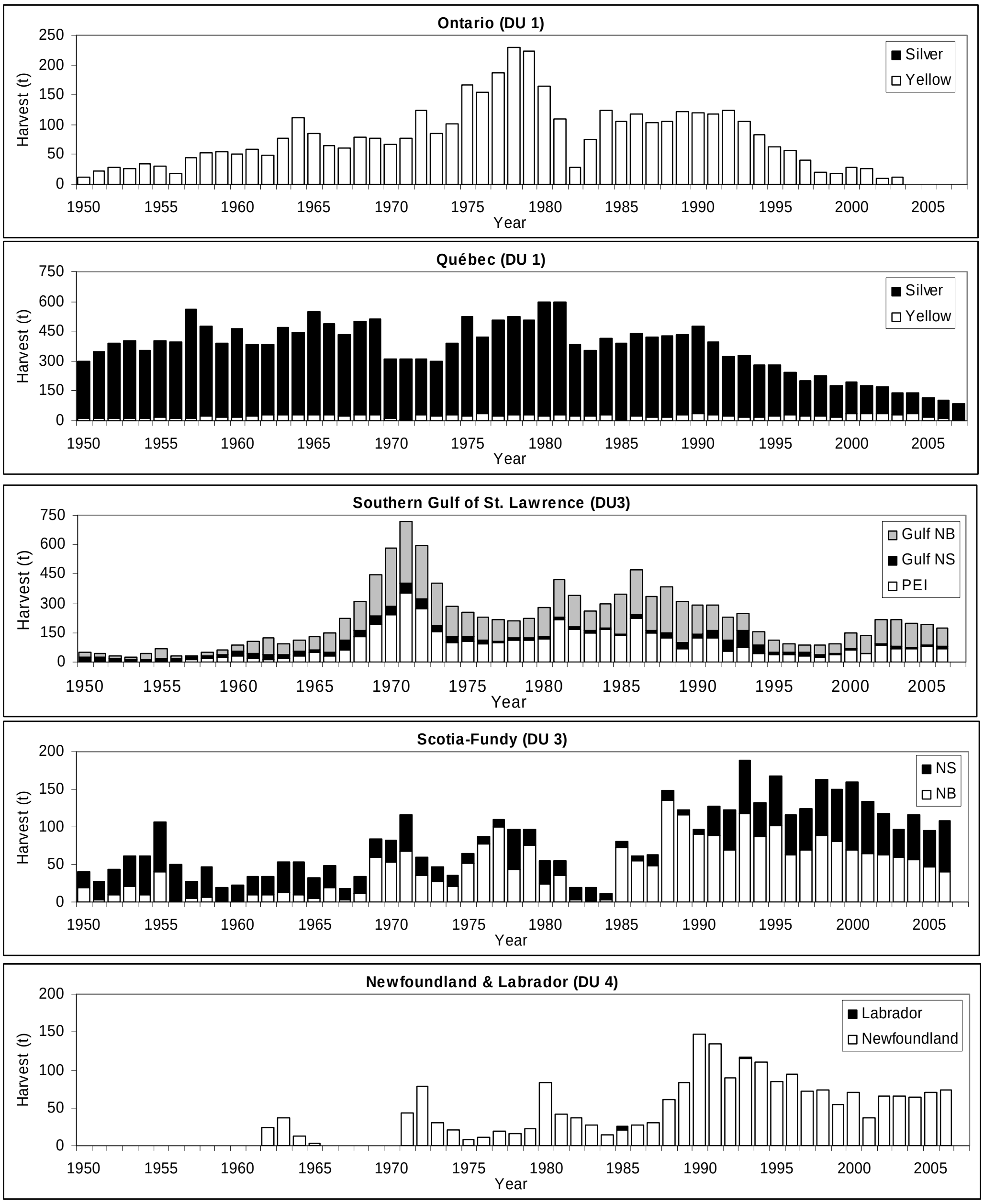

Figure 3. Reported landings (t) of American eel in Canada 1950–2007.

CA.G. Scientific surveys of the stock

CA.G.1 Recruitment surveys/ascending young eels

Long-term datasets on recruitment of young eels in Ontario and Québec include the Chambly ladder (since 1997), the Beauharnois trap and ladder (starting in 1994), the Saunders eel ladder (initiated in 1974), and the Sud-Ouest River ladder (since 1994). Two other series targeting yellow eel exist: the Bay of Quinte trawling survey, starting in 1972, and, a standardized electrofishing series in Lake Ontario which was first collected data in 1984.

In the most downstream location (DU 2), on the Sud-Ouest River, a continuing juvenile year-class strength index (YCSI) was developed and has been maintained since 1994. This index allows the evaluation of the relative contribution of each cohort ascending this river. The YCSI reveals a general and drastic decline in cohort relative abundance (Figure 4) which might possibly be related to a general decline of the overall recruitment of the species.

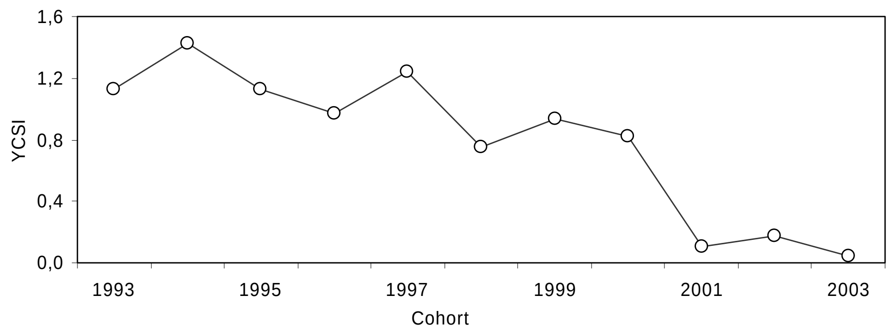

Figure 4. Year-Class Strength Index for American eel, Sud-Ouest River, Québec, Canada.

On the Richelieu River (DU 1), the Chambly ladder is operated at a dam during the upstream migration. Total annual count was 9875 during the first year and decreased rapidly the following years (Table 1), most probably representing a pluri-annual accumulation of young eels in front of the dam before the opening of the eel ladder. The actual annual counts of the recent years (range: 239–3336) are certainly insufficient to support annual historical landings of silver eel (ca. 35 t). No age estimation is available on this location.

Table 1. Young eels ascending the Chambly ladder from 1998 to 2007 (data from Bernard and Desrochers 2007).

Year	Total count (n)	Mean length (mm)	Standard error (mm)
2007	1340	327.4	69.6
2006	434	283.3	93.4
2005	2177	324.8	73.4
2004	727		
2003	3336		

2002	240		
2001	357		
2000	239		
1999	3685	331.3	52.7
1998	9875	386.3	79.3

At the Beauharnois Power Dam, the first anthropogenic obstacle for eels migrating upstream in the St. Lawrence, two ladders are operated and total count, along with mean length, are routinely monitored by Hydro-Québec. Last year migrant numbers revealed a slight decrease along with an increasing mean length (Table 2). However, compared to what was needed to support historical fisheries in the watershed, these counts are still very low. No age estimation has been available for this site since 2004 but decreasing mean size suggests that age structure has changed since the implantation of the eel ladders.

Table 2. Total count and mean length of ascending juvenile eels in the Beauharnois ladder from 1994 to 2007 (data from Bernard and Desrochers, 2007).

	West side ladder		East side ladder		
Year	Total count (n)	Mean length (mm)	Total count (n)	Mean length (mm)	Total
2007	52 969	360.6	1	-	52 970
2006	50 389	349.0	28 127	339.5	78 516
2005	51 694	344.3	2 932	347.1	54 626
2004	42 635	350.8	15 951		58 586
2003	32 684	365.9	26 885	382.8	59 569
2002	10 503	426.2	32 608	388.5	43 211
2001	13 099	420.6			13 099
2000	6881	448.3			6881
1999	10 692	468.7			10 692
1998	5441	471.7			5441
1995	17 072	449.6			17 072
1994	24 721	430.0		448.9	24 721

The next man-artificial obstacle for upstream migrants on the St. Lawrence River is the Moses-Saunders Power Dam, located 85 km upstream from Beauharnois. An eel ladder first built in 1974 and operated by Ontario Power Generation is located on the Canadian side of the Moses-Saunders Power Dam and represents the longest-term dataset on yellow eel recruitment in the St. Lawrence River system. In 2006, a second ladder was put in operation, on the US side of the power dam: respectively 8184 and 13 144 eels transited this new passage facility in 2006 and 2007. At this dam, numbers of eels moving up the ladders have declined by three orders of magnitude over the past 22 years, from over 1-million in 1982 and 1983 to 14 204 in 2007 (Table 3). The size of eels observed at the Saunders ladder has decreased in recent years.

Table 3. Total count and mean length of juvenile eels ascending ladders at the Moses-Saunders from 1974 to 2007.

YEAR	SAUNDERS LADDER		MOSES LADDER		MOSES-SAUNDERS
	Total Count (n)	Mean length (mm)	Total Count (n)	Mean length (mm)	Total Count (n)
2007	2860	386.6	11 344	400.9	14 204
2006	8960	383.7	8184	382.8	17 144
2005	14 891	413.6			14 891
2004	11 325	456.0			11 325
2003	2876	479.3			2876
2002	2663	469.2			2663
2001	944	454.7			944
2000	2895	457.1			2895
1999	1860	457.9			1860
1998	3432	471.6			3432
1997	6117	470.9			6117
1996					
1995	35 076				35 076
1994	163 518	492.8			163 518
1993	8289	414.3			8289
1992	11 534				11 534
1991	40 241	433.6			40 241
1990	121 907	429.8			121 907
1989	258 622	458.2			258 622
1988	213 187	404.0			213 187
1987	465 364	409.8			465 364
1986	230, 70	406.1			230, 70
1985	935 320	404.3			935 320
1984	647 480	382.4			647 480
1983	1 313 570	367.0			1 313 570
1982	1 013 848	374.6			1 013 848
1981	748 724	362.7			748 724
1980	253 758	373.5			253 758
1979	869 135				869 135
1978	794 600	318.9			794 600
1977	966 800	367.8			966 800
1976	659 478	347.9			659 478
1975	936 128	347.0			936 128
1974	130 000				130 000

Two other indices for yellow eels are in place in Lake Ontario and their results can be related to the decline of the eel passage at Moses-Saunders. Both the Bay of Quinte trawling index and an electrofishing index in the eastern part of Lake Ontario have declined by 1 and 2 orders of magnitude because the 1980s and are currently not significantly different from zero (Table 4). Although available information and indices cannot be combined into a quantitative assessment to the overall abundance population, they clearly reveal a general decline as a consequence of reduced recruitment and reduction of distribution area.

Table 4. Numbers of eel captured in Bay of Quinte trawls and electrofishing (Casselman and Marcogliese, 2007) conducted in eastern Lake Ontario.

Year	Bay of Quinte, eels per trawl	Eastern Lak.e Ontario, eels electrofished per hour
2007	0.000	0.21
2006	0.000	0.49
2005	0.000	1.23
2004	0.000	0.52
2003	0.000	0.65
2002	0.013	3.36
2001	0.006	6.82
2000	0.053	9.37
1999	0.074	21.60
1998	0.123	12.90
1997	0.085	7.30
1996	0.356	14.90
1995	0.091	10.50
1994	1.157	30.00
1993	0.434	22.70
1992	0.585	44.40
1991	0.454	38.50
1990	0.356	64.10
1989	0.952	93.00
1988	0.299	68.80
1987	1.552	89.00
1986	0.865	82.90
1985	0.778	63.10
1984	0.330	85.60
1983	0.557	
1982	1.884	
1981	1.530	
1980	0.252	
1979	0.767	
1978	0.417	
1977	1.064	
1976	1.286	
1975	1.543	
1974	0.997	
1973	1.620	
1972	1.873	

The longest fisheries-independent time-series of American eel abundance come from the electrofishing surveys in the southern Gulf of St. Lawrence (DU 3). These include series of yellow eel capture from Restigouche River (from 1970), the Miramichi River (from 1952), and the Margaree River (from 1957; Figure 5). The series with the greatest sampling intensity is that of the Miramichi, which reveals stable trends in the 1950s and 1960s, a peak in the 1970s, a trough in the late 1980s and early 1990s, and subsequent recovering numbers.

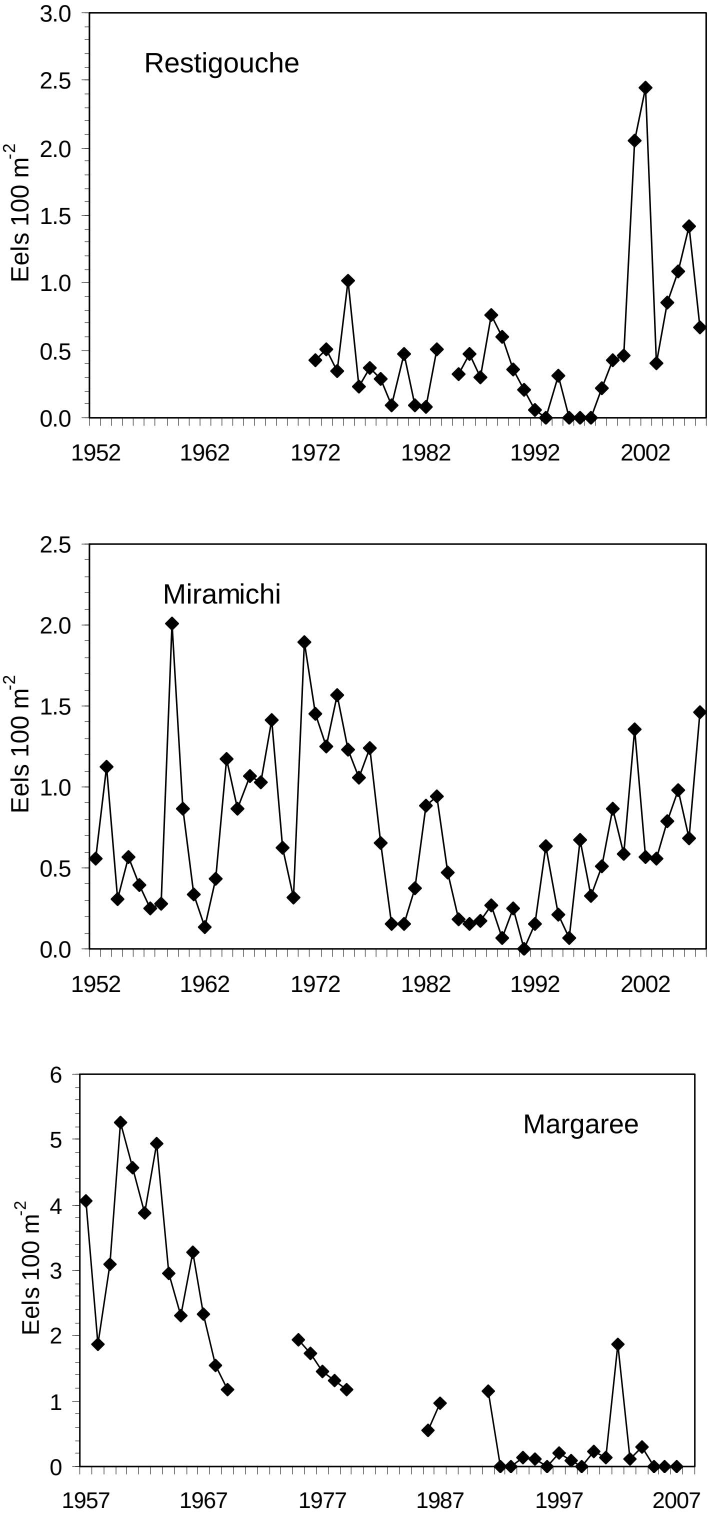

Figure 5. Densities of American eels in Southern Gulf of St. Lawrence River, based on electrofishing surveys. Data from Cairns *et al.*, 2008.

CA.H. Catch composition by age and length

Catch composition by length is not routinely done for fisheries. The silver eel fishery in the St. Lawrence estuary has a very long history. Harvest composed of large migrating female decreased drastically and average weight gradually rose from 1,16 to 1,64 kg between 1996 and 2007 (Figure 6).This observation suggests an ageing population in the Upper St. Lawrence River and Lake Ontario that is not sufficiently supplemented by recruits. The same pattern was also observed in the Richelieu River from the mid 1980s to the 1990s.

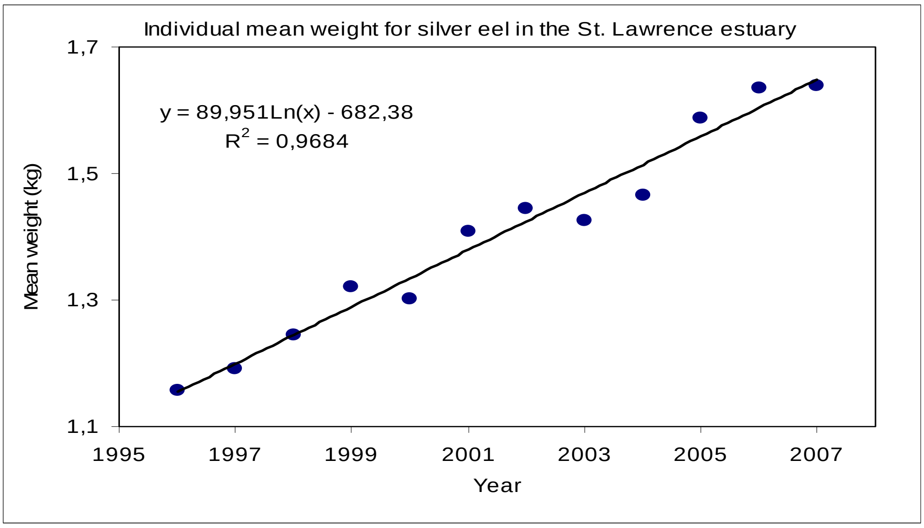

Figure 6. Silver eel mean weight harvested in the St. Lawrence estuary fishery from 1996 to 2007. (Verreault, G., Ministère des Ressources naturelles et de la Faune du Québec, unpublished data).

Age composition is restricted to specific research projects in Ontario, Québec (DU 1 and DU2) and the Maritimes (DU 3). In the latter, short-term series (2–4 years) are available for unexploited and exploited sites (see Cairns *et al.*, 2007a for details). Long term series (>10 years) is restricted to only two sites, the Saunders dam eel ladder (Ontario) and the Sud-Ouest River (Québec).

CA.H.1 Saunders dam eel ladder

Age composition of eels ascending the ladder at the R. H. Saunders Hydro Generation Station was evaluated by Casselman, 2008. Juvenile eels ranged in age from 3 to 19 (Figure 7). The broadest age distributions were in the 2003 and 2004 samples, along with the highest modal ages (10 and 9 years, respectively). There were appreciably younger fish in 2005, in the 4–7 age range, slightly more than twice as many as in 2004. In 2006 and 2007, young fish were similarly abundant. It is quite obvious that there was increased recruitment of appreciably younger eels to the ladder in 2005, and this persisted to 2007. Several relatively strong cohorts of eels ascended the Saunders ladder during this 5-year period. These cohorts indicated increased recruitment in 1992-93 and 1995–96, as well as a stronger multiple-year cohort from 1998 to 2002.

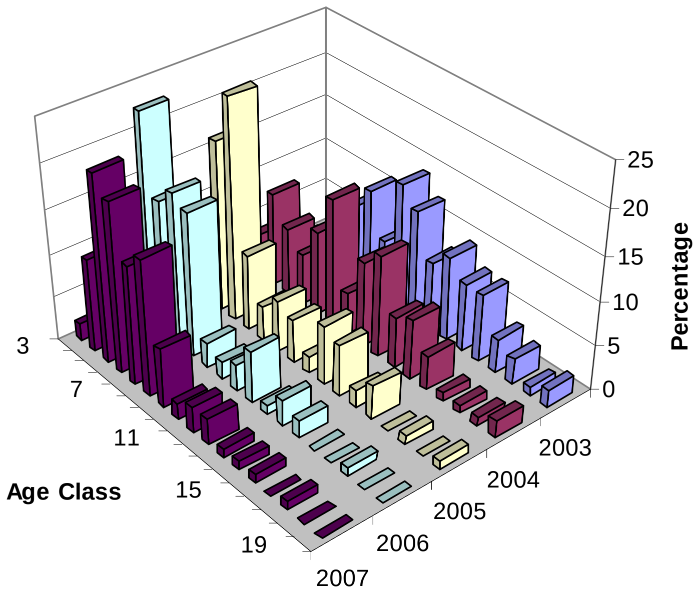

Figure 7. Age class distribution observed in eels ascending the Saunders eel ladder (Casselman, 2008).

CA.H.2 Sud-Ouest River

The Sud-Ouest River is located on the south shore of the St. Lawrence estuary in DU 2 and upstream migrants have been sampled for length and age structure since 1994. On this site, total abundance and age structure are monitored routinely. Abundance of upstream migrants varied from 16 617 in 1994 to 2171 in 2006. Over this period, mean length increased significantly (Figure 8).

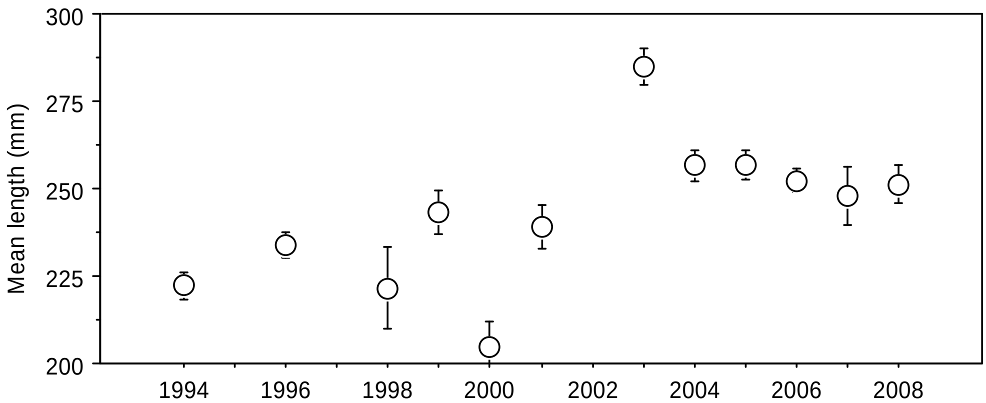

Figure 8. Mean length (C.I. 95 %) for upstream migrant eels in the Sud-Ouest River from 1994 to 2008.

This length increase reflects a shift in age structure over time. In fact, mean age was estimated at 4.2 years in 1994 but it increased gradually to 6.0 over a half generation time.

Young cohorts (<3 years) are now virtually absent in the migration (Figure 9), probably a result of poor recruitment in the system.

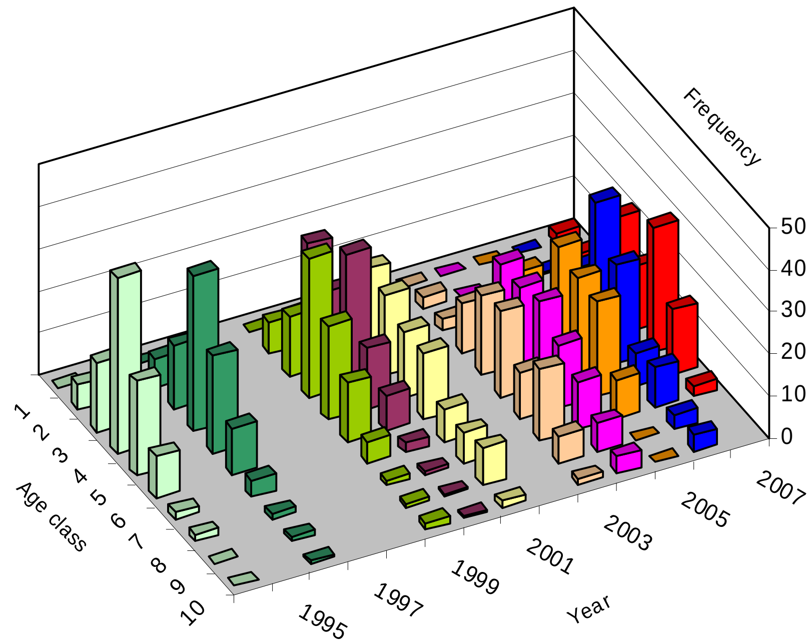

Figure 9. Age structure for upstream migrant eels, Sud-Ouest River, 1994–2007.

CA.H.3 Stocking

Eel stocking with elvers and advanced elvers from Atlantic Canada (DU 3) was done in the Richelieu River/Lake Champlain (DU 1) and Lake Ontario (DU 1; Table 5). For the Richelieu River/Lake Champlain, the Eel Fishermen's Union of Québec is in charge of this activity and financial and scientific support is provided by Hydro-Québec and provincial agencies. For Lake Ontario, the Ontario Power Generation company was in charge of the stocking. A monitoring programme was initiated by provincial agencies in recent years.

Table 5. American eel stocking in Canadian waters.

Year	Richelieu River/ Lake Champlain		Lake Ontario	
2005	600 000	105 kg	-	-
2006	1 000 000	200 kg	144 300	100 kg
2007	421 500	74.2 kg	450 000	90 kg
2008	746 000	145 kg	2 001 561	375 kg

The repeat in 2007 of yellow eel population estimates previously performed in three large bays in Lake Champlain in 1979 and 1985 confirmed the very low abundance of yellow eel in the Richelieu River-Lake Champlain watershed and will contribute to the monitoring of these stockings.

CA.I Other biological sampling

CA.I.1 Parasites

To avoid parasite transfers, screenings are routinely done for elvers caught in DU 3 before their stocking in fresh-waters locations in DU 1. Screenings for viruses (IHNV, ISAV, IPNV and EVH) and *Anguillicola crassus* in individuals prior to stocking were negative during these years. During summer 2006 and 2007, 914 yellow eels were collected from 17 sites in the Maritime provinces, Québec and Ontario and *Anguillicola crassus* was found for the first time in the country. This swimbladder parasite is now present in New Brunswick and Nova Scotia (Antigonish and Cape Breton; Ken Oliveira, University of Massachusetts, pers. comm.).

CA.I.2 Contaminants

Concentrations of many contaminants in the North American environment were high in the 1960s and 1970s, then decreased as bans and restrictions took effect. The St. Lawrence River-Great Lakes system receives a wide variety of pollutants, some of which have lethal (Dutil *et al.*, 1987, Castonguay *et al.*, 1994a) or sublethal (Couillard *et al.*, 1997) effects on eels. Concentrations of most contaminants, including PCBs and mirex, in eels migrating through the St. Lawrence Estuary fell in the 1980s (Hodson *et al.*, 1994). This trend presumably reflects decreased contaminant exposure, but does not takes into account the presence of new contaminant (for example the brominated compounds) and the increasing number of non native species in the Great Lakes watershed that alter fish community composition and foodweb energy flow, leading to subsequent change to pathways and fate of contaminants.

Recently, a 3-year research project on the role of chemicals in the decline of the American eels was initiated to evaluate if eels accumulate sufficient chemical contaminants during their growth and maturation to cause embryo toxicity, and to estimate when contaminants might have affected eel. Under the leadership of Dr Peter V. Hodson (Queen's University), a team of university and government scientists, including colleagues in the US and Europe are collecting fresh and archived samples of eels from reference and contaminated ecosystems. The eels are analysed for concentrations of chemicals known to be embryo-toxic, such as chlorinated and brominated organic compounds, selenium, and alkyl tin. The toxicity of extracted chemicals will be assessed with a battery of tests using fish embryos and fish cells in culture.

CA.I.3 Predators

No study available for natural populations. In the Richelieu River, in summer 2007, comparison of predation rates of elvers in the first 18 hours after day and night stocking revealed that short-term post stocking predation was very low and that stocking during night-time does not offer better survival conditions.

CA.J. Other sampling

CA.K. Stock assessment

Stock assessment was done for all DU's during the COSEWIC process. A bi-national recovery framework focusing on American eel in the St. Lawrence River and Lake Ontario below Niagara Falls extending to the St. Lawrence estuary (DU 1 and a portion of DU 2) is under completion by the Great Lakes Fisheries Commission.

CA.L. Overview, conclusions and recommendations

The Canadian Eel Working Group has developed a preliminary Management Plan for American eel. This plan, still under public consultation, includes a number of goals and objectives in order to rebuild overall abundance of American eel in Canada to its mid-1980s level. It is mainly based on the need:

- to reduce eel mortality from all sources by 50% relative to the 1997–2002 average,
- to achieve a net gain in abundance and escapement by ensuring access to and passage from quality habitats, specifically, provide upstream passage to an additional 10% of lost eel habitat in each jurisdiction every 5 years; to help reaching this objective, a GIS decision tool is under development to identify the watersheds where to intervene in priority,
- to maintain and, where required, develop fishery-independent abundance indices,
- to ensure presence of eels in areas where abundance has collapsed by stocking young eels,
- and develop a Canada/USA management plan.

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Report on eel stock and fisheries- Latvia 2008

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Reporting period: This report was completed in September 2008 and contains data including 2007.

LV.B. Introduction

Historically the eel fishery in Latvia is carried out in coastal waters, river estuaries and lagoon- type lakes close by the sea. After the initiation of artificial restocking of eel in 1930s, fisheries were organized in the inland lakes and lake outlets, too. At present eel commercial fisheries are carried out in 17 lakes and along 500 km of the coastline in ICES Subdivision 28.

Only stationary gears are used in eel fisheries by Latvian fishers. Since 1930 to 1950s anchored bottom long- lines have been the main gear in eel fisheries in the coastal waters. Fyke- and trapnets as well as eel weirs are mainly used gear in the inland waters fisheries. Currently different construction fykenets and trapnets are more common gear in the eel fisheries.

Only in some lakes fisheries targeting eel still exist. In the coastal waters eel mostly is bycatch in mixed fisheries used small mesh size gear and targeting other fish species, especially herring and eelpout.

Current management measures of eel stock exploitation limits:

- the number of gear in coastal and inland waters;
- local closures regarding season and placement of gear;
- the construction of gear (size, mesh size);
- size limit (40 cm) for commercial fisheries and angling and bag limit (for angling only).

In accordance with WFD territory of Latvia is separated in four River Basin Districts.

LV.C Fishing capacity

In the coastal waters of Latvia there are no fisheries companies targeting only eel. In 2007 70 fishing rights owners reported eel bycatch.

In the inland waters eel catches are reported in 14 lakes belonging to three river basin districts. In 2007 45 fishing rights owners where engaged in eel fishery in lakes.

Only two of these lakes are accessible for diadromous fish, other watercourses are blocked by HPS dams, fisheries in these waterbodies based on restocked eel.

Eel fisheries in the RBD's 2007, Latvia.

RBD	Number of lakes with eel fisheries	Surface of RBD (km2)	Number of fisher's leaseowners	Catch of eels (t)	Data source
Daugava	11	27 041.5	23	5.5	Logbooks
Venta	2	15 632.7	21	3.0	Logbooks
Lielupe	1	8841.7	1	<0.1	Logbooks
Gauja	No eel fisheries				

LV.D Fisheries effort

Effort in eel fisheries.

Number of gear used									
1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Waterbodies accessible for eel									
Fyke nets less <30 m									
65	65	65	65	65	65	70	68	68	68
Lakes not accessible for eel, restocked									
Trapnets in river outlets from the lakes, less <30 m									
-	26	26	26	26	26	23	9	9	9
Trapnets in river outlets from the lakes, wider >30 m									
27	27	28	27	27	25	24	23	23	23
Eel weirs									
10	10	6	6	10	11	11	11	11	11

Fisheries effort is fixed by the limited number of gear used in the both inland and coastal fisheries.

LV.E Catches and landings

In 2007 in total 1.2 t of eel was landed in coastal waters and 8.6 in inland waters.

LV.E.1 Catches of glass eel

There is no catch of glass eel in Latvia.

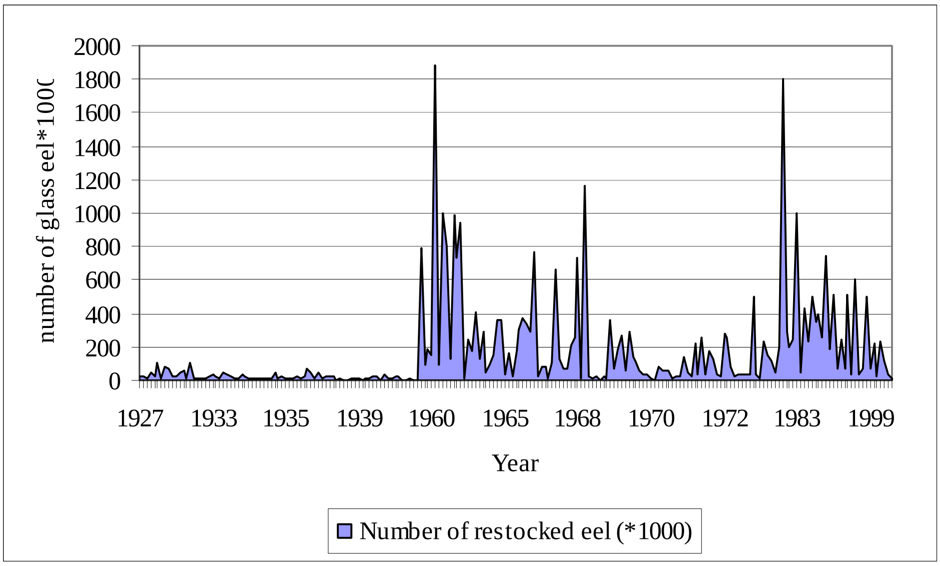
LV.E.2 Restocking

The first official glass eel and young yellow ell stocking are carried out in 1927. Interruptedly eel re-stocking has been performed till nowadays, the maximum was fixed in 1960–1970s. From the dawn of eel restocking till 1990s this measure was organized by the state (for example to increase an income and welfare of fishers in 1930s).

In the last decade eel restocking are carried out by the fishing rights owners or lakes leaseholders. There are no eel restocking financed by state programmes.

All the data of restocking from 1927 is available from database including information on waterbodies.

The eel re-stocking in Latvia inland waters

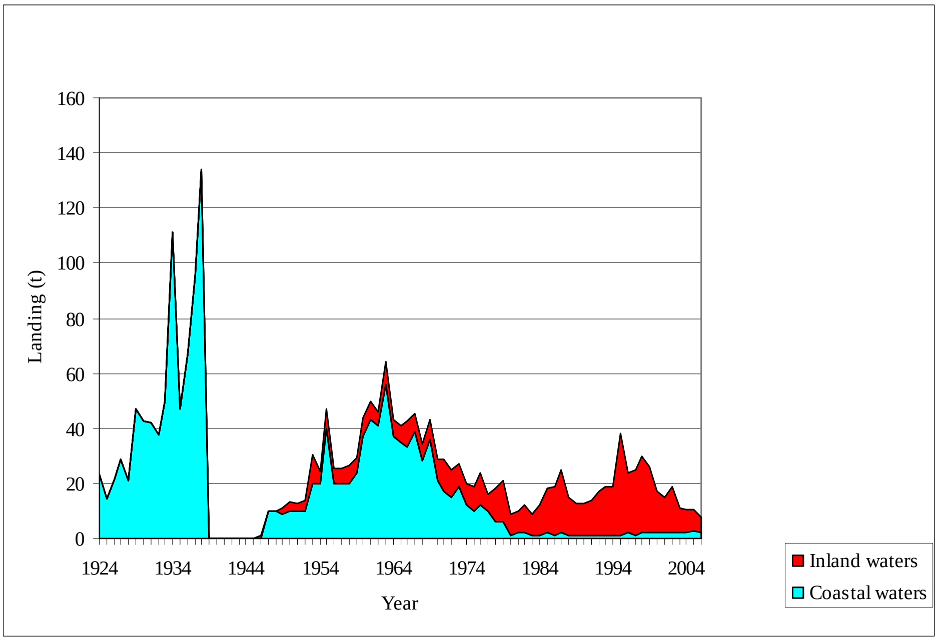


Restocking of eel in Latvia late years (2005–2007)

Year	Number of restocked eel (*1000)
2005	120 (glass eel)
2006	6 (elvers)
2007	18 (elvers)

LV.E.3 Catches of yellow and silver eel

Latvian fisheries legislation does not contribute the separation of eel catch in two different strains. Only small-scale data based on biological sampling still exist. This data were collected in summer of 2005–2006 from three reference areas/fishers who voluntarily checked the own catch and marked the yellow or silver eel presence.



Eel landings in coastal and inland waters of Latvia

In the course of time the fisheries statistics principles, organization and collection changed significantly. At present eel fisheries statistics in the inland waters by RBD's would be accessible from 1946, but in the coastal waters from the period of 1927–1938 and 1946 till now.

From 1992 fisheries statistics in coastal and inland waters of Latvia are based on monthly logbooks with declared daily catch if fishing carried out. Each logbook embodies data regarding fishers, fishing area, gear used and caught. Monthly logbooks collected by the Marine and Inland waters Administration regional officers. The logbook data are processed and stored in LFRA.

LV.E.4 Aquaculture

There is no eel aquaculture in Latvia.

LV.E.5 Recreational fisheries

In 2007 the new angler's inquiry is organized. To obtain the data for National fisheries data collection programme, questions regarding eel angling included in questionnaire. In total 3000 individual anglers will survey in this study.

Results of anglers' inquiry 2007

METHOD-INTERVIEW	
Number of anglers in LV	100 000
Number of anglers in survey	3223
Average angling days/catch per year	49 days/58kg
Number of anglers reporting the eel catch (N?/%)	77/4.1
Proportion of eel in catch	<1%
Estimated eel catch	~4 t
Method- direct registration of catch	
Number of anglers interviewed in situ	1386
Proportion of eel in catch	1 jeb 0.2%
Zušu daudzums lomos pēc tiešās uzskaites	~1.9t

LV.F Catch per unit effort

Catch per unit effort data are available form 1999 for inland waters and 1990 for coastal fisheries.

LV.G Scientific surveys of the stock

No eel stock surveys in Latvia

LV.H Catch composition by age and length

Eel has been included in National Fisheries Data Collection programme since 2006. Eel sampling is organized in 2 areas-near the river Daugava outlet in the Gulf of Riga and the lake Kisezers connected with the river Daugava without migration barriers for migratory species. (Figure 5). Sampling is carried out by commercial fishers' operated with standard gear. Sampling includes following parameters: body length, weight, sex, length of pelvic fin, eye diameter, otholits.

The number of sampled eel in Fisheries data collection programme

YEAR	LOCATION OF SAMPLING	NUMBER OF SAMPLED EEL
2008	Lake Kisezers	94
2008	Gulf of Riga	26

LV.I Other biological sampling

No other biological sampling of eel in Latvia.

LV.J Other sampling

The river fish monitoring covers all country territory by ~100 electrofishing sites. Only few specimens of eel were caught in monitoring 2006–2008.

River fish monitoring effort in the rivers of Latvia

Year	Fished area (m2)	Number of rivers	Number of sites	Number of eels caught
2005	7700	23	71	0
2006	13 115	44	117	3
2007	23 510	48	118	0
2008	30 280	52	128	3

LV.K Stock assessment

Eel landing statistics and effort data were collected every year by LFRA and reported to Ministry of Agriculture.

LV.L Sampling intensity and precision

Sampling intensity exceeds DCR requirements.

LV.M Standardization and harmonization of methodology

Biological samples of eel were collected from landings by two fishers' family enterprises through all fishing season from April to October.

LV.N Overview, conclusions and recommendations

Several conclusions:

The eel landings in LV coastal and inland waters continue decreasing; in fact it reaches historically lowest level.

The share of unreported catches of eel seems to be high, therefore catch and landing statistics should be verified.

General results of river fish monitoring demonstrated the very low abundance of eel in the rivers.

LV.O Literature references

(The full bibliography of references regarding eel in Latvia).

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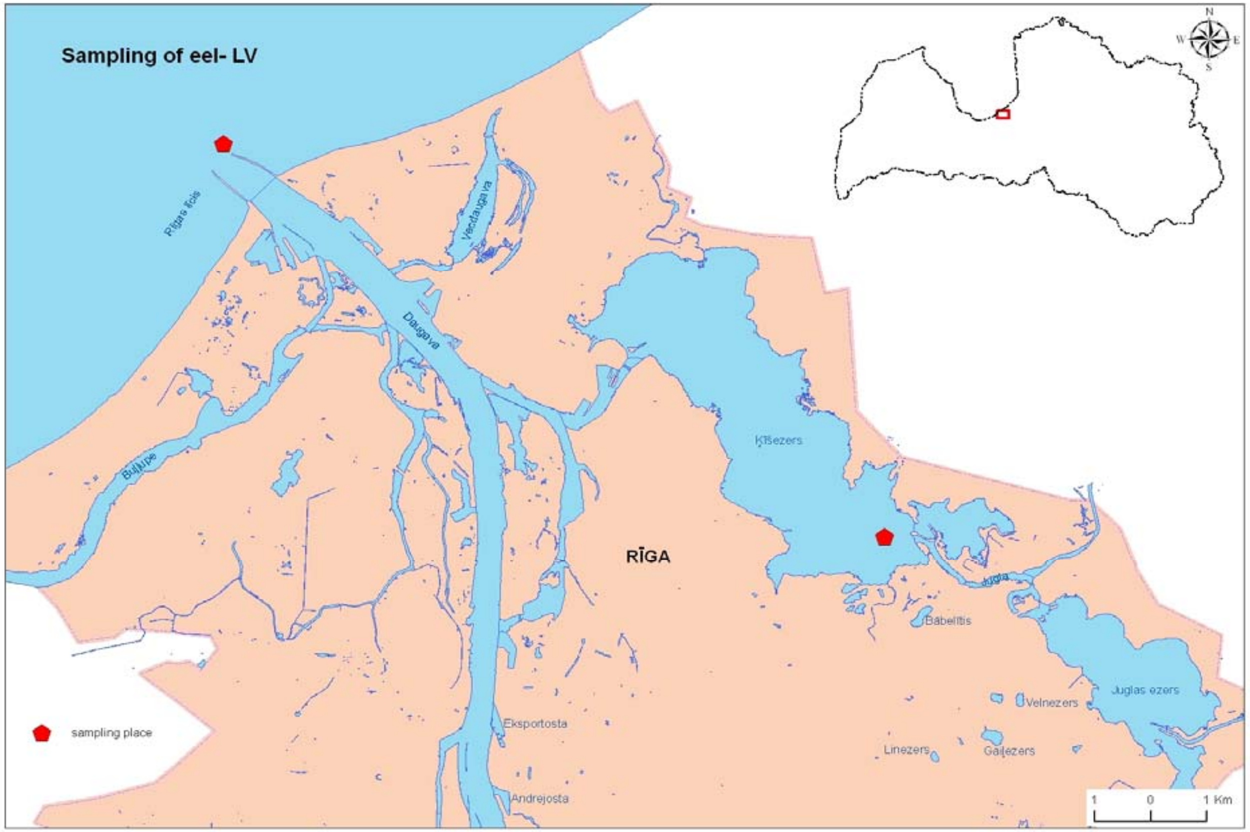
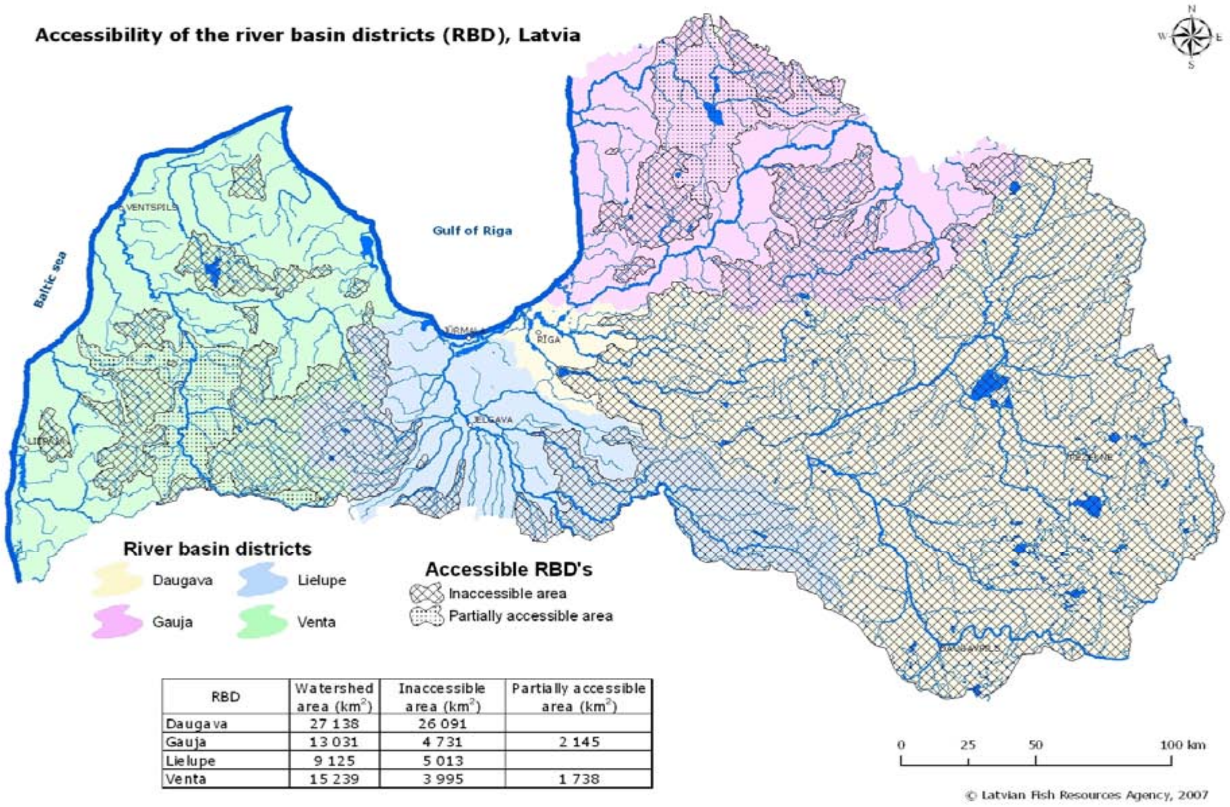


Figure LV.5 Location of eel sampling 2006–2007.



RBD	Watershed area (km²)	Inaccessible area (km²)	Partially accessible area (km²)
Daugava	27 138	26 091	
Gauja	13 031	4 731	2 145
Lielupe	9 125	5 013	
Venta	15 239	3 995	1 738

Figure LV.6 Latvia RBD's and their accessibility.

Report on the eel stock and fishery in France 2007

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FR.B. Introduction

FR.B.1 Presentation of the eel fisheries in France

The French eel fisheries occur mainly in inland waters (rivers, estuaries, ponds and lagoons) and also in coastal waters (see Figure FR. 1 and Table FR.a). The glass eel fisheries are more important in the Bay of Biscay region but they are also found in the Manche region. The yellow eel fisheries occur in the same areas and also concern the upper parts of the rivers of the Atlantic coast, the Rhine and tributaries. The Mediterranean lagoons produce the most part of yellow eels and bootlace eels are targeted for exportation towards Italy. Silver eel fisheries are limited to some rivers, mostly in the Loire basin.

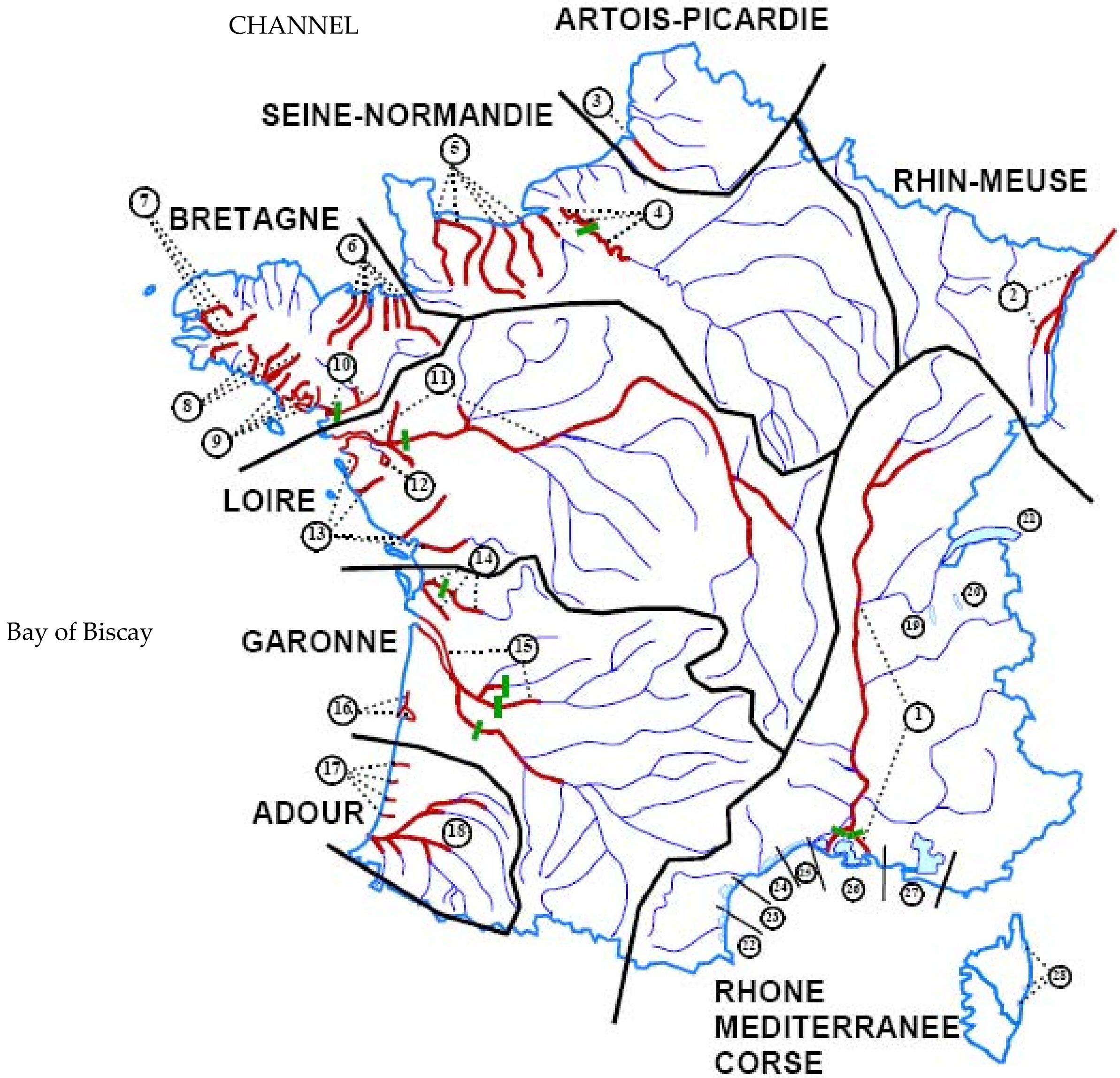


Figure FR. 1 Inland waters in France (eel fisheries in red; tidal limits in green). The numbers correspond to the list of fishing zones in Table FR.a. The management unit names and limits are in black (redrawn from Castelnaud, 2000).

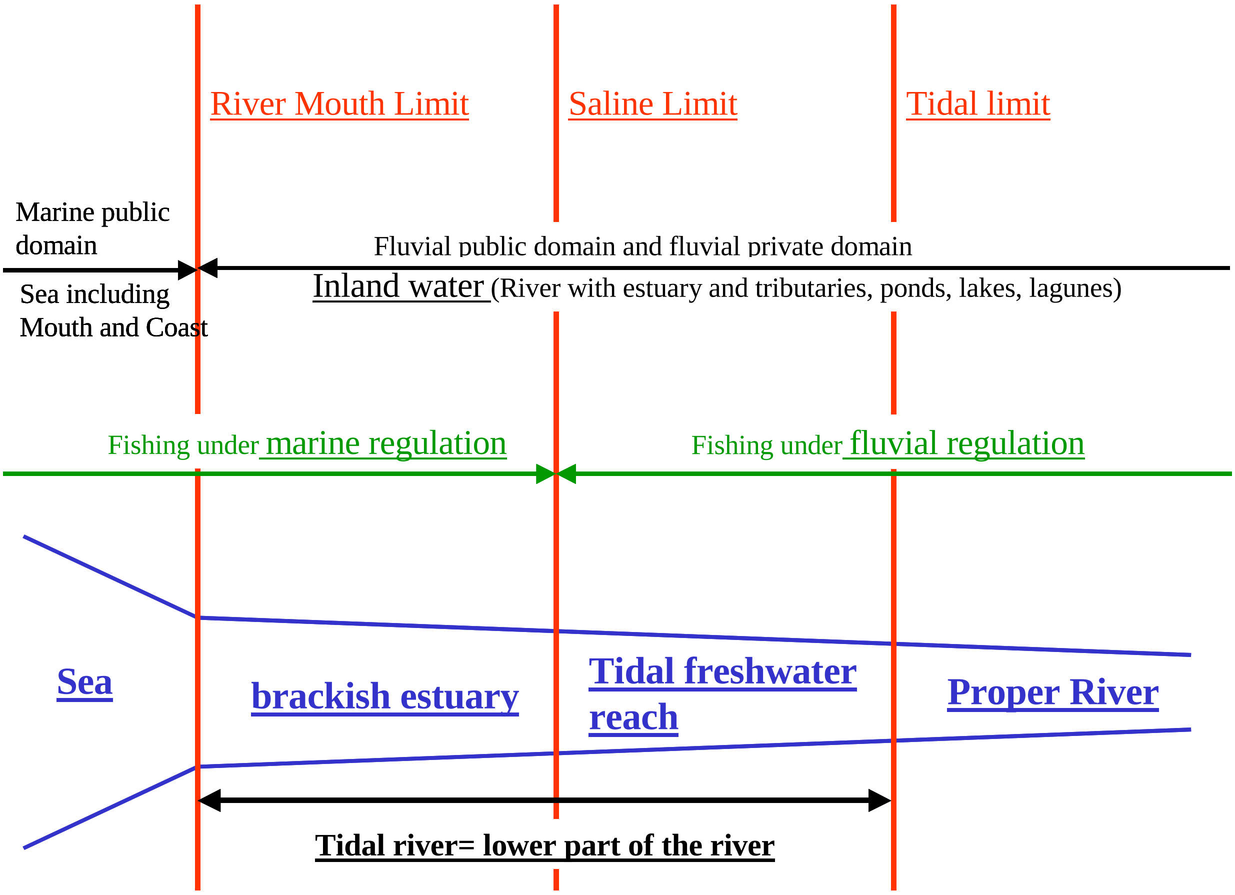
Table FR.a Fishing zones in French inland waters related to the 8 management units (COGE-POMI; modified from Castelnaud *et al.*, 2000, unpublished data).

(Number from Figure FR. 1) Fishing zone – Surface for lagoons	COGEPOMI
(1) Delta du Rhône	Rhône-Méditerranée Corse
(1) Fleuve Rhône aval et amont, Saône, Doubs	Rhône-Méditerranée Corse
(2) Fleuve Rhin, Ill	Rhin Meuse
(3) Estuaire Somme	Artois-Picardie
(4) Estuaire Seine, Fleuve Seine aval	Seine Normandie
(4) Fleuve Seine amont, Risle	Seine Normandie
(5) Estuaires Touques, Dives, Orne, Aure, Vire	Seine Normandie
(6) Estuaires Couesnon, Rance, Fremur, Arguenon, Gouessan, Gouet	Bretagne
(7) Estuaires Elorn, Aulne, Odet	Bretagne
(8) Estuaires Laïta, Scorf, Blavet	Bretagne
(9) Rivières d'Etel, d'Auray, de Penerf, Golfe du Morbihan	Bretagne
(10) Estuaire Vilaine aval	Bretagne
(10) Estuaire Vilaine amont, Fleuve Vilaine aval, Oust, Chere, Don	Bretagne
(11) Estuaire Loire, Loire aval, Erdre, Sèvre Nantaise	Loire
(11) Fleuve Loire amont, Maine, Mayenne, Allier	Loire
(12) Lac de Grand-Lieu	Loire
(13) Baie de Bourgneuf, Estuaires Vie, Lay, Sèvre Niortaise	Loire
(14) Estuaire Charente, Fleuve Charente aval, Estuaire Seudre	Garonne
(14) Fleuve Charente amont	Garonne
(15) Estuaire Garonne, Garonne aval, Dordogne aval, Isle	Garonne
(15) Fleuve Garonne amont, Dordogne amont	Garonne
(16) Canal de Lège	Garonne
(16) Delta d'Arcachon	Garonne
(17) Courants de Mimizan, Contis, Huchet, Vieux-Boucau	Adour
(18) Estuaire Adour, Fleuve Adour, Nive, Bidouze, Gaves de Pau et d'Oloron, Luy	Adour
(19) Lac du Bourget	Rhône-Méditerranée Corse
(20) Lac d'Annecy	Rhône-Méditerranée Corse
(21) Lac Léman	Rhône-Méditerranée Corse
(22) Etang de Canet - 480 ha	Rhône-Méditerranée Corse
(22) Etang de Salses Leucate - 5800 ha	Rhône-Méditerranée Corse
(23) Etang de Lapalme - 600 ha	Rhône-Méditerranée Corse
(23) Etang de Bages-Sigean - 3700 ha	Rhône-Méditerranée Corse
(23) Etang de Campignol – 115 ha	Rhône-Méditerranée Corse

(Number from Figure FR. 1) Fishing zone – Surface for lagoons	COGEPOMI
(23) Etang de l'Ayrolle – 1320 ha	Rhône-Méditerranée Corse
(23) Etang de Gruissan – 145 ha	Rhône-Méditerranée Corse
(24) Etang de Thau – 7500 ha	Rhône-Méditerranée Corse
(25) Etang d'Ingril – 685	Rhône-Méditerranée Corse
(25) Etang de Vic – 1255 ha	Rhône-Méditerranée Corse
(25) Etang de Pierre- Blanche – 371 ha	Rhône-Méditerranée Corse
(25) Etang du Prévost – 294 ha	Rhône-Méditerranée Corse
(25) Etang de l'Arnel – 580 ha	Rhône-Méditerranée Corse
(25) Etang du Grec – 270 ha	Rhône-Méditerranée Corse
(25) Etang Latte-Méjean – 747 ha	Rhône-Méditerranée Corse
(25) Etang de l'Or – 3200 ha	Rhône-Méditerranée Corse
(26) Etang du Ponant – 200 ha	Rhône-Méditerranée Corse
(26) Petite Camargue gardoise – 1200 ha	Rhône-Méditerranée Corse
(26) Etang du Vacares et des Impériaux – 12000 ha	Rhône-Méditerranée Corse
(27) Etang de Berre – 15500 ha	Rhône-Méditerranée Corse
(28) Etang de Palo – 210 ha	Rhône-Méditerranée Corse
(28) Etang d'Urbino – 790 ha	Rhône-Méditerranée Corse
(28) Etang de Diana – 570 ha	Rhône-Méditerranée Corse

From 1999 to 2001, the total number of professional fishers fishing eel, seeking one or several stages, was about 1800 with an estimated total catch of 200 tons of glass eels and 900 tons of yellow or silver eels (Castelnaud and Beaulaton, unpublished data).

Illegal fishers are targeting glass eels in the tidal parts of rivers for commercial purpose. Their number and the amount of their catches had never been clearly quantified.



Fishermen category	Marine professional fisherman=MP Marine amateur fisherman with or without boat =MA	Marine professional fisherman=MP River professional fisherman =FP River amateur fisherman with gears with or without boat =FA Anglers (with rods and sometines with gears) =AN
Fishing rights	MP : quota of licences CIPE (quota of glass eels stamps) MA : no licences, gears limited by rules	MP et FP : quota of licences (quota of glass eels stamps) FA : quota of licences AN : rod licence and quota of licences for gears

Figure FR.2 Inland waters and fisheries limits, fishers categories and fishing rights by zones (Castelnaud and Beaulaton, 2005, unpublished data).

FR.B.2 Management and monitoring system

The administrative saline limit separates two different fishery regulations (see Figure FR.2), marine and fluvial (fresh water). The marine fisheries are located in coastal water, brackish estuaries and in the Mediterranean lagoons. The fresh-water fisheries are located upstream from the saline limit and comprise rivers, lakes, ponds, ditches and canals. In large estuaries there is a special zone, called the “tidal fresh-water reach”, located between the saline limit and the tidal limit, where some marine professional fishers can fish along with river fishers although these are not allowed to go downstream the saline limit.

In brackish and coastal waters, amateur fishers do not need licenses to fish with authorized fishing gears. A system of licenses is set up for marine professional fishers, for river professional and amateur fishers in inland waters. The glass eel fishery is limited with a quota of glass eel stamps and the silver eel fishery is limited by personal authorizations. In the Mediterranean lagoons, **where glass eel fishing is forbidden**, there are also limitations in the number of marine professional fishers and fishing capacities but no system of licences exists.

In the rivers under fluvial regulation, the fishing rights are delivered to fishers by the local Fluvial Fisheries Administrations. The regulation systems in brackish estuaries and Mediterranean lagoons are the result of a negotiation between fishers' organizations (respectively "Commission des poissons migrateurs et des estuaires" and "Prud'homies") and Marine Fisheries Administrations.

The marine professional fisheries in Atlantic coastal areas, estuaries and tidal part of rivers in France have been monitored since 1993 by the Centre National de Traitement Statistiques (CNTS, ex-CRTS) depending from the Direction des Pêches Maritimes et de l'Aquaculture (DPMA) of the Ministry of Agriculture and fisheries. No similar system exists for the marine professional fishers fishing eel in the Mediterranean lagoons.

The river professional and amateur fishers in rivers above marine estuaries (and in lakes) have been monitored since 1999 by the ONEMA (Office National de l'Eau et des Milieux Aquatiques, ex-CSP) in the frame of the « Suivi National de la Pêche aux Engins et aux filets » (SNPE).

These two monitoring systems are based on compulsory declarations of captures and effort (logbooks) using similar fishing forms collected monthly (Table FR.b) with the help of some local data collectors.

Beside these obligatory systems, for which reliability, accuracy and availability of data are variable, local scientific monitoring are developed in the Gironde, the Adour and the Vilaine basin for instance. Also data on annual captures are provided for some sectors by the local fishery administrations: Directions Départementales des Affaires Maritimes (DDAM), Directions Départementales de l'Agriculture et de la Forêt (DDAF).

Table FR.b. Official administrative monitoring systems in France.

SEA	INLAND WATERS	
Salt water	**Brackish water**	**Freshwater**
Marine Public domain: Sea Coast	**Marine Public domain: Estuaries**	**Fluvial Public domain: parts of rivers above estuaries, lakes**
Professionnal fishermen	Professionnal fishermen	Professionnal fishermen
no specific license	Quota of licenses by estuary (specific for glass eel since 1993 and for eel since 2005)	Quota of licenses by river section and by lake (specific for glass eel since 1988)
Logbook for sea fishing	Compulsory logbook (by day, by gear) since 1993 treated by CNTS (ex-CRTS) and Ifremer until 2001, no more data available	Compulsory logbook (by day, by gear) since 1999 treated by ONEMA (ex-CSP) until 2002
Few oriented fishery on eel, few data available		Local scientific monitoring of landings and effort since 1978, Cemagref, evalution of productions by some DDAF Services
Non professionnal fishermen, amateurs and anglers	Local scientific monitoring of landings and effort since 1978, Cemagref, Ifremer, IAV, evalution of productions by some Affaires Maritimes Services	
No licence, no logbook		Non professionnal fishermen, amateurs and anglers
	Non professionnal fishermen, amateurs and anglers	since 1988)
	No licence, no logbook	Compulsory logbook (by day, by gear) 1999-2002 treated by ONEMA (ex-CSP)
	Marine Public domain: Mediterranean lagoons	
	Professionnal fishermen	Anglers
	No license but limitation of the number of fishermen by lagoon No logbook, some technical and scientific surveys	Licenses per departement No logbook, ponctual estimates (ONEMA, ex- CSP)
	Non professionnal fishermen, amateurs and anglers	**Private domain: others parts of rivers above estuaries, others parts of lakes**
	No licence, no logbook	Professionnal fishermen No licence, no logbook, ponctual estimate of effort (ONEMA, ex- Non professionnal fishermen, amateurs and anglers Licenses per departement No logbook, ponctual estimate of effort (ONEMA, ex- CSP)

To manage the migratory species and their fisheries all along the watershed (under marine and fluvial regulation), special organizations, called "Comités de Gestion des

Poissons Migrateurs" (COGEPOMI), have been created in 1994. There are 8 COGEPOMI (management units, grouping basins), one for each important group of basin: Rhine-Meuse, Artois-Picardie, Seine-Normandie, Bretagne, Loire, Garonne, Adour and Rhone-Méditerranée-Corse (see Figure FR. 1 and Table FR. a). They gather representatives of fishers' organizations, administrations and research centers. Each COGEPOMI propose a management plan and funding every five years and has to monitor them. The plan determines conservation and management actions, restocking operations, proposes fishing regulations for both recreational and professional fisheries.

Until now, these management plans did not aim at achieving a particular escapement rate for eel, and the results of management actions have not really been evaluated. Although this system allows for a global approach, and tries to solve environmental problems such as migration barriers or turbine mortality, it does not give for the moment, a consistent management basis for eel at the national level by lack of central regulation and designing of practical management rules. In 2006 and 2007, the ministers in charge of eel management have asked the scientific community to propose the basis of a national plan on eel management, suitable at the River Basin District level.

FR.C. Fishing capacity

FR.C.1 Glass eel

The professional glass eel fishing gear is variable from a river to another (Table FR. c).

Table FR.c. Size and dimensions of the nets allowed in the French inland waters to professional fishers. The numbers in bracket correspond to the COGEPOMI in Figure FR.1 (source Castelnaud, 2002).

TYPE	SHAPE	TOTAL FISHING SURFACE (2 NETS)	BASINS AND REGULATIONS, M=MARINE , F=FRESHWATER; COGEPOMI
Pushnet	Circular	2.262 m²	Nord pas de Calais (m), ARTOIS-PICARDIE Picardie (m), ARTOIS-PICARDIE Normadie (m), SEINE-NORMANDIE Bretagne (m), BRETAGNE Loire (m + f), LOIRE Baie de Bourneuf (m), LOIRE Garonne, Dordogne, Isle (f), GARONNE Adour (f), ADOUR
Large pushnet (Pibalour)	Rectangular	8 to 14 m²	Gironde (m), GARONNE Charente (m), GARONNE Seudre (m), GARONNE
Handed scoopnet	Oval	Close to 2.262 m	Arcachon (m), GARONNE Garonne, Dordogne, Isle (f), GARONNE Courants Landais, Adour (m), ADOUR
Pushnet	Square	2.88 m²	Lay (m), LOIRE
Pushnet	Rectangular	4.32 m²	Sèvre Niortaise (m), LOIRE
Pushnet	Rectangular	3.60 m²	Vie(m), LOIRE

The classical and basic gear used to fish glass eel is the scoopnet of different sizes and shapes. Scoopnets are handled from the river bank for amateur fishers (1 scoopnet of small size) or handled from a boat for professional fishers (1 scoopnet of large size and oval) or pushed by a boat (2 scoopnet of large size and circular). They are called "pibalour" when they are rectangular, wider and pushed by a boat.

For amateur fishers, the scoopnet dimension is 0.19 m^2 in all basins.

The poachers with or without boat can use the different gears and techniques described but also special poaching devices like very large nets called "chaussette" or passive traps called "caisse à civelles" (see Luneau *et al.*, 2003 for more details).

The glass eel fisheries involve pure estuarine or river professional fishers, coastal professional fishers and some shellfish farmers (Champion and Perraudeau, 2000).

A socio-economic study of the coastal fishery in the Bay of Biscay was carried out in 2000 in the frame of the Pecosude project (Leaute and Caill-Milly N., 2003). The survey concerned 248 commercial fishers representing 20% of the whole population. Seven classes of fishing boats were built. Nineteen surveys concerned the class of « pure glass eel boat » and 36 the class of "estuarine boat".

The river and estuarine professional fishers have small boats, 18 years old, 6.5 m long, 2.5 TJB *de jauge*, 41 kW. They are handled by a mean number of 1.1 fishers. Others types of boat are used by coastal marine professional fishers for glass eel like "trawlers", "dredgers". Those are larger (8 m) and more powerful boats (72 kW) (Caill-Milly, 2001).

FR.C.2 Yellow and silver eel

In inland waters, the eel pot (10 mm mesh size minimum, last entrance larger than 40 mm) is the common fishing gear used by all categories of fishers to fish yellow eel. The shapes are much diversified according to the basin and also the fishing zone; the eel pots are not always baited. The fykenet is also used by the professionals only, with a 10 mm mesh size minimum. A barrier can be associated. Others gears exist: deep-lines, lift nets, "vermée" for anglers.

The main fishing gear used in Mediterranean lagoons is a fykenet (mesh size 10 mm) transformed with wings ("ganguis") and with three chambers ("capéchade"). In some places, fixed fisheries are made of batteries of fykenets. These fixed fisheries have to let a passage for the migration from the lagoons to the sea of euryhalines species which are mostly captured (sea breams in particular).

The special gear called "dideau" used to fish silver eel in the Loire basin was introduced in large rivers from the Netherlands in the early 20th century. It is a sort of trawl used from a fixed boat. The net measures 25 m of length with a mouth of 10 m width and 5 m height. The mesh size starts at 16 cm at the mouth and ends at 10 mm.

FR. D. Fishing effort

FR.D.1 Glass eel

For marine professional fishers the quota of seasonal license for glass eel has been limited to 1137. Between 1999 and 2005, the total number of licenses delivered was 900 to 1000. There were 936 marine professional fishers fishing for glass eel in 1997 (Castelnaud, 2000) and around 1050 in 2001 (Table FR. d**).** The total number of marine professional fishers is higher than 1000 licences, probably because one licence permit with stamps to fish in several estuaries or because some fishers fish without licence).

For river professional fishers, from 1999 to 2005, the number of seasonal licenses has decreased from 430 to 360 (from Briand *et al.*, 2005). In 2000, 432 licenses were distributed as following: 186 Adour, 147 Loire, 26 Charente, 77 Gironde). In fact there were 300 river professional fishers fishing for glass eel in 1997 (Castelnaud *et al.*, 2000) and 241 in the last evaluation (Table FR. d); the difference between number of licences and number of river fishers is the number of licences delivered to marine professional fishers who can fish in the tidal fresh-water reach under fluvial regulation; see Figure FR.2).

For legal river amateur fishers, the number of licenses was stable from 1993 to 1999 with an average of 617. Since 1999, the number of legal river amateur fishers has decreased to 285 in 2005 and 193 in 2006. The amateur glass eel fishery has been banned in 2006 in the Loire River.

Finally a total mean number of about 1300 professional fishers has been evaluated during the period 1999–2001 and this figure has not changed much these last years (Table FR.d).

Table FR.d Mean number of glass eel professional fishers per basin from 1999 to 2001; except [a] year 1989 Castelnaud *et al.*, 1994; [b] year 1997, Castelnaud *et al.*, 2000; [c] year 2000, Cuende *et al.*, 2002. Source CSP, CRTS, Cemagref.

COGEPOMI	Fishing zone	Marine professional	Fluvial professional	Total
Artois-Picardie/Seine-Normadie	Manche - Seine-Normandy	10a		10
Bretagne	Bretagne (Vilaine excluded)	86a		86
Bretagne	Vilaine	131		131
Loire	Loire	278	50b	328
Loire	Vendée	209		209
Garonne	Charente-Seudre	163	24	187
Garonne	Gironde	75	75	150
Garonne	Arcachon	42		42
Adour	Adour + courants landais	57	92c	149
	Total France	1051	241	1292

Fishing effort is determined by the number of boats/fishers and the size of nets which varies with the fishers' categories and the fishing zone (Table FR.c) (Castelnaud, 2002). It depends also on the speed and power of the boat and the fishing duration.

FR.D.2 Yellow eel

Yellow eel fisheries are not under specific quotas of stamps like glass eel fisheries. Fishermen often target yellow and silver eels indistinctly.

FR.D.2.1 Inland fisheries

The inland fisheries are scattered and involve professional fishers, amateur fishers with gears and anglers with rods.

Whatever the category, the number of fishers has been decreasing since 1987 (Briand *et al.*, 2005).Only a part of the 450 professionals fishers fishing diadromous species in inland waters target eel at yellow and silver stages (Castelnaud, 2000), their number is evaluated at 128 marine and 107 river professional fishers (Table FR.e). The most part of these marine professional fishers and two thirds of these fluvial fishers also target glass eel.

Table FR.e Mean number of yellow eel professional fishers per fishing zone from 1999–2001(Source CSP, CRTS, Cemagref; except [a] 1997, Castelnaud, 2000;[b] 2000, Sauvaget, 2001).

COGEPOMI	Fishing zone	Marine professional	Fluvial professional	Total
Artois-Picardie/Seine-Normadie	Manche - Seine-Normandy	5(a)	1	6
Bretagne	Bretagne (Vilaine excluded)	13(b)		13
Bretagne	Vilaine	2	1	3
Loire	Loire	16	28	44
Loire	Grand Lieu		8	8
Loire	Vendée	5		5
Garonne	Charente-Seudre	1		1
Garonne	Gironde	30	42	72
Garonne	Arcachon	42		42
Adour	Adour + courants landais	14	10	24
Rhône-Méditerranée-Corse	Rhone		4	4
Rhin-Meuse	Rhin		8	8
Rhône-Méditerranée-Corse	Méditerranée	513	5	518
	Total	641	107	748

FR. D.2.2 Atlantic coastal fisheries

On the Atlantic coast, (Désaunay and Aubrun, 1988) described in the past an important fishery of yellow eel by trawling. This activity nowadays is unreported or has collapsed (Table FR.f). Recently, there might have been changes in eel exploitation in connection with the new use of fykenets.

Table FR.f. Number of boats fishing eels on the Atlantic and Channel coasts. Source 1 Désaunay and Aubrun, 1988; 2 Champion and Perraudeau, 2000; 3 Sauvaget *et al.*, 2001.

COGEPOMI	Fishing zone	1986 Nb boat (1)	1997 Nb boat (2)	2000 Nb boat (3)
Artois-Picardie	Manche	9	?	
Seine-Normandie	Seine-Normadie	7	2 to 3	
Bretagne	Bretagne-Sud	5		9
Bretagne	Vilaine	3		
Loire	Loire	115		
Loire-Garonne	Vendée-Charente	80 to 90		
Garonne	Arcachon	2		

FR. D.2.3 Mediterranean fisheries

Since 1988, the number of 400 to 500 marine professional fishers targeting eel in the Mediterranean lagoons has been regularly announced. Nevertheless, a strong decrease of the population has been noticed (see details in Table FR. m): 63% between 1969 and 1994 on the Palavasiens lagoons (fishing zone 25, see Table FR. a) (Ruiz, 1994) and 33 % between 1986 and 1996 on the Gruissan and Bages-Sigean lagoons (Loste and Dusserre, 1996; Dusserre and Loste, 1997). The most reliable data are collected by the Cépralmar in the Languedoc-Roussillon region which yield the main part of French Mediterranean eels and totalise 430 marine professional fishers targeting eel in 2002 (Loste and Dusserre, 1996; Dusserre and Loste, 1997; Cepralmar, 2003).

The most recent evaluation (Castelnaud *et al.*, 2000) estimates that 513 marine professional fishers were fishing yellow eel in 1997 in all the French Mediterranean lagoons (Table FR.e).

FR.D.3 Silver eel

If we do not consider the Mediterranean fisheries, where an unknown part of silver eel can be captured, the only significant fishery of silver eel is in the Loire basin, with 11 fishers using the special gear called "dideau".

In 2002 the special five years authorizations for fishing silver eel in private waters were stopped by the local fishery administration (extinction in 2006; more than 200 authorizations existed yet in 2000 from Changeux, 2001).

FR.E. Catches and landings

FR.E.1 Historical series of catches and landings for glass eels and yellow eel

In 1999 the production of glass eels was estimated at 255 tons, with a turnover of 35.2 millions euros in the whole French basins (Table FR. g).The historical analysis of the series of captures concerning the main landing areas of the Atlantic coast highlights a fall of the glass eel productions starting in the eighties.

Table FR.g Estimation of the total glass eel production and of the number of fishers in France from 1970 to 2000. (MP: Marine professional fishers, PF: professional river fishers, River and Marine non-pro: river and marine amateur fishers and poachers); (1) unknown number of marine amateur fishers to be added; (2) marine non-professional fishers included; (3) comprising 110 t from marine amateur fishers; (4) number of licenses delivered.

Year	1970	1979	1986	1989	1999	2000
Production MP (t)	450	1175		300	225	180
Production PF and river non-pro f(t)	895	675		110	30	16,6
Total Production (t)	1345	1850	500	520 (3)	255	196,6
Mean price /kg (€)	2,75	5,65		61	138	120
Total value (M€)	2,74	10,44	12,5	30,5	35.2	
Number MP(1)	648	964	850	886	936	970 (4)
Number PF and River non-professionals	2424	2588	4000(2)	1512	761	671
Number Marine non-pro	(1)	(1)		2055	109	(1)
Origin of the data	Popelin, 1971	CIPE, 1982	Desaunay and Aubrun, 1988	Castelnaud *et al.*, 1989	Castelnaud, 2002 Castelnaud *et al.*, 2003 (5)	Castelnaud *et al.*, 2003 (5)

The estimation of inland waters captures for years 1999 and 2000 in Table FR. g, made by Cemagref, ONEMA (ex-CSP) and CNTS (ex-CRTS) for the FAO-FIDI has been revised with the estimation for year 2001 and the new figures are reported in Table FR.i. This table contain the result of an extrapolation from the scientific estimations obtained in the main basins monitored (Adour, Gironde, Loire and Vilaine) with a relation obtained from the comparison with the punctual evaluation of total production for France available: years 1979 and 1989 in Table FR.g and years 1999, 2000 indicated just above, for professional fishers and the same years for non-professional fishers, apart 1979.

On the basis of this attempt, considering the FAO database, where gaps and under-evaluated figures were found, a more realistic temporal series has been built by biological stages (glass eel, yellow+ silver eel) and fishers' categories from 1978 to 2005. It was based on the annual results produced by the punctual scientific investigations (years available in Table FR **h**) and the extrapolation of the results obtained in the main basins monitored (Adour, Gironde, Loire and Vilaine). After 2005, some data for these main basins are available but the extrapolation has not been made because this result of total productions become progressively uncertain and as to be furnished by the official statistical monitoring systems, according to the analysis and recommendations made on the French eel management plan.

Table FR.h. Glass eel professional catches in the large French basins and total production in France for professional and non-professional fishers. MP: marine professional fishers, PF: river professional fishers, Non professional: amateur fishers including poachers for Gironde; numbers in black= estimations by extrapolation; 0t = less than 1t.

	Professional fishers catch (tons)								Non professional fishers catch (tons)			
Season	Adour		Gironde		Loire		Vilaine	Total (1)	Adour	Gironde	Loire	Total (2)
	MP	FP	MP	FP	MP	FP	MP					
1978			27	83	514	12	106	1484		108		647
1979			28	90	620	22	209	1850		116		697
1980			46	167	508	18	95	1667		217		1303
1981			45	78	288	15	57	967		151		904
1982			50	37	261	13	98	917		36		219
1983			49	26	241	19	69	808		27		161
1984			31	26	168	15	36	550		26		156
1985			16	12	145	9	41	446		12		71
1986	8		26	14	113	10	53	432		14		87
1987	10		32	25	131	14	41	486		29		172
1988	12		25	7	165	12	47	511		7		40
1989	9		38	16	78	9	37	410		17		110
1990	3	4	29	9	81	16	36	338		9		54
1991	2	4	36	10	31	5	15	193		14		87
1992	8	12	17	8	32	7	30	188		13		77
1993	6	7	30	12	80	11	31	325		22		130
1994	3	7	35	7	95		24	340	18	12	0	74
1995	8	4	47	10	127	6	30	439	10	19	0	113
1996	4	3	21	4	73	8	22	257	12	4		25
1997	5		33	11	67	4	23	276	6	6		39
1998	2	7	14	2	61		18	189	7	1		6
1999	4	2	41	8	80	7	15	242	2	3	1	6
2000	10		21	4	74	6	14	206		0	1	2
2001	2		9	0	33	3	8	101		0	0	1
2002	1,8		28	9	42	8	16	206		6		37
2003	0,6		10	1	53	4	9	151		0		
2004	1,8		13	1	20		8	76		0		

								Non professional fishers catch (tons)	
	Professional fishers catch (tons)								
2005	3,2	13	4	17	3	7	88	0	2
2006	1,7	8	1					0	
2007	1,4	7	1					0	

This work leads to the following data (total for professional and non-professional fishers, anglers excluded) in Table FR.i:

- glass eel landings in inland waters from 1978 to 2001,
- yellow and silver eel landings in inland waters from 1986 to 2001 and in the Mediterranean lagoons from 1983 to 2001;
- eel production in France compared to uncorrected data registered by FAO-FIDI.

Table FR.i Estimate of capture of glass eels and yellow eels (few silver eel fisheries) in France and comparison with FAO database (Fishstat).

stage	glass eel	yellow eel (+silver)	yellow eel (+silver)	yellow eel (+silver)	all stages	all stages
area	inland water	inland water	mediterranean lagoons	France	France	France - FAO
1978	2 131					
1979	2 547					
1980	2 970					
1981	1 871					
1982	1 135					
1983	969		1 700			
1984	706		1 810			
1985	516		1 501			
1986	518	720	1 224	1 944	2 462	2 687
1987	658	700	1 362	2 062	2 720	1 978
1988	551	700	1 565	2 265	2 816	2 109
1989	520	440	1 306	1 746	2 266	1 672
1990	392	380	1 398	1 778	2 170	1 674
1991	280	380	1 265	1 645	1 925	1 450
1992	264	380	941	1 321	1 585	1 164
1993	456	380	900	1 280	1 736	864
1994	414	380	900	1 280	1 694	607
1995	552	380	900	1 280	1 832	320
1996	282	380	900	1 280	1 562	403
1997	314	323	900	1 223	1 537	1 782
1998	195	250	900	1 150	1 345	449
1999	248	105	900	1 005	1 253	289
2000	214	86	900	986	1 200	399
2001	101	102	900	1 002	1 103	415

FR.E.2 Catches and landings by fishing sector for glass eels and yellow eel

The mean production of glass eel is given for the recent period 1999–2001 by fishing sectors in Table FR.j.

Table FR.j. Mean landings in tons of Glass eel per sectors of the period 1999–2001 (Sources: CSP-SNPE, CRTS, Cemagref, Affaires maritimes except for *, period 1994–1998). Number of fishers corresponding in Table section C.

COGEPOMI	Fishing sectors	Marine and river professionals	River amateurs
Artois-Picardie/Seine-Normandie	Manchel - Seine-Normandie	2.7*	
Bretagne	Bretagne (Vilaine excluded)	?	
Bretagne	Vilaine	12.5	
Loire	Loire	70.3	0.6
Loire	Vendée	26.4	
Garonne	Charente-Seudre	18.9	
Garonne	Gironde	27.6	1.0
Garonne	Arcachon	?	
Adour	Adour + courants landais	15.5	0.4
	Total	173.9	2

The mean production of yellow eel is also given per fishing sectors globally for the same period (Table FR.k).

Table FR.k. Mean landings in tons of Yellow eel per sectors for the period 1999–2001 (Source CSP, CRTS, Cemagref; except for [a] 2000–2002, Changeux, 2003a,[b] 1997, Robion and Adam 1997 (unpublished),[c] 1997, (Castelnaud, 2000), [d] 1996, CRTS com pers. Number of fishers corresponding in Table Section C.

COGEPOMI	Fishing sectors	Marine and river professionals	River amateurs	Anglers
Artois-Picardie/Seine-Normandie	Manche- Seine-Normandie	? + 0.5		
Bretagne	Bretagne (Vilaine excluded)			
Bretagne	Vilaine	0.8	2.7	
Loire	Loire	49.6	30.2	49 (a)
Loire	Grand Lieu	36 (b)		
Loire	Vendée	15 (c)	2.4 (c)	
Garonne	Charente-Seudre	3.3	2.1	
Garonne	Gironde-Garonne-Dordogne	27.1	7.3	
Garonne	Arcachon	21 (d)		
Adour	Adour + courants landais	3.3	1.1	
Rhône-Mediterranée-Corse	Rhone	18.8	0.6	
Rhône-Mediterranée-Corse	Méditerranée (lagoons)	900	?	
Rhin-Meuse	Rhin	2.7	0.3	
	Total	>1078	46.7	>39

Some historical data on yellow eel landings by coastal marine professional fishers are available for 1986 (Table FR.l).

Table FR.l Historical yellow eel landings of the coastal eel fishery, Atlantic and Manche régions (Désaunay and Aubrun, 1988).

COGEPOMI	FISHING ZONE	1986
Artois-Picardie	Manche	25
Seine-Normandie	Seine-Normadie	40 to 60
Bretagne	Bretagne-Sud	10
Bretagne	Vilaine	10
Loire	Loire	?
Loire-Garonne	Vendée-Charente	60
Garonne	Gironde	
Garonne	Arcachon	2
Adour	Adour et Courants landais (d)	

Concerning Mediterranean lagoons the eel catches have reached 2000 t/yean during the 1980s. They have decreased progressively to 900 tons in 1998 with 200 t for the Camargue and Corsica and 700 t for the Languedoc-Roussillon (VERGNE *et al.*, 1999) and now seem to be stable. The Table FR.m gathers the data available on numbers of marine professional fishers and productions of eel (yellow and silver) in the different lagoons. The total of captures registered was around 730 t, which is less than the total announced by VERGNE *et al.*, 1999 because these authors referred to commercial data.

Table FR.m. Total production from Mediterranean lagoon fisheries from various authors. (Ximenes *et al.*, 1990; Ruiz, 1994; Loste and Dusserre, 1996; Dusserre and Loste, 1997).

Secteurs	Zones de pêche	Effectif de pêcheurs	captures anguilles	Captures poissons	Sources
Etangs du Roussillon	(22) Etang de Canet	10	?	?	Prud'homie
	(22) Etang de Salses Leucate	40	?	150 t total	Prud'homie
Etangs du Narbonnais	(23) Etang de Lapalme	2	?	?	Loste et Dusserre (1996), Prud'homie
	(23) Etang de Bages-Sigean	28	120	+100 t other fishes	
	(23) Etang de Campignol	22	50	+30 t other fishes	Dusserre et Loste (1997)
	(23) Etang de l'Ayrolle				
	(23) Etang de Gruissan				
Etang de Thau	(24) Etang de Thau	290	120	?	Vergnes et al. (1999), Mazouni et al (1999)
Etangs Palavasiens	(25) Etang d'Ingril	38	47	+ 13 t other fishes	Ruiz (1994)
	(25) Etang de Vic				
	(25) Etang de Pierre- Blanche				
	(25) Etang du Prévost				
	(25) Etang de l'Arnel				
	(25) Etang du Grec				
	(25) Etang Latte-Méjean				
	(25) Etang de l'Or				
Etangs Camarguais	(26) Etang du Ponant	8	?	?	Prud'homie
	(26) Petite Camargue gardoise	15	?	?	Prud'homie
	(26) Etang du Vacares et des Impériaux	20	40	?	Vergnes et al. (1999)
Etang de Berre	(27) Etang de Berre	30	150	?	Vergnes et al. (1999)
Etangs de Corse	(28) Etang de Palo	10	87	?	Ximenes et al. (1990), Ximenes (com. pers.)
	(28) Etang d'Urbino				
	(28) Etang de Diana				

FR.E.3 Restocking

No restocking recorded at the central level.

FR.E.4 Aquaculture

No data.

FR.E.5 Catch of recreational fisheries

Several local attempts to evaluate the fishing pressure of anglers on eel have been set up in France: on the river Loire (Chancerel 1991; Ricou 2003; Changeux *et al.*, 2003; Baisez, 2006), in the Cotentin marshes (Changeux and Michelot, 2006), in the northern part of France near Calais (Fasquelle and Ledouble, 2006), in the Adour basin (Samuel Marty, Migradour, com.pers.) and in the Rhine river (Vauclin and Storck, 2002). On this basis and different hypothesis, we have tried to make an estimate of catches or fishing effort on eel for French anglers.

One can consider that there are now about 2 millions of fresh-water anglers in France (Changeux, in press). In 2005 only 1.25 millions of them were paying their fishing tax (Source ONEMA). The others 0.75 millions are occasional anglers or don't practise in large public rivers or marshes were eel is still abundant. Finally, the number of tax is widely used as a low hypothesis to asses the population of anglers. This information is known per department and has been updated every year by the CSP-ONEMA since 1942. We can hope this situation will stand with the recent changing's in the organization of fishing administration. Considering this population, the annual activity of an angler is approximately for eel of 17 fishing session per year (Changeux, in press).

We have retained four types of department following the distribution map of Chancerel (1994): 1-department with high to mean density of eels, two-dimensionalepartment with mean to low density, 3-department were eel presence is marginal, and 4-department not accessible to eel. The proportion of anglers fishing for eels at least once a year varies between 30%, in the department where the species is abundant, to 1% in the department were it is absent (Table FR. n). This last figure is not nil because there are some anglers searching for eel who pay their tax in these departments and travel to fish in other department where eel is more abundant. The estimation of the number of eel anglers give around 147 300 in France (Table FR. o). The capture per unit of effort vary (cpue) in the same way from 3 to 0,003 eels per fishing session. This last value considers the smaller number of days the anglers from distant department, may spend on eel.

Table FR.n. Hypothetic per cent of anglers seeking for eel and associate capture per unit of effort (cpue in nb eels per fishing session) for the four types of departments.

Departement type	Percent of eel anglers	CPUE (eel per session)
High to medium density	30%	3
Medium to low density	15%	0,3
Marginal presence	5%	0,03
Not accessible to eel	1%	0,003

The application to entire France (Table FR. o), using a mean annual activity estimate of 17 fishing session per angler, and a mean weight of 127.61 g per eel, gives a total amount of 508.6 t/year. This seems to be a high value if we consider that we count 17 fishing session for anglers who have fished for eel at least once a year. But it's a way to offset the small number of anglers given by the tax.

Looking to this simulation in detail, we find for the Loire basin a weight of captures which is very close to the previous figure of Chancerel, 1991: 136 t/year related to 100 to 150 t/year. For Loire-Atlantique our estimate is 14% lower than the result of the 2000 study (42 t of eels against 49 given by Changeux *et al.*, 2003, see Table FR.k). However this first assessment will be useful to draw up a protocol for a regular national survey (Changeux, 2007).

Table FR.o. Assessment of the number of anglers seeking for eels at least once a year, the associate number of fishing session, number and weight of eels based on the number of tax sold in 2005.

Bassin	Eel density class	Departement	Nb of tax	Nb of anglers for eels	Nb of sessions	Nb of eels	Weight of eels (kg)
Adour	Densité forte à moyenne	Pyrénées-Atlantiques	16 327	4 898	83 268	249 803	31 877
Adour	Densité moyenne à faible	Landes	16 049	2 407	40 925	12 277	1 567
Adour	Présence marginale	Hautes-Pyrénées	12 159	608	10 335	310	40
Total Adour			44 535	7 913	134 528	262 390	33 484
Artois-Picardie	Densité forte à moyenne	Pas-de-Calais	26 246	7 874	133 855	401 564	51 244
Artois-Picardie	Densité forte à moyenne	Somme	16 654	4 996	84 935	254 806	32 516
Artois-Picardie	Densité moyenne à faible	Nord	38 334	5 750	97 752	29 326	3 742
Total Artois-Picardie			81 234	18 620	316 542	685 696	87 502
Bretagne	Densité forte à moyenne	Finistère	6 436	1 931	32 824	98 471	12 566
Bretagne	Densité forte à moyenne	Morbihan	10 999	3 300	56 095	168 285	21 475
Bretagne	Densité moyenne à faible	Côtes-d'Armor	9 819	1 473	25 038	7 512	959
Bretagne	Densité moyenne à faible	Ille-et-Vilaine	18 548	2 782	47 297	14 189	1 811
Total Bretagne			45 802	9 486	161 254	288 457	36 811
Corse	Densité moyenne à faible	Corse	5 266	790	13 428	4 028	514
Total Corse			5 266	790	13 428	4 028	514
Garonne	Densité forte à moyenne	Charente-Maritime	18 407	5 522	93 876	281 627	35 938
Garonne	Densité forte à moyenne	Gironde	26 682	8 005	136 078	408 235	52 095
Garonne	Densité moyenne à faible	Charente	14 653	2 198	37 365	11 210	1 430
Garonne	Densité moyenne à faible	Dordogne	18 563	2 784	47 336	14 201	1 812
Garonne	Densité moyenne à faible	Lot-et-Garonne	12 223	1 833	31 169	9 351	1 193
Garonne	Présence marginale	Corrèze	11 612	581	9 870	296	38
Garonne	Présence marginale	Haute-Garonne	25 644	1 282	21 797	654	83
Garonne	Présence marginale	Gers	8 026	401	6 822	205	26
Garonne	Présence marginale	Lot	9 264	463	7 874	236	30
Garonne	Présence marginale	Tarn-et-Garonne	10 499	525	8 924	268	34
Garonne	Inaccessible	Ariège	9 647	96	1 640	5	1
Garonne	Inaccessible	Aveyron	17 281	173	2 938	9	1
Garonne	Inaccessible	Cantal	10 116	101	1 720	5	1
Garonne	Inaccessible	Lozère	6 866	69	1 167	4	0
Garonne	Inaccessible	Tarn	14 517	145	2 468	7	1
Total Garonne			214 000	24 178	411 044	726 313	92 683
Loire	Densité forte à moyenne	Loire-Atlantique	21 459	6 438	109 441	328 323	41 897
Loire	Densité forte à moyenne	Maine-et-Loire	28 084	8 425	143 228	429 685	54 832
Loire	Densité forte à moyenne	Vendée	17 771	5 331	90 632	271 896	34 697
Loire	Densité moyenne à faible	Indre-et-Loire	19 109	2 866	48 728	14 618	1 865
Loire	Densité moyenne à faible	Loir-et-Cher	11 764	1 765	29 998	8 999	1 148
Loire	Densité moyenne à faible	Deux-Sevres	15 172	2 276	38 689	11 607	1 481
Loire	Présence marginale	Allier	12 326	616	10 477	314	40
Loire	Présence marginale	Cher	12 787	639	10 869	326	42
Loire	Présence marginale	Indre	10 063	503	8 554	257	33
Loire	Présence marginale	Loiret	14 326	716	12 177	365	47
Loire	Présence marginale	Mayenne	12 056	603	10 248	307	39
Loire	Présence marginale	Nièvre	13 768	688	11 703	351	45
Loire	Présence marginale	Puy-de-Dôme	17 722	886	15 064	452	58
Loire	Présence marginale	Sarthe	19 970	999	16 975	509	65
Loire	Présence marginale	Vienne	13 802	690	11 732	352	45
Loire	Présence marginale	Yonne	12 655	633	10 757	323	41
Loire	Inaccessible	Creuse	8 066	81	1 371	4	1
Loire	Inaccessible	Loire	15 778	158	2 682	8	1
Loire	Inaccessible	Haute-Loire	12 223	122	2 078	6	1
Loire	Inaccessible	Haute-Vienne	15 204	152	2 585	8	1
Total Loire			304 105	34 587	587 988	1 068 710	136 379
Meuse	Présence marginale	Ardennes	12 469	623	10 599	318	41
Meuse	Présence marginale	Meuse	10 795	540	9 176	275	35
Total Meuse			23 264	1 163	19 775	593	76
Rhin	Densité moyenne à faible	Bas-Rhin	26 611	3 992	67 858	20 357	2 598
Rhin	Densité moyenne à faible	Haut-Rhin	14 820	2 223	37 791	11 337	1 447
Rhin	Présence marginale	Meurthe-et-Moselle	16 826	841	14 302	429	55
Rhin	Présence marginale	Moselle	16 772	839	14 256	428	55
Rhin	Présence marginale	Vosges	13 051	653	11 093	333	42
Total Rhin			88 080	8 548	145 300	32 884	4 197
Rhône-Méditerranée	Densité forte à moyenne	Bouches-du-Rhône	8 075	2 423	41 183	123 548	15 766
Rhône-Méditerranée	Densité forte à moyenne	Hérault	12 831	3 849	65 438	196 314	25 052
Rhône-Méditerranée	Densité moyenne à faible	Alpes-Maritimes	6 428	964	16 391	4 917	628
Rhône-Méditerranée	Densité moyenne à faible	Gard	12 373	1 856	31 551	9 465	1 208
Rhône-Méditerranée	Densité moyenne à faible	Pyrénées-Orientales	9 514	1 427	24 261	7 278	929
Rhône-Méditerranée	Densité moyenne à faible	Var	8 839	1 326	22 539	6 762	863
Rhône-Méditerranée	Densité moyenne à faible	Vaucluse	11 599	1 740	29 577	8 873	1 132
Rhône-Méditerranée	Présence marginale	Ain	19 540	977	16 609	498	64
Rhône-Méditerranée	Présence marginale	Alpes-de-Haute-Provence	7 635	382	6 490	195	25
Rhône-Méditerranée	Présence marginale	Ardèche	13 662	683	11 613	348	44
Rhône-Méditerranée	Présence marginale	Aude	10 237	512	8 701	261	33
Rhône-Méditerranée	Présence marginale	Côte-d'Or	16 599	830	14 109	423	54
Rhône-Méditerranée	Présence marginale	Doubs	15 592	780	13 253	398	51
Rhône-Méditerranée	Présence marginale	Drôme	11 538	577	9 807	294	38
Rhône-Méditerranée	Présence marginale	Isère	22 531	1 127	19 151	575	73
Rhône-Méditerranée	Présence marginale	Rhône	14 938	747	12 697	381	49
Rhône-Méditerranée	Présence marginale	Haute-Saône	11 974	599	10 178	305	39
Rhône-Méditerranée	Présence marginale	Saône-et-Loire	30 764	1 538	26 149	784	100
Rhône-Méditerranée	Présence marginale	Territoire-de-Belfort	2 193	110	1 864	56	7
Rhône-Méditerranée	Inaccessible	Hautes-Alpes	7 819	78	1 329	4	1
Rhône-Méditerranée	Inaccessible	Jura	12 725	127	2 163	6	1
Rhône-Méditerranée	Inaccessible	Savoie	12 749	127	2 167	7	1
Rhône-Méditerranée	Inaccessible	Haute-Savoie	13 569	136	2 307	7	1
Total Rhône-Méditerranée			293 724	22 915	389 527	361 699	46 159
Seine-Normandie	Densité forte à moyenne	Calvados	7 865	2 360	40 112	120 335	15 356
Seine-Normandie	Densité forte à moyenne	Eure	8 994	2 698	45 869	137 608	17 560
Seine-Normandie	Densité forte à moyenne	Manche	10 659	3 198	54 361	163 083	20 811
Seine-Normandie	Densité forte à moyenne	Seine-Maritime	7 168	2 150	36 557	109 670	13 995
Seine-Normandie	Densité moyenne à faible	Oise	10 221	1 533	26 064	7 819	998
Seine-Normandie	Densité moyenne à faible	Orne	8 526	1 279	21 741	6 522	832
Seine-Normandie	Densité moyenne à faible	Paris et couronne	6 460	969	16 473	4 942	631
Seine-Normandie	Densité moyenne à faible	Val-d'Oise	3 937	591	10 039	3 012	384
Seine-Normandie	Présence marginale	Aisne	15 768	788	13 403	402	51
Seine-Normandie	Présence marginale	Aube	9 686	484	8 233	247	32
Seine-Normandie	Présence marginale	Eure-et-Loir	8 650	433	7 353	221	28
Seine-Normandie	Présence marginale	Marne	12 913	646	10 976	329	42
Seine-Normandie	Présence marginale	Haute-Marne	9 572	479	8 136	244	31
Seine-Normandie	Présence marginale	Seine-et-Marne	17 024	851	14 470	434	55
Seine-Normandie	Présence marginale	Yvelines	4 585	229	3 897	117	15
Seine-Normandie	Présence marginale	Essonne	8 875	444	7 544	226	29
Total Seine-Normandie			150 903	19 132	325 228	555 211	70 850
Total			1 250 913	147 332	2 504 614	3 985 981	508 655

FR.F Catch per unit of effort

FR.F.1 Glass eel cpue in the Gironde basin

The Gironde basin is the tidal part (Figure FR.1 and Figure FR.2) of the Garonne basin, comprising the brackish estuary and the tidal fresh-water reach of the Garonne River, Dordogne River and of its tributary, the Isle River. The results are providing by the Cemagref statistical monitoring system.

One of the notable features of the glass eel fishery in the Gironde during the 1978–2003 period is the major shift from scoopnet catches in favor of large pushnet catches. (Figure FR.3 and Table FR.p). The fishery is currently very largely a large pushnet fishery in the estuary, whereas formerly it was a mixed-gear fishery in both the brackish and fresh estuary. After a strong decrease of the glass eel abundance in the Gironde Basin between 1981 and 1985, the situation at present seems stationary, at a very low level (Figure FR.3 and Table FR.p). The 2003 season is close to the worst historical level (2001).

Table FR.p. Catches of glass eel for professional large pushnet (LPN), small pushnet (SPN) and scoopnet (SN) and non professional scoopnet fishers, cpue on the Gironde basin for 1978–2007 (Source: Cemagref).

	Total Catch (t)				CPUE (kg/day)
Year	Pro. LPN	Pro. SN	Pro. SPN	NonPro. SN	Pro. LPN
1977–1978	26.7	83.3		107.8	12.8
1978–1979	28.0	89.7		116.2	14.0
1979–1980	45.8	167.3		217.1	25.4
1980–1981	45.5	78.3		150.6	14.9
1981–1982	49.6	36.6		36.5	10.9
1982–1983	49.5	25.8		26.9	12.7
1983–1984	30.5	26.0		26.0	17.6
1984–1985	16.3	11.7		11.8	8.1
1985–1986	26.3	13.6		14.4	8.8
1986–1987	31.9	25.0		28.6	13.5
1987–1988	25.4	6.7		6.7	9.3
1988–1989	37.5	15.6		17.3	7.1
1989–1990	28.6	8.6		9.0	5.6
1990–1991	36.0	9.6		14.5	8.5
1991–1992	17.0	8.0		12.8	4.5
1992–1993	29.6	11.6		21.7	8.9
1993–1994	34.6	6.5		12.4	9.2
1994–1995	47.5	9.6		18.9	7.9
1995–1996	21.4	1.5	2.2	4.2	4.7
1996–1997	33.0	3.6	7.9	6.4	6.3
1997–1998	14.1	0.4	1.7	1.0	3.8
1998–1999	40.6	0.8	7.5	2.7	8.9
1999–2000	21.2	0.1	3.4	0.3	6.6
2000–2001	8.8	0.0	0.2	0.1	1.9
2001–2002	28.3	3.8	4.7	6.2	4.9
2002–2003	9.5	0.1	0.8	0.1	2.7

Year	Total Catch (t)				CPUE (kg/day)
	Pro. LPN	Pro. SN	Pro. SPN	NonPro. SN	Pro. LPN
2003–2004	13.3	0.1	1.0	0.1	2.5
2004–2005	12.9	0.8	3.5	0.5	2.7
2005–2006	8.1	0.0	1.2	0.0	2.4
2006–2007	7.1	0.1	0.8	0.1	2.2

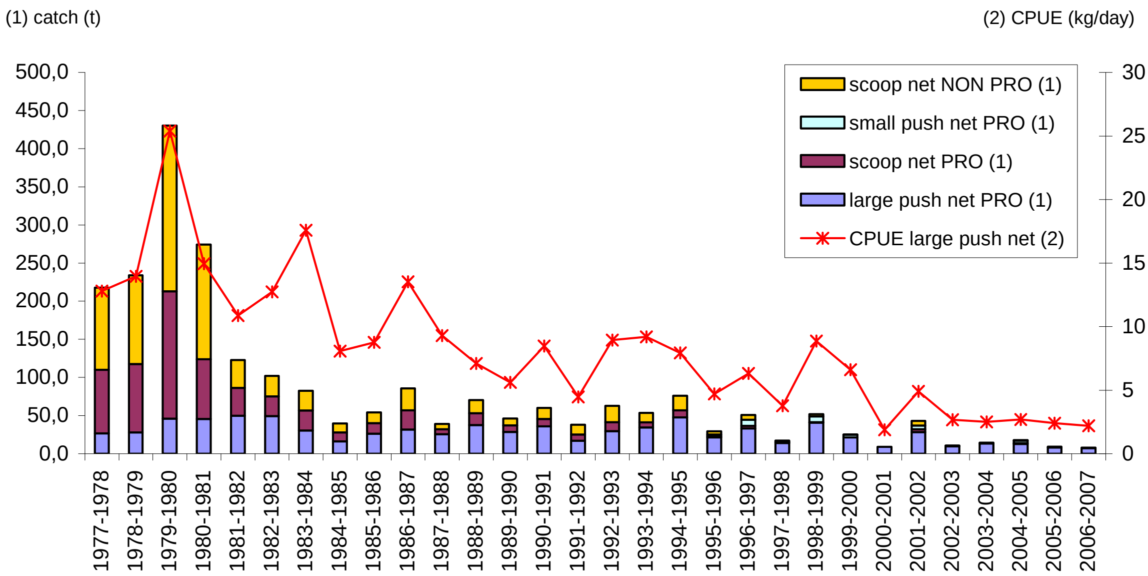


Figure FR.3.Cumulated capture of glass eel for professional and non professional fishers, cpue on the Gironde basin for 1978–2007 (Source: Cemagref).

The use of GLM model with these fishery data has permitted to correct the variation of catches and effort between fishers. The glass eel cpue in the Gironde is a valid abundance index, the same trend is obtained for two métiers (large pushnet and scoopnet) and two zones (brackish and fresh estuary) (Beaulauton and Castelnaud, in press). This result confirms the decreasing trend of glass eel in the Gironde basin.

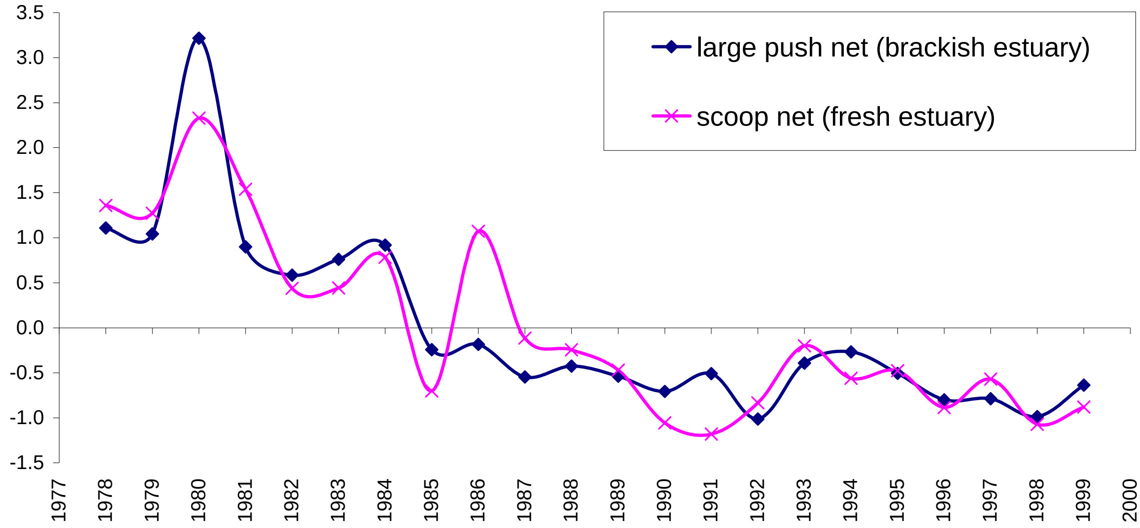


Figure FR.4. Standardized cpue (from GLM) for the large pushnet (*Pibalour*) and the scoopnet (*Tamis*) métiers for the period 1978–1999 (Beaulaton and Castelnaud, in press).

FR.F.2 Yellow eel cpue in the Gironde basin

The eel pot cpue for yellow eel has fallen down between 1988 and 1989, slightly increased until 1998 before decreasing again until 2004. The total catches have decreased although the number of fishers has also decreased. But changes in the fishing power and in the tactics have increased the real effort and our effort unit does not reflect these changes. Consequently, this cpue is not fully representative of the real current tendency of the abundance which presents certainly a more marked decrease.

To analyse this situation, a biological sampling through the professional fishery has been made in 2004 and 2005. This sampling will permit to precise the effort parameters, the stock structure and the fishing impact on the stock. If this study is maintained during several years, it will be possible to evaluate the magnitude of the yellow eel stock with VPA methods (Sparre, 1979; Ardizzone and Corsi, 1985; Gascuel and Fontenelle, 1994; Dekker, 2000).

We will also apply GLM methods on eel pot cpue, to precise and verify the tendency of yellow eel abundance.

Table FR.q. Catches of yellow eel for professional and non professional eel pot fishers, cpue on the Gironde basin for 1978–2007 (Source: Cemagref).

Year	Total Catch (t)		CPUE (kg/eelpot/month)
	Pro.	Non Pro.	Pro.
1978	195.5	204.1	
1979	241.3	229.5	
1980	181.4	155.7	
1981	187.8	148.8	
1982	157.9	133.1	
1983	71.8	76.2	
1984	103.8	164.1	
1985	106.0	170.3	
1986	124.5	160.5	
1987	94.8	134.3	1.9
1988	102.3	97.7	1.9
1989	67.1	40.2	0.9
1990	47.1	28.3	0.8
1991	26.3	15.8	1.2
1992	46.1	27.7	1.1
1993	35.7	21.4	0.9
1994	35.2	21.1	1.0
1995	36.9	18.4	1.3
1996	25.7	7.7	1.1
1997	32.2	9.7	1.5
1998	24.4	7.3	1.5
1999	21.8	1.5	1.1
2000	20.0	1.4	1.1
2001	18.0	0.6	1.2
2002	13.1	1.1	1.0
2003	10.4	0.5	0.9
2004	14.4	1.3	1.4
2005	8.6	0.6	0.8
2006	8.4	1.3	0.9
2007	8.8	1.3	1.0

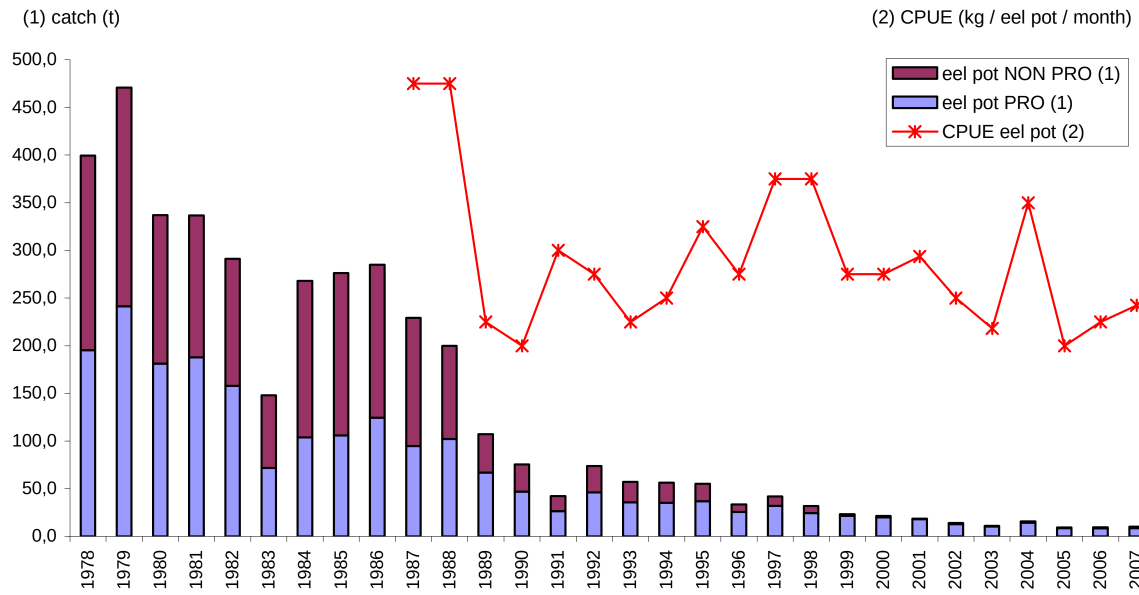


Figure FR.5. Cumulated catch of yellow eel for professional and non professional fishers, cpue on the Gironde basin for 1978–2007 (Source: Cemagref).

FR.F.3 Glass eel cpue in the Adour basin

The results are providing by Ifremer in connection with CNTS.

Table FR.r. Mean, maximum minimum annual cpue (Kg/trip) for the glass eel fishery (hand nets) in the Adour estuary (source: Ifremer/CNTS).

Year	CPUE mean	CPUE Min	CPUE Max	Year	CPUE mean	CPUE Min	CPUE Max
1927/1928	5	4.7	5.3	1984/1985	2.4	1.5	3.3
1928/1929	5.5	4.4	7	1985/1986	1.5	0.6	2.1
1929/1930	6.7	4.3	9.9	1986/1987	3.3	0.3	5.3
1930-1931	18.7	10.1	35.2	1987/1988	3.7	1.4	5.6
				1988/1989	4.1	0.9	6.2
1965/1966	5.1	1.3	8.8	1989/1990	1.2	0.2	2.1
1966/1967	6.4	4.1	9.7	1990/1991	0.7	0.15	1.1
1967/1968	10.1	3	23.3	1991/1992	2.9	0.4	4.4
1968/1969	5	0.9	7.8	1992/1993	2.4	1.3	2.3
1969/1970	7.5	3.6	11.2	1993/1994	1.4	0.8	1.9
1970/1971	4.6	2.9	5.6	1994/1995	2.6	0.85	3.9
1971/1972	4.4	1.5	7.8	1995/1996	1.53	0.75	1.8
1972/1973	4.5	3.5	6.8	1996/1997	1.6	1.13	1.97
1973/1974	7.4	4.3	12.3	1997/1998	1.07	0.49	1.31
1974/1975	5	2.2	7.9	1998/1999	1.82	1.05	2.21
1975/1976	11	3.3	16	1999/2000	4.43	2.77	4.34
				2000/2001	0.49	0.53	1.05
1978/1979	10			2001/2002	0.89	0.48	1.23
1979/1980	5			2002/2003	0.31	0.09	0.45
				2003/2004	0.6	0.2	0.9

Year	CPUE mean	CPUE Min	CPUE Max	Year	CPUE mean	CPUE Min	CPUE Max
				2004/2005	1.13	0.42	2.17
				2005/2006	0,72	0,46	0,96
				2006/2007	0,66	0,15	0,91
				2007/2008	0,76	0,04	1,13

FR.F.4. Comparison of yellow eel cpue between the Adour and the Gironde basins

The exploitation of the yellow eel in the Adour and the Gironde basins can be compared with two long historical series (Figure FR.6 and Figure FR.7). The Adour data concern marine professional fishers (source: Ifremer) and the Gironde data correspond to marine and river professional fishers (source: Cemagref). Catches have significantly decreased from 1978 to 1986 (Gironde data) mainly because of a strong decrease in nominal effort, the cpue (ratio between catch and nominal effort) has revealed a great variability during this period. From 1987 onwards (Adour and Gironde data), the nominal effort decreased slightly whereas catches fell. In the Adour basin, cpue decreased sharply in a first period (1987–1990) then decreased but more slightly (from 1990 onwards). In the Gironde basin, the decrease is more continuous since 1986. The overall decrease of cpue (1987–2003) in both basins seems to be of the same order of magnitude.

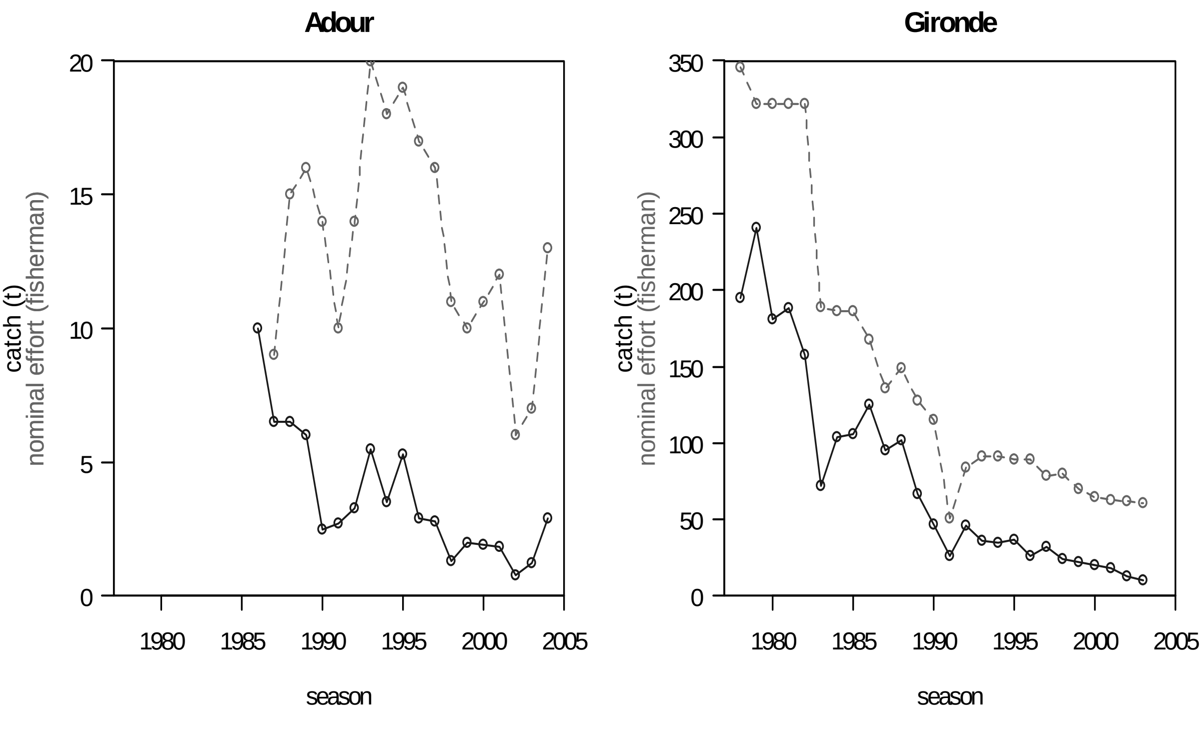


Figure FR.6. Catch (solid line) and nominal effort (dashed line) in the Adour (left panel) and Gironde (right panel) basins over the period 1978–2004. Source: Adour = Ifremer; Gironde = Cemagref.

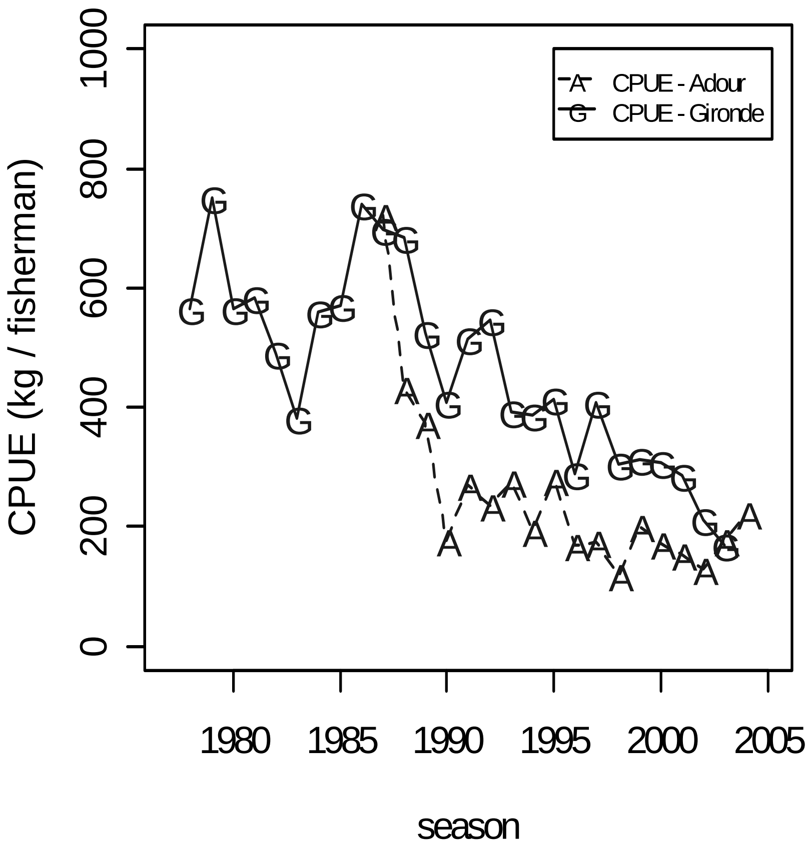


Figure FR.7. Cpue in the Adour (dashed line) and Gironde (solid line) basins over the period 1978–2004. Source: Adour = Ifremer; Gironde = Cemagref.

FR.G Scientific surveys of the stock

FR.G.1 Recruitment surveys, glass eel

A recruitment surveys have been set up in the Gironde since 1979. In the Adour it has been set since1998 and in the Loire and Isle (tributary from the Gironde) since 2004 as part of the Indicang project. The methods are described in (Feunteun *et al.,* 2002). A fishery and trap based survey is also conducted in the Vilaine from 1996. The Loire time-series is based on catches.

FR.G.1.1 Recruitment survey, the Gironde

The Gironde survey consists in a monthly sampling of 24 stations (surface + deep) distributed along four transects. This monitoring uses a research vessel (Figure FR.8) and aims at evaluating the abundance variations of the juveniles of fish and crustacean and the adults of small species.

Figure FR.8 The "Estuarial" boat used for scientific survey in the Gironde (Source: Cemagref).

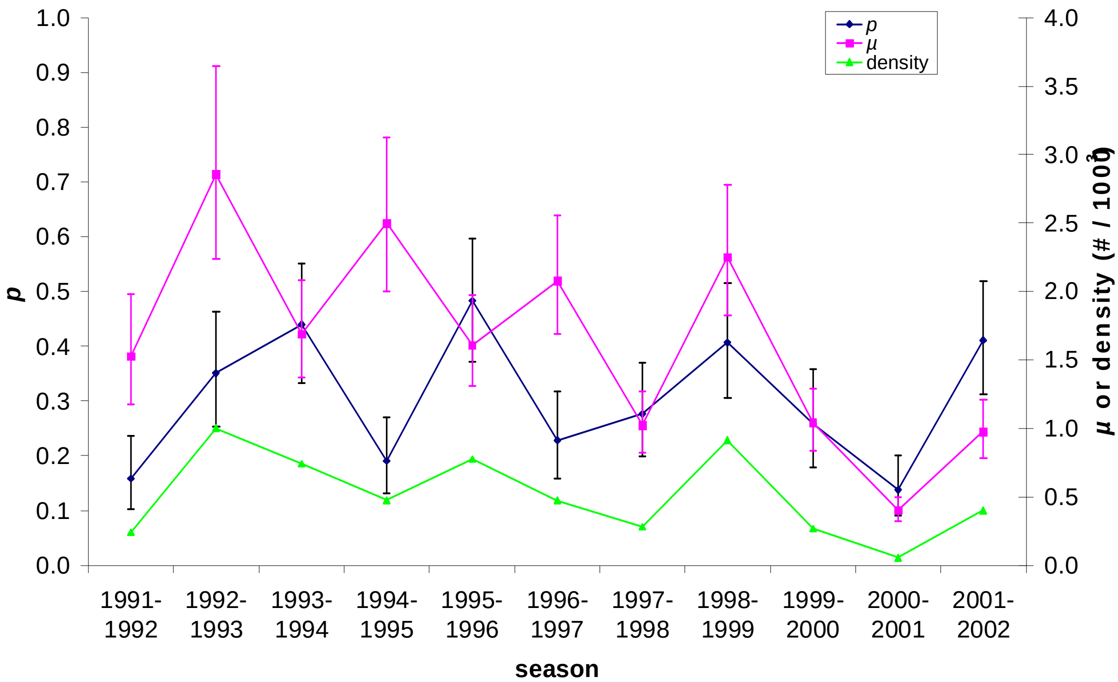


Figure FR.9. Results for glass eel of a delta-gamma analysis for season effect (p=probability of positive capture, μ=mean capture for only positive capture, density=p*μ) (extracted from Lambert, 2005).

These data were recently analysed by (Lambert, 2005) using a delta-gamma approach (Stefánsson, 1996). This method allows separate analyses of the presence probability (p) and positive capture (μ) and joint analyse through overall density. The delta and gamma approaches were both performed thanks to generalized linear models (GLM;

(McCullagh and Nelder, 1989)) with spatial and temporal effects. Only results on season effect for glass eel are presented in Figure FR. 9. (For more details see Lambert, 2005). All combinations of p and μ are encountered. However, we can notice some peculiar seasons like 2000–2001 for which glass eels were rarely caught (low p) and when caught, in small number (low μ), resulting in a very low density. In the main, this analysis confirms results coming from fishery data (see FR.F.1) even if some little differences remain to analyse.

FR.G.1.2 Recruitment survey, the Adour

The Adour survey aims at estimating the glass eel flux transported during flood tide in the estuary. The protocol is based on the simultaneous catch of glass eels located at the surface (Figure FR.10) and in full water along three longitudinal transects. These catches are done downstream from the dynamic tide reversal area, at a fixed station and during the entire flood.

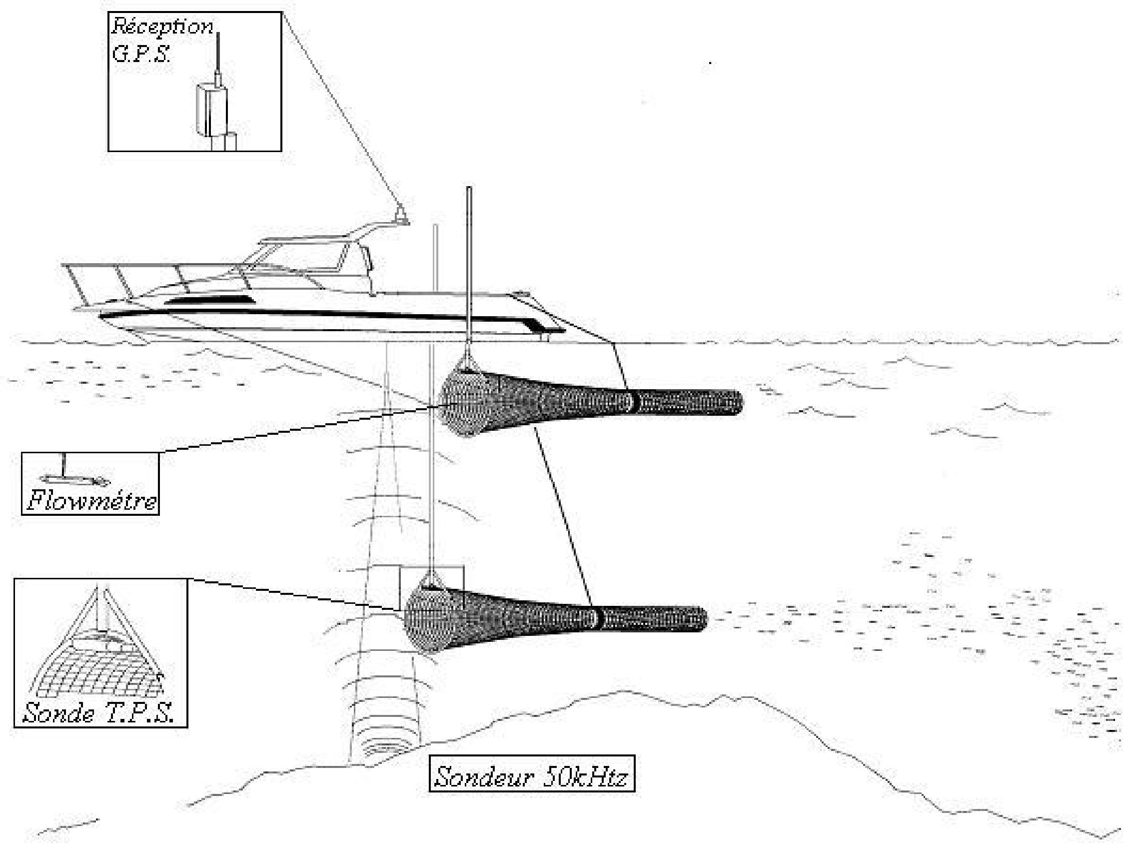


Figure FR.10. Descriptive diagram of the materials of catch and positioning used in the Adour protocol (Source: Cereca).

The variability of the glass eel captures over the recent period 1985–2002 (Table Fr.s) seems especially related to the fluctuations of hydro-climatic conditions (Figure FR.11).

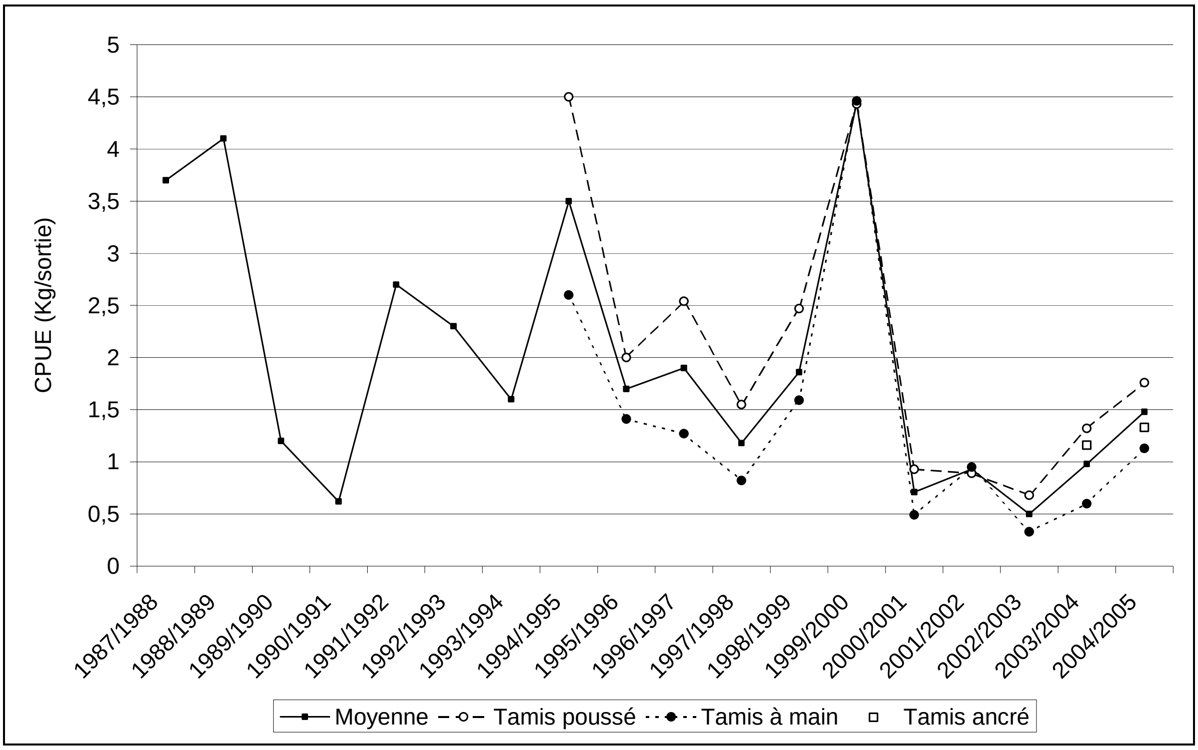


Figure Fr.11. Variations of glass eels captures per type of fishing gears in the Adour estuary. Moyenne = mean, tamis poussé = small pushnet, tamis à main = scoopnet, tamis ancré = fixed scoopnet (Lissardy *et al.*, 2007).

Table Fr.s. Total catches for the glass eel fishery (from 2000 only marine fishers combining small pushnets and scoopnets) in the Adour estuary.

DECADE				
Season (n-1,n)	1970	1980	1990	2000
0			3.2	9
1			1.5	2
2			8	2,4
3			5.5	0.6
4			3	1.7
5			7.5	3,2
6		8	4.1	
7		9.5	4.6	
8		12	1.5	
9		9	4.3	

FR.G.1.3 Time series of catches of glass eel and yellow eel, the Vilaine

The Vilaine time-series is collected from total catches of the fishery. As the fishing closure has been modified from 1996, those catches are corrected from the evaluation of the standing stock after the closure of the fishery. These evaluations are based on marking recaptures surveys performed in April and May and modelling (Table FR.t). The results of the monitoring of the trapping ladder are summarized in Figure Fr. 12.

Table Fr.t. Time series for the Vilaine glass eel recruitment (corrected from late arrivals).

Season (n-1,n)	1970	1980	1990	2000
0		95	35.9	14.45
1	44	57	15.35	8.46
2	38	98	29.57	15.90
3	78	69	31	9.37
4	107	36	24	7.49
5	44	41	29.7	7.36
6	106	52.6	23.286	6.6
7	52	41.2	22.85	7.7
8	106	46.6	18.90	5.1
9	209	36.7	16	

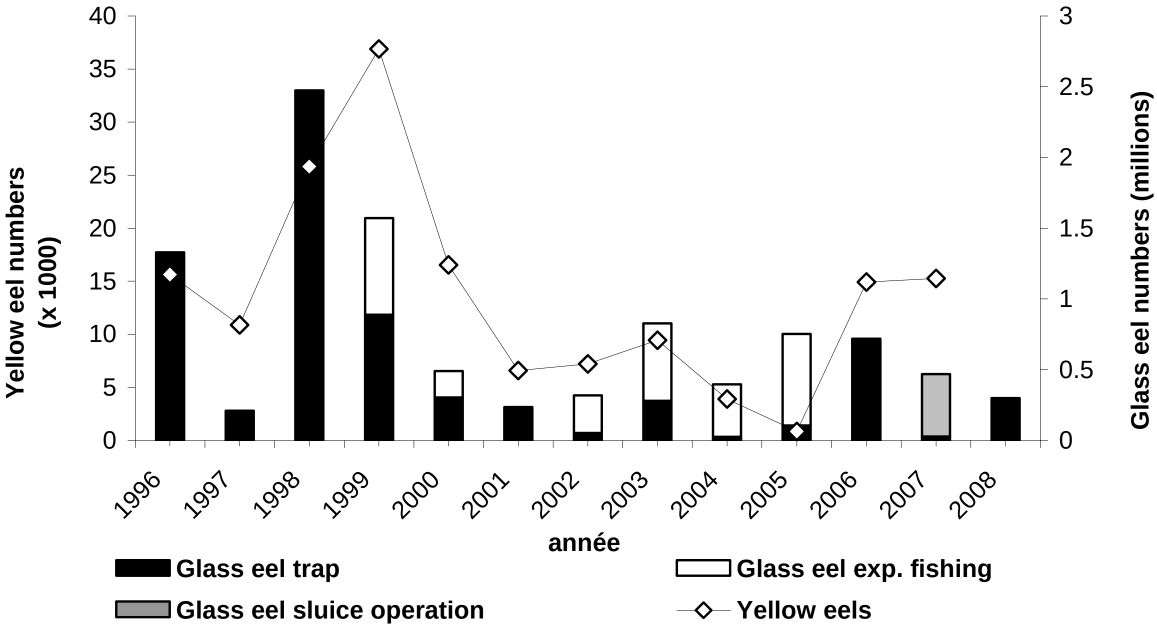


Figure Fr.12. Number of glass eel and yellow eel collected and counted at the Vilaine trapping ladder.

FR.G.1.4 Time series of catches, the Loire

The historical data of glass eel fishery (Table FR.u) have been provided by Ifremer and for the recent years, the Tableau de Bord Loire has gathered them from CSP, CRTS, DDAM.

Table Fr.u. Time series for the Loire glass eel fishery, marine and fluvial professionals until 2001, only marine professionals from 2002 to 2007 (* an assumption was made for catches of fluvial fishers, not available for this year).

Decade Season (n-1,n)	1950	1960	1970	1980	1990	2000
	86	411	453	526	96	80
1	166	334	330	303	36	33
2	121	185	311	274	39	42
3	91	116	292	260	91	53
4	86	142	557	183	103*	27
5	181	134	497	154	133	17
6	187	253	770	123	81	15
7	168	258	677	145	71	21
8	230	712	526	177	66	
9	174	225	642	87	87	

FR.G.2 Stock surveys, yellow eel

Specific stock surveys were performed in small basin (Frémur, Oir). The results are in previous ICES reports.

The "Reseau hydrobiologique et piscicole" (RHP) is a survey of 761 stations yearly sampled with electrofishing. These samples are used to determine the ecological status request by the Water framework directive. The abundance of eel distribution reveals a classical downstream increase in density (Figure FR. 13). No peculiar trend can by given by the first analysis of the 1995–2003 time-series (see p. 21 of Anonymous, 2004.). A detailed observation of the stations of higher density in 1995 reveals significant erosion during the first year of the monitoring. A programme starting in 2006 will analyses the data more deeply.

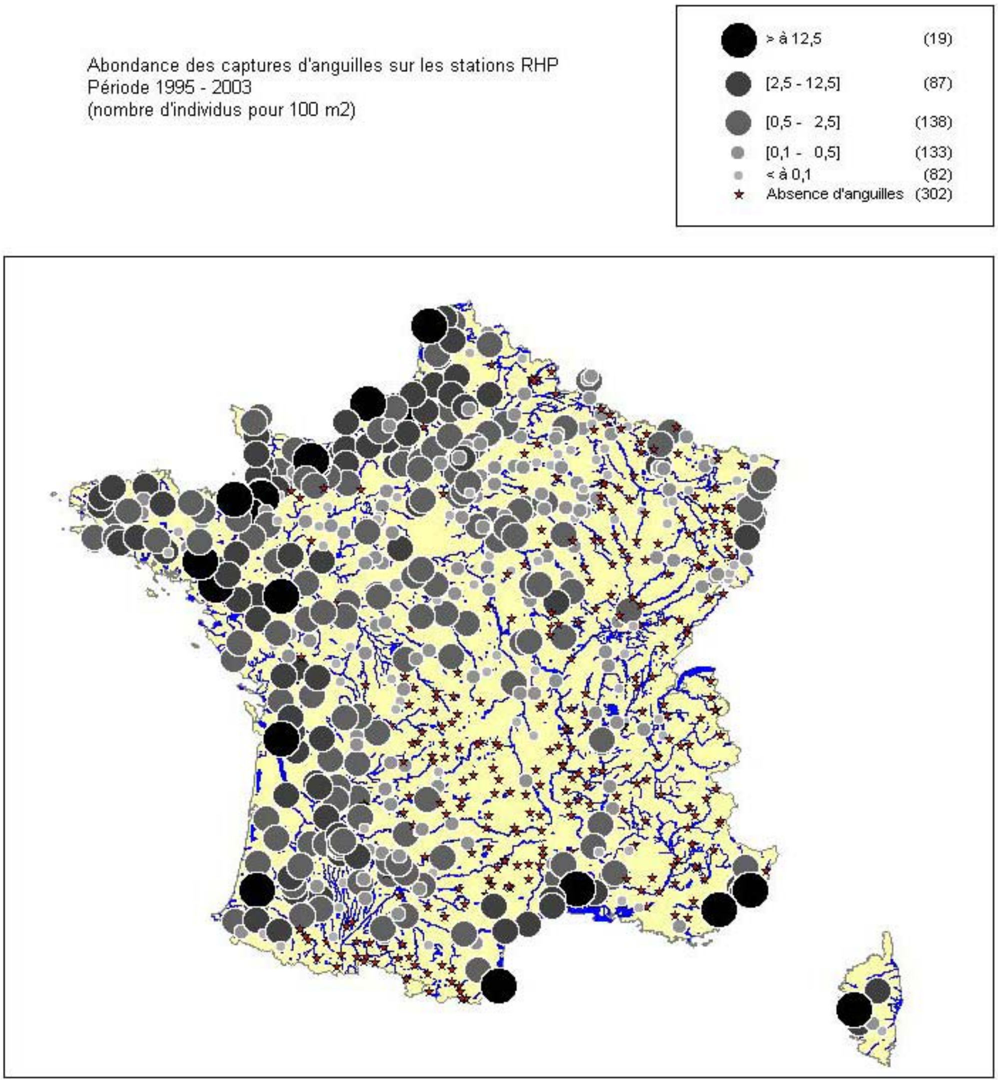


Figure FR.13. RHP electrofishing stations, mean value from 1995 to 2003 (Source: *CSP*).

FR.G.3 Silver eel

These silver eel fluxes to the sea were assessed using the sequential fishery in the Loire basin following a mark-recapture protocol (Boury and Feunteun, unpublished).

No other information is available on silver eel stock.

FR.H. Catch composition by age and length

There is no routine programme measuring the catch composition by age and length in France.

FR.I. Other biological sampling (age and growth, weight, sex, maturity, fecundity)

There is no routine programme measuring parameters of the eel population dynamics at the national level in France.

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Report on the eel stock and fishery in Belgium 2007

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BE.B Introduction

This report is written in preparation of the EIFAC/ICES Working Group on Eel meeting at Leuven (3–9 September 2008). For description of the river basins in Belgium see the 2006 Country Report Belpaire (2006).

BE.C Fishing capacity

Professional coastal and sea fisheries

Following a global European downward tendency, the Belgian fleet consisted in 2005 of in all 121 motorized vessels, with a power of 65 643 and a gross registered tonnage of 22 694. The national fishing fleet represents 0.1% of the European fleet, 1.1% of the European tonnage and 0.9% of the total engine power (2005 data) (EC, 2006). The fleet consists mostly of beam trawlers, the remainder being otter trawlers. There are data available on fishing effort.

Estuarine fisheries on the Scheldt

Fishing capacity has decreased last 5 five years. The estuarine Scheldt fisheries around 2000 was performed by two boat trawlers (one beam trawler and one otter trawler) and by ca. 30 semi professional fishers fishing with fykes (estimated at 150 fykes). The trawl fisheries was focused on eel, but recently boat fishing has been prohibited, and only fyke fishing is permitted. The number of licensed fishers decreased from 17 in 1999 to nine licenses in the last three years. See Figure BE.1 for a time-series between 1992 and 2008. A license allows a fisher to use a maximum of five fykenets, which means that at most 45 legal fykenets are used in the estuary.

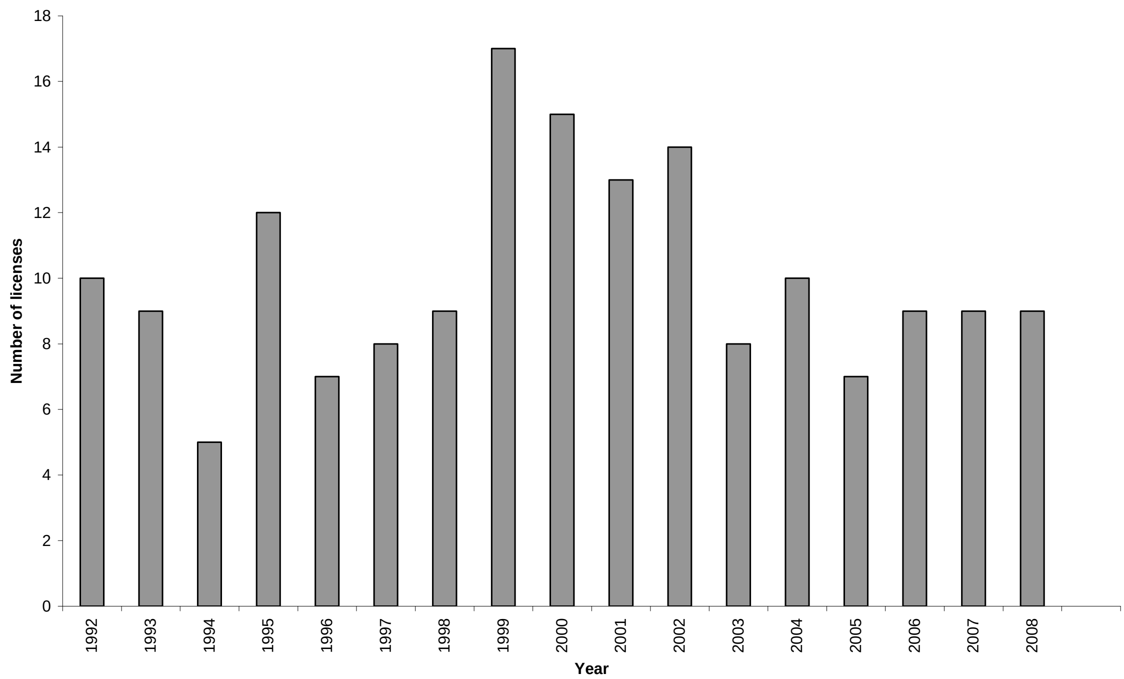

Figure BE.1 Time series of the number of licensed semi professional fishers on the Scheldt from 1992 to 2008 (Data Section Forest and Green, AMINAL).

Recreational fisheries in the Flemish Region

The number of licensed anglers was 60 520 in 2004, 58 347 in 2005, 56 789 in 2006 and 61 043 in 2007. The time-series demonstrates a general decreasing trend from 1983 (Figure BE.2). However in 2007 there was again an increase in the number of Flemish anglers (+7.5% compared to 2006). From an inquiry among anglers it was estimated that ca. 8% were eel fishers (Vandecruys, 2004).

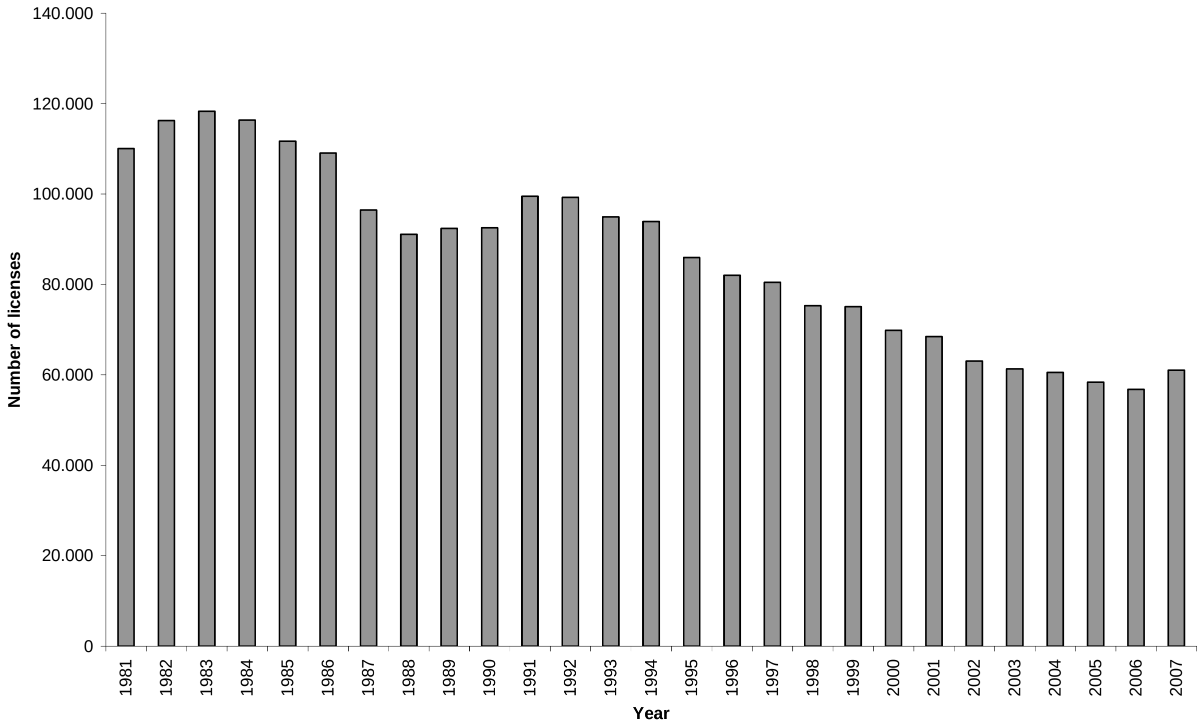

Figure BE.2 Time series of the number of licensed anglers in Flanders since 1980 (Data Agency for Nature and Forests).

Recreational fisheries in the Walloon Region

Although in constant decline since the nineties, fishers are still a well represented community in the Walloon region. The number of licensed anglers was 65 687 in 2004, 63 145 in 2005, 59 490 in 2006. For the year 2007, 60 404 fishing licenses were attributed for fishing activity in rivers, ponds and lakes (Figure BE.3). As in Flanders, the decreasing trend in the numbers of anglers seems to stop; there was a (slight) increase compared to 2006 (+1.5%). According to estimations given by the Nature and Forestry Division (DNF) of the Walloon Environment and Natural Resources DG (DGRNE), approximately 50 000 persons exercise fishing activity in private waters and closed ponds dedicated to recreational angling.

Figure BE.3. Number of fishing licences issued in the Walloon region since 1995 (Source MRW-DGRNE-DNF)

Recreational fisheries in the Brussels-Capital

The number of licensed anglers is approximately 1400 (Data Brussels Institute for Management of the Environment).

In total, there are approximately 123 000 licensed recreational fishers in Belgium for 2007, which is an increase of ca. 4% compared to 2006. It was not possible to split out this information per RBD; however this is feasible as databases exist concerning the localities where licenses were emitted.

BE.D Fishing effort

No specific data. See also under Section BE.C.

BE.E Catches and landings, restocking and aquaculture

Catches and landings-Professional coastal and sea fisheries

Professional coastal and sea fisheries are of minor relevance with respect to eel catches as this fisheries is targeted on sole, plaice, turbot and cod, and bycatch of eels is of minor importance. Eel catches are small and unpredictable. Usually these eels are sold directly on the quay. Only exceptionally, eels are presented for selling in the fish market and reported in these statistics.

Catches and landings-Estuarine fisheries on river Scheld

No official landing statistics for the fyke fisheries are available. Last year's report estimated on the basis of some fishers' logbooks and on the basis of cpue data on scientific monitoring, the total landings of eels by fyke fishers roughly at five tonnes per year around 2000. New data were available from a volunteer network (unpublished data; data collected in the framework of a study about diadromous fish in the Scheldt estuary, funded by the mobility and public works department, maritime access division). In 2007, a volunteer network was started to monitor the fish community in the Scheldt estuary using fykenets. Volunteers were asked to regularly control a fykenet that is deployed at the low-tide level. Fish are identified, counted and measured. Based on the results of two sampling stations in the Lower-Zeescheldt in 2007 (see for locations Figure BE.4), the impact of fykenetting on the eel population can be estimated for the estuary. Figure BE.5 gives an overview of the temporal trends in the eel catches (weight and number) from the two locations in the Lower-Zeescheldt. The fykenet at Kennedytunnel (KT) was checked daily, the fykenet at Liefkenshoektunnel (LhT) once every two days. If assumed that eel are caught between 1 March and 15 November and the fykes are emptied daily, a fisher can catch between 62 kg (Liefkenshoektunnel) and 277 kg (Kennedytunnel) eel per year per fyke. Extrapolated to 45 licensed fykenets in the Zeescheldt, this results in a total annual catch of 2.8 to 12.4 tons of eel. The assumption that the fykenets are continuously used throughout the fishing season and emptied daily is an overestimation. Based on a fishing effort of 2 days a week, the total catch fluctuates between 3.8 and 0.4 tons of eel per year. The preliminary results for 2008 suggest that the total catch of eel is about 50% lower that in 2007.

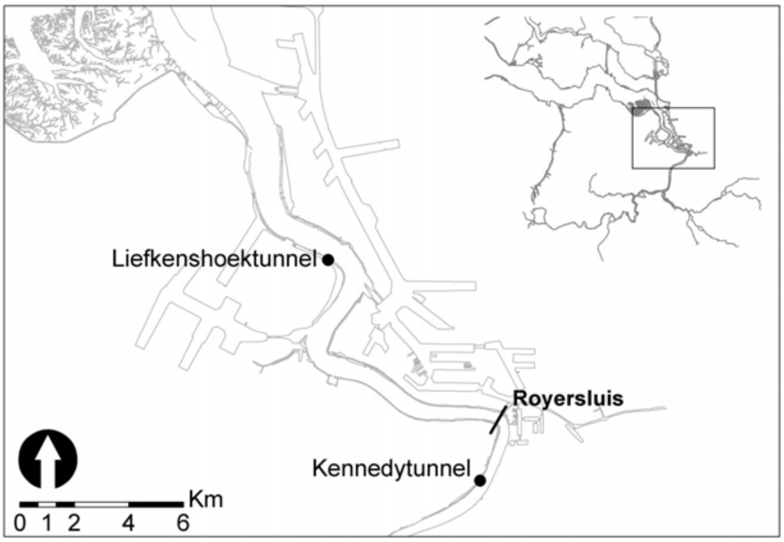

Figure BE.4 Locations in the Zeescheldt that are monitored in the framework of the volunteer network. Licensed fishers are only allowed to deploy fykenets downstream of the Royersluis.

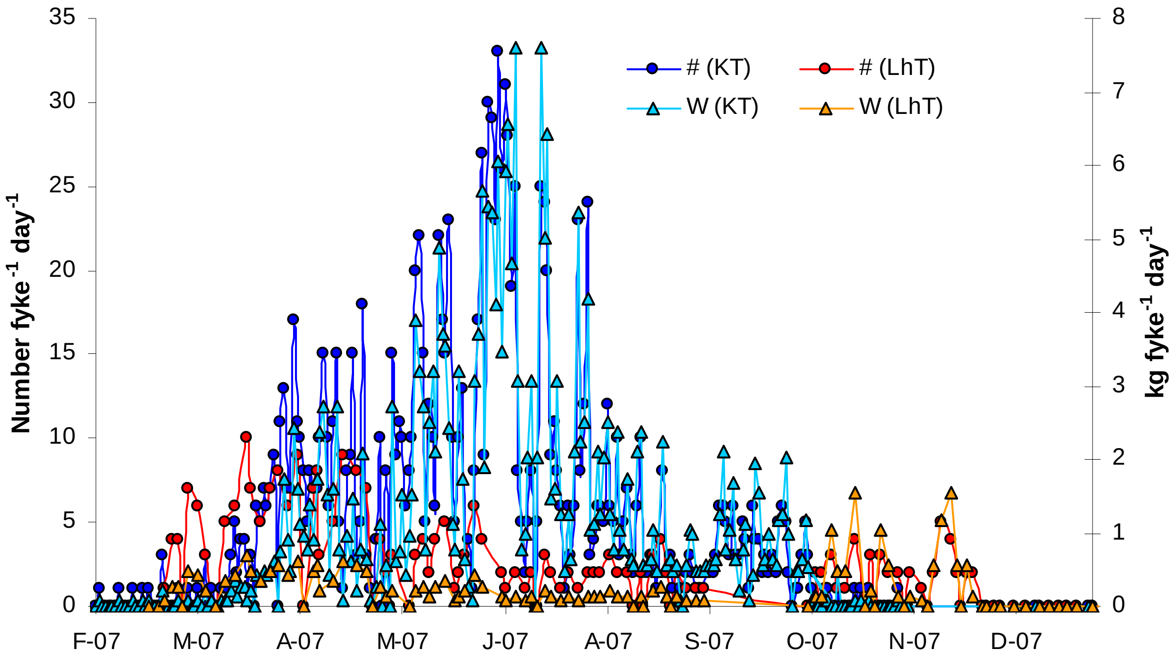

Figure BE.5 Number (left axis) and weight (kg; right axis) of eel per day per fykenet at the locations near Liefkenshoektunnel (LhT) and Kennedytunnel (KT) in 2007.

Catches and landings-Recreational fisheries

Recreational catches of eels are not recorded; data exist on number of licenses per region, and results of inquiries.

As will be clear from the information below there is a big gap in knowledge concerning the recording of eel landings from recreational fisheries in Belgium. Data available are only rough estimates.

Recreational fisheries in the Flemish Region

We repeat here the information of last year's report.

There are no official data on the catches of eels. A recent estimate of the total amount of fish (all species) taken from Flemish waters by recreational anglers was 431 tonnes. 28% or 121 tonnes of the total number of extracted fish are eels (De Vocht and De Pauw, 2005). However, the catches and the number of extracted eels have been considerably influenced by a catch and release obligation for eels. This law was brought out as a result of the high PCB levels measured in most Flemish eels.

Another estimate can be deduced from data from Bilau *et al.*, 2007. In 2003, 61 245 individuals in Flanders had a fishing license for public waters. A survey on specific aspects of recreational fisheries, including the issue of taking home a catch, was carried out (Vandecruys, 2004). The survey included questions on the fish species caught and taken home as well as the number and the weight of the fish caught and taken home. A total number of 3001 of the licensed anglers (out of 9492 contacted) completed a questionnaire about recreational fishing. Respectively 1.9% and 5.3% of these anglers indicated that they "always" (group A) or "sometimes" (on average: 1 out of 5 eels caught) (group B) take home the eel they have caught. Based on extrapolation to all licensed fishers, the number of people taking home the eel, caught in Flemish public waters is estimated to be 4429 (7.2% of licensed anglers). Considering the catch and release obligation for eels in all public waters in Flanders, this is a large proportion, and an underestimate of the situation where all eels may legally taken home.

Based on the number of fishing occasions (average of 41.67 and 42.03 trips/year, respectively for group A and B), the number of eels caught per occasion (average of 4.14 and 3.12, respectively for group A and B) and a mean weight of edible portion per eel (150 g), it has been calculated that individuals in group A take home on average 25.9 kg of edible eel per year or a mean of 498 g week^{-1}. For group B it was calculated to be 3.9 kg per year or 76 g week^{-1} (Bilau *et al.*, 2007). The total estimate for Flanders is thus 43 tonnes of eels per annum, which is approximately one third of the estimate by De Vocht and De Bruyn, 2005 (Table BE.1).

Table BE.1 Rough estimate of the catch (in kg) of recreational fisheries in Belgium.

Country		drainage area km2		Estimate for the 1.9% or 1164 anglers each taking 25.9 kg eel per annum	Estimate for the 5.3 % or 3246 anglers each taking 3.9 kg per annum	Total estimate	
BE	Flanders	13.521		30148	12659	42807	
	Wallonia	16.845		no data	no data	no data	
	Brussels	162		no data	no data	no data	
BE	sum	30.528					

Recreational fisheries in the Walloon Region

Although eel has traditionally been caught by anglers in the Walloon region, mainly in the Meuse, but also in the lower and middle Ourthe and the Semois, there are no official estimates about the catches of eels in the Walloon region. Precise quantitative figures of fishing catches are thus lacking.

However, in 2002, a survey by the Federation of Anglers in Wallonia estimated that 60% of the anglers considered the eel as a valuable species, 34% of the anglers specifically fished for eels, and 8% never did. In 63% of the fishing efforts, the eels were kept for human consumption.

This survey demonstrated that 41% of the anglers still considered, at that time, that eels were commonly caught. More then half the anglers catch them and the others rarely. In 61% of the fishing occasions one eel is caught, in 26% of the cases two are caught, in 11% of the cases 3 eels are caught. In 1% of the fishing occasions more then 3 eels are caught. 63% of the eels are eaten. (Data from an inquiry from the Federation of Anglers in Wallonia).

In the Walloon region, fishing of eels is prohibited since 2006 (Walloon Government, 2006). By modification of the 1954 law on fishing activities, there is now an obligation to release captured eels whatever their length. So from 2006 on, recreational catches of eel in Wallonia should be zero.

Recreational fisheries in Brussels-Capital

No information on eel catches.

Stocking

Stocking in Flanders

Glass eel and young yellow eels were used for restocking inland waters by governmental fish stock managers. The origin of the glass eel used for restocking from 1964 onwards was the glass eel catching station at Nieuwpoort on river Yser. However, as a consequence of the low catches after 1980 and the shortage of glass eel from local origin, foreign glass eel was imported mostly from UK or France.

Also young yellow eels were restocked; the origin was mainly the Netherlands. Restocking with yellow eels was stopped after 2000 when it became evident that also yellow eels used for restocking contained high levels of contaminants (Belpaire and Coussement, 2000). So only glass eel is stocked from 2000 on (Figure BE.5). Glass eel restocking will be proposed as a future management measure in the EMP for Flanders.

In recent years the glass eel restocking could not be done each year as a consequence of the high market prices. Only in 2003 and 2006 respectively 108 and 110 kg of glass eel was stocked in Flanders (Figure BE.5 and Table BE.2). In 2008 117 kg of glass eel from UK origin (rivers Parrett, Taw and Severn) was stocked in Flemish water bodies.

Table BE.2 Re-stocking of glass eel in Belgium (Flanders) since 1994, in kg of glass eel.

Decade			
Year	1980	1990	2000
0			0
1			54
2			0
3			108
4		175	0
5		157,5	0
6		169	110
7		144	0
8		0	117
9		251,5	

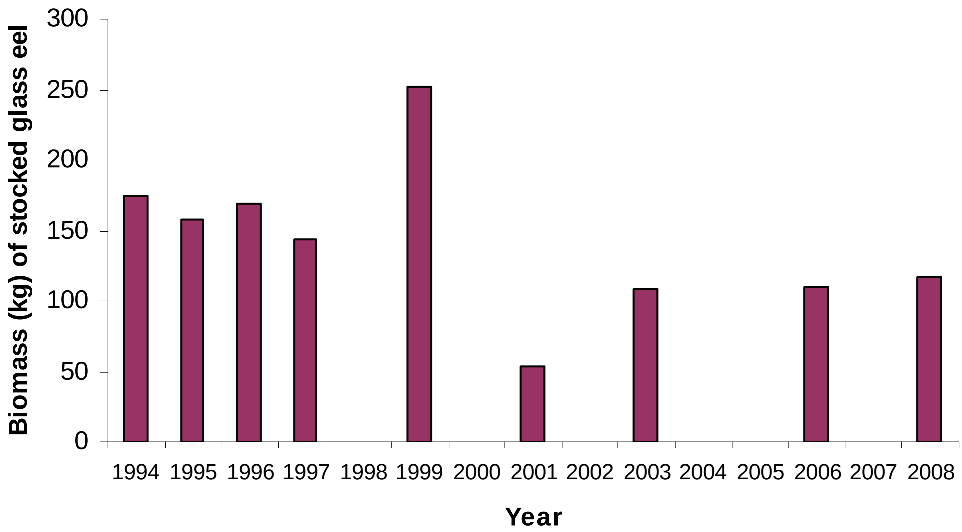

Figure BE.6. Re-stocking of glass eel in Belgium (Flanders) since 1994, in kg of glass eel.

Stocking in Wallonia

Restocking data for yellow eel were made available by the Service de la Pêche of the Walloon Region. Restocked eels were yellow eels from length classes <15 cm (not glass eel), 15–25 cm and >30 cm (Figure BE.7 and Table BE.3).

Where during the period 2000–2005 restocked biomass over Walloon Rivers, lakes and canals fluctuated between 100 and 500 kg, no eel restocking was performed in 2006 or in 2007 in the Walloon region.

Table BE.3 Restocking of yellow eel in Belgium (Walloon region) over the period 1999 to 2007, in kg of yellow eel. For 2000 and 2001 data were provided as partly biomass and partly numbers. In this case total restocked biomass was calculated using an expected mean weight of 10 g for eels <15 cm, of 20 g for eels 15–25 cm and 100 g for eels >30 cm. (Data Service de la Pêche, Walloon Region).

DECADE			
Year	1980	1990	2000
0			535
1			355
2			105
3			101
4			311
5			324
6			0
7			0
8			
9		1268	

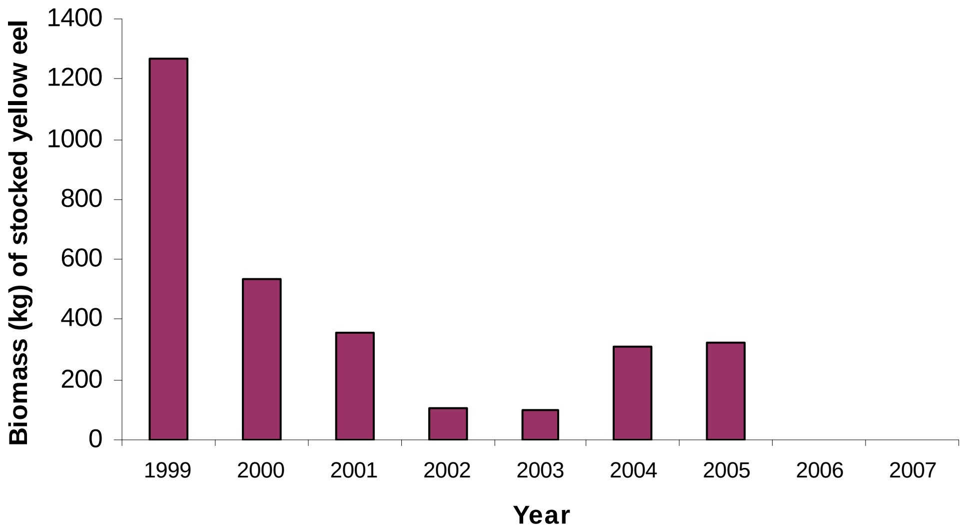

Figure BE.7. Restocking of yellow eel in Belgium (Walloon region) over the period 1999 to 2007, in kg of yellow eel. For 2000 and 2001 data were provided as partly biomass and partly numbers. In this case total restocked biomass was calculated using an expected mean weight of 10 g for eels <15 cm, of 20 g for eels 15–25 cm and 100 g for eels >30 cm. (Data Service de la Pêche, Walloon Region).

Stocking has also been performed by recreational fisheries. Below is reported stocking information provided by federations of recreational fisheries societies in the Walloon region.

Year	Fishing Society	Stocking location	Stocking quantity
1961	Commission piscicole provinciale du Hainaut	Dendre downstream Deux-Acren	100.000 glass eels from Holland
1967	Fédération des Sociétés de Pêche et de Pisciculture du Centre	Canal Charleroi-Bruxelles	380kg (approx 25 eels/kg)
1967	Union des Pêcheurs des Bassins de l'Escaut et de l'Yser	Canal de Willebroek	100kg (20/30 units per kg)
		Canal Charleroi-Brussels-Hal	300kg (20/30 units per kg)
		Canal Charleroi-Hal-Faucquez	200kg (20/30 units per kg)
		Canal Leuven-Malines	500kg (20/30 units per kg)
1974	Ligue des Pêcheurs de l'Est	Lac de Butgenbach	80.000 glass eels
1976	Fédération des Pêcheurs du Brabant	Canal Charleroi-Brussels-Hal	?
1978	Commission piscicole provinciale du Brabant	?	50kg of glass eels from Yser estuary
1986	Amicale des Pêcheurs de la Haute Meuse Liègeoise	Meuse	
		Ile de Bas-Oha (Meuse)	2.250 glass eels
		Spawning ground Ampsin (Meuse)	2.250 glass eels
		Darse (Meuse)	2.250 glass eels
		Engis (Meuse)	2.250 glass eels
1986	Amicale des Pêcheurs du Brabant	Ruisbroek-Lembeek	Glass eels from Nieuwpoort
1987	Fédération des Sociétés de Pêche et de Pisciculture du Centre	Old Canal Charleroi-Brussels	300kg of eels (20/30 units per kg)
1988	Fédération des Sociétés de Pêche et de Pisciculture du Centre	Old Canal Charleroi-Brussels	300kg of eels (20/30 units per kg)
1991	Fédération Royale des Sociétés de Pêche et de Pisciculture du Centre	Old Canal Charleroi-Brussels	313kg of eels (20/30 units per kg)
1991	Amicale des Pêcheurs du Brabant	Canal of Charleroi (between Ruisbroek and Hal)	150kg of “small eels”
1992	Fédération Royale des Sociétés de Pêche et de Pisciculture du Centre	Old Canal Charleroi-Brussels	314kg of (20/30cm eels)

Year	Fishing Society	Stocking location	Stocking quantity
1993	Fédération Royale des Sociétés de Pêche et de Pisciculture du Centre	Old Canal Charleroi-Brussels	275kg of (20/30cm eels)
1996	Amicale des Pêcheurs du Brabant	Canal of Charleroi (Brussels)	« Small eels » no qtty info
1998	Amicale des Pêcheurs du Brabant	Canal of Charleroi-Leeuw-St-Pierre-Lembeek	100kg no stage info
1999	Amicale des Pêcheurs du Brabant	Canal of Charleroi	2kg glass eels
2000	Amicale des Pêcheurs du Brabant	Canal of Charleroi (between Ruisbroek and Hal)	2kg glass eels
2001	Amicale des Pêcheurs du Brabant	Canal of Charleroi (between Ruisbroek and Hal)	2kg glass eels
2003	Amicale des Pêcheurs du Brabant	Wachte Beek de Leeuw-St-Pierre	Glass eels (no qtty info)

Data collected from the official publication of Federation Sportive des Pêcheurs Francophones de Belgique.

Other stocking data-from telephonic survey of other Federations. Not presented as table because of data heterogeneity. (Period 1971 to 2002.)

Schelde RBD

Sambre: stocking of 82 kg of eels measuring 20/30 cm in 1993 between lac du Ry Jaune and lac de Féronval.

Upper Escaut: no stocking reported.

Petite* and *Grande Gette: no stocking reported.

Haine* and *Trouille: no stocking reported.

Meuse RBD

Meuse: main stocking operations downstream of Pont de Wandre (to a lesser extent Berwinne downstream Val Dieu).

1971 to 1974-40 000 glass eels per year.

1978-67 500 glass eels per year.

1979 and 1980 -20 kg glass eels per year.

End of stocking since 1981.

Semois

1966: more than 100 000 glass eels from Oostende stocked in Alle-sur-Semois.

1988: stocking of unknown quantity (info on price 330 Belgian francs/kg).

1992: 20 kg of 30 cm yellow eels in Alle-Sur Semois (from pisciculture Dos Santos).

1993: 20 kg in Alle-Sur Semois.

1994 and 1995: 30 kg in Alle-Sur Semois.

1996–2000: no stocking.

2001: 20,7 kg (896 individuals stocked in Alle-484 individuals stocked in Bohan) (from PibaS.A-indicative price was 19 Belgian francs).

2002: 23 kg (eels of 20 cm length).

Aquaculture

Actual eel production through aquaculture in Belgium is zero.

Flanders

Although around 2000, two farms for intensive production of eels in recirculation systems were operating for a total production of 125 tonnes per annum (Belpaire and Gerard, 1994), eel culture has stopped completely around 2004.

Wallonia

The only eel farming society (Pi.B.A. S.A.) in the Walloon region started its activities in 2000 and ceased in 2005. No feedback was obtained from the owner or controlling authorities as to the activities and results of this society.

BE.F Catch per unit of effort

We repeat here the information of last year's country report.

There are some data on the catch per unit of effort for the estuarine fyke fisheries on the Scheldt. These cpue data were collected from scientific monitoring. The cpue is strongly influenced by temporal and regional variation. Figure BE.8 gives the trend in cpue of estuarine fyke fishing from 1995 to 2007 in the Scheldt estuary. Additional data of other sampling stations along the estuary are available.

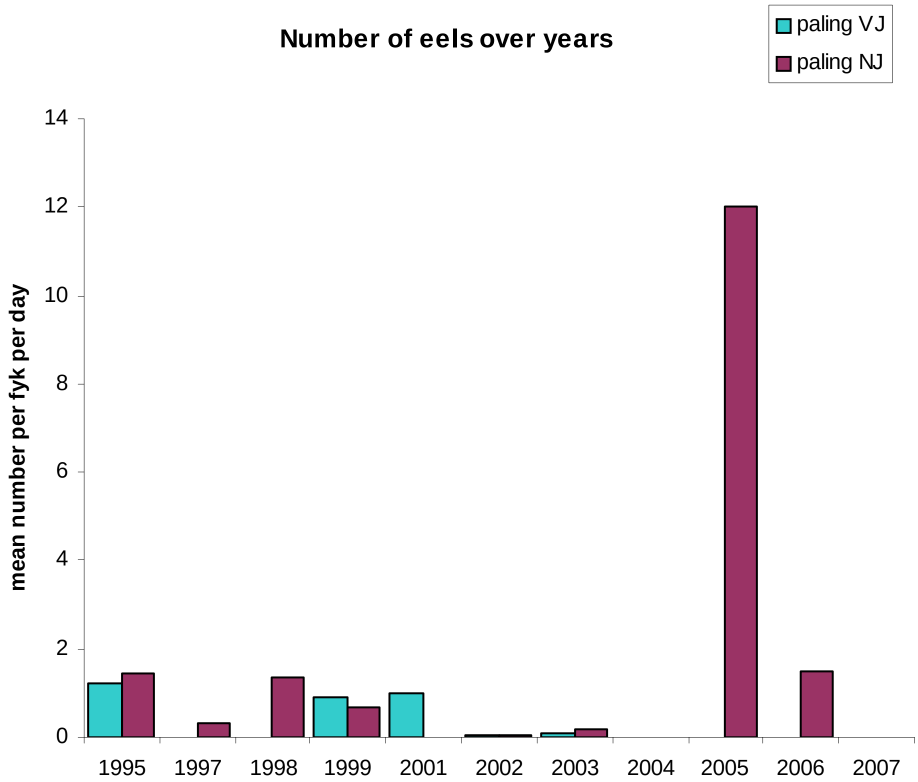

Figure BE.8 Mean number of eel per day per fyke from 1995 to 2007 in the Scheldt estuary at Zandvliet (Cuveliers *et al.*, 2007).

Additional recent information about catches per unit of effort has been provided under "5-Catches and landings, Estuarine fisheries on the river Scheldt" (see Figure BE.5 for fluctuations of eels per fyke per day through the fishing season).

BE.G Scientific surveys of the stock

Glass eel recruitment at Nieuwpoort at the mouth of River Yser (Yser basin)

Fisheries on glass eel are carried out by the Flemish government. The glass eels are used exclusively for restocking in inland waters in Flanders. In Belgium, commercial glass eel fisheries are forbidden by law.

Long term time-series on glass eel recruitment are available for the Nieuwpoort station at the mouth of the river Yser. Recently new initiatives have been started to monitor glass eel recruitment in the Scheldt basin (see below).

For extensive description of the glass eel fisheries on the river Yser see Belpaire, 2002; 2006.

Figure BE.7 and Table BE.3 give the time-series of the total annual catches of the dipnet fisheries in the Nieuwpoort ship lock and give the maximum day catch per season. Since the last report the figure has been updated with data for 2008.

Fishing effort in 2006 was half of normal, with 130 dipnet hauls during only 13 fishing nights between March 3rd, and June 6th. Catches of the year 2006 were extremely low and close to zero. In fact only 65 g (or 265 individuals) were caught. Maximum day catch was 14 g. These catches are the lowest record since the start of the monitoring (1964).

In 2007 fishing effort was again normal, with 262 dipnet hauls during 18 fishing nights between February 22nd, and May 28th. Catches were relatively good (compared to former years 2001–2006) and amounted 2214 g (or 6466 individuals). Maximum day catch was 485 g. However this 2007 catch represents only 0.4% of the mean catch in the period 1966–1979 (mean = 511 kg per annum, min. 252–max. 946 kg).

In 2008 fishing effort was normal with 240 dipnet hauls over 17 fishing nights. Fishing was carried out between February 16th and May 2nd. Total captured biomass of glass eel amounted 964.5 g (or 3129 individuals), which represents 50% of the catches of 2007. Maximum day catch was 262 g.

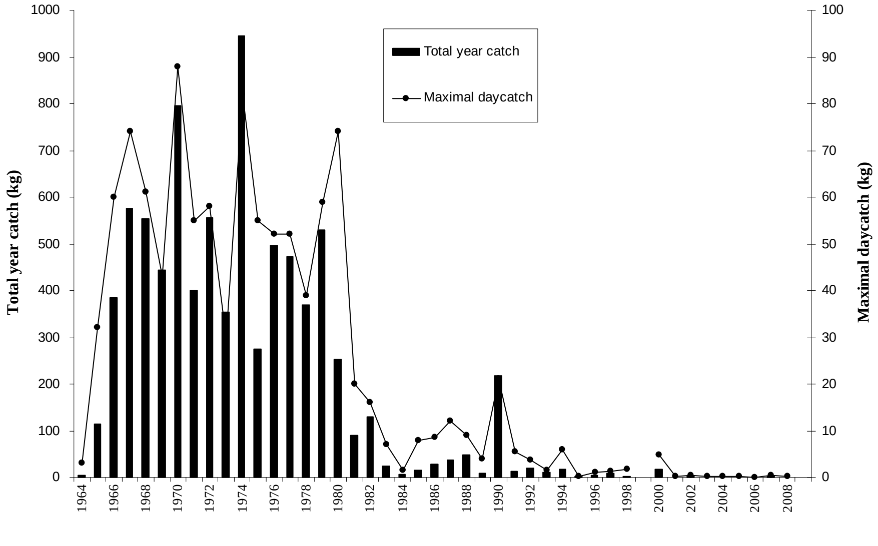

Figure BE.9 Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort (total year catches and maximum day catch per season). Data Provincial Fisheries Commission West-Vlaanderen.

Table BE.4 Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort (total year catches and maximum day catch per season). In Table BE.4 the presented data are the total year catches. Data Provincial Fisheries Commission West-Vlaanderen.

DECADE					
Year	1960	1970	1980	1990	2000
0		795	252	218,2	17,85
1		399	90	13	0,7
2		556,5	129	18,9	1,4
3		354	25	11,8	0,539

4	3,7	946	6	17,5	0,381
5	115	274	15	1,5	0,787
6	385	496	27,5	4,5	0,065
7	575	472	36,5	9,8	2,214
8	553,5	370	48,2	2,255	0,964
9	445	530	9,1		

Other glass eel recruitment studies

From April to July 2007 the immigration of glass eels in the Scheldt estuary was studied using artificial substrates as described by Silberschneider, 2001-(unpublished data; data collected in the framework of a study about diadromous fish in the Scheldt estuary, funded by the mobility and public works department, maritime access division). Substrates were deployed at the outlet of sewage treatment plants and drainage systems in the Zeescheldt and tributaries (Rupel, Lower Nete and Kleine Nete) and were checked once every two days for glass eels. Figure BE.10 gives an overview of the relative number of glass eels that were caught at each of the locations. Numbers were generally very low (on average 1 or 2 glass eels per substrate per day). Probably, glass eel densities in the Scheldt estuary were too low for an optimal use of the substrate method. In addition, catches in 2007 from a permanent sampling station more upstream in the Zeescheldt suggest that the glass eel recruitment was very low in 2007. At this station, glass eels are caught by a volunteer at the effluent of a sewage treatment plant. The glass eels hide under stones in the effluent canal, where they are caught with a small hand net. Data that were collected in this way are available since 2004.

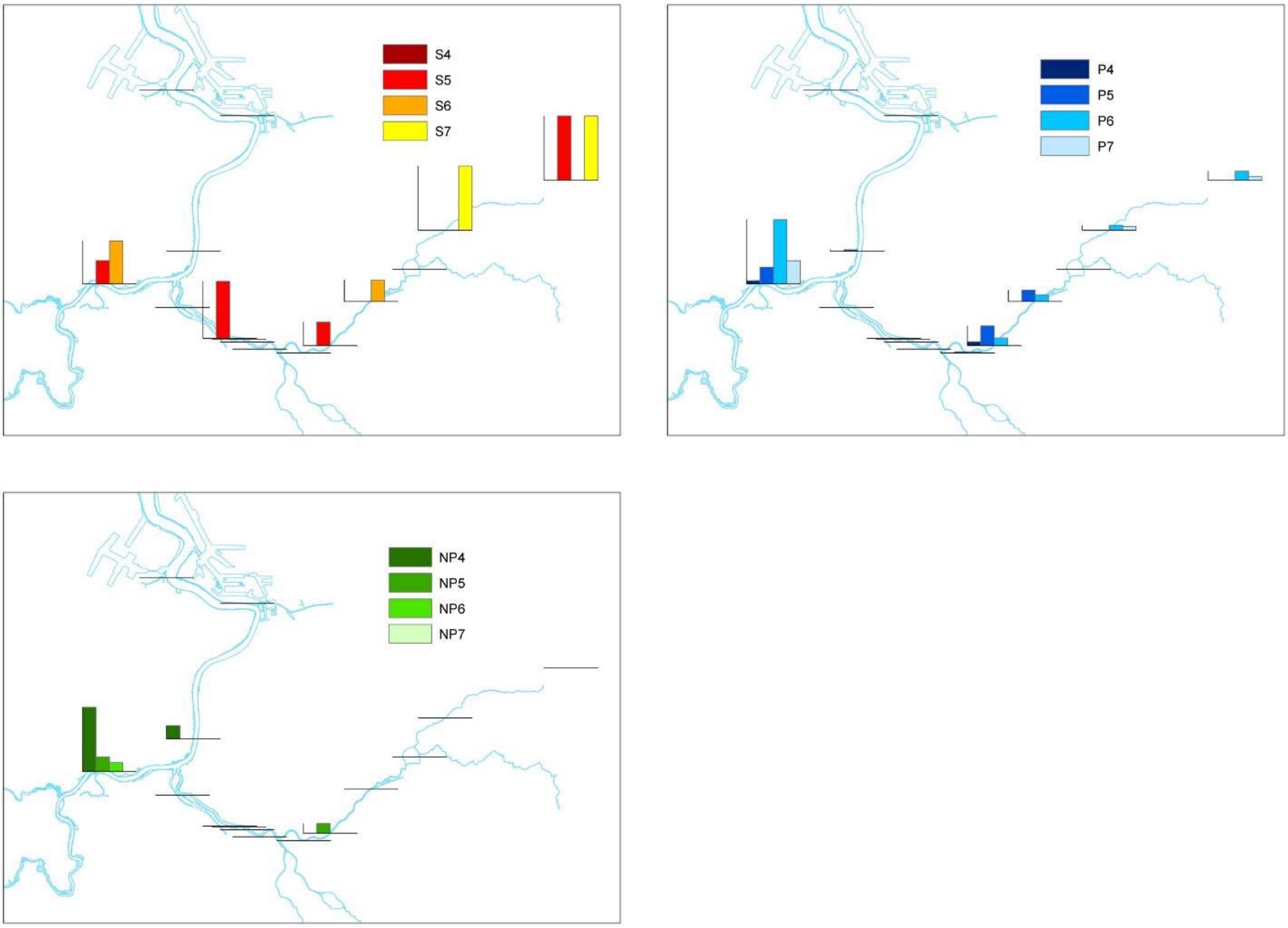

Figure BE.10 Relative number of glass eels caught in artificial substrates in 2008. NP = Not pigmented; P = Pigmented and S = newly metamorphosed eels. The color of the bars represents the month (4 = April to 7 = July).

The results from the hand net sampling at the sewage treatment plant were compared to the results from the glass eel catches in the River Yser (unpublished data; data kindly provided by the Agency of Nature and Forest, fisheries commission West-Vlaanderen). In Figure BE.11 the daily total catches (number day^{-1}) in the Yser (IJ) and the Zeescheldt (ZS) from the last 5 years are compared. Both stations are about 195 km apart. The graph demonstrates that the peak of the glass eel recruitment in the Zeescheldt (half May) occurs approximately 50 days after the peak in the Yser (end of March). In addition, Figure BE.12 shows that the average yearly catches at both stations are quite well synchronized: 2005 and 2007 were 'good' years for glass eel catches, whereas 2006 and 2008 were 'bad' years.

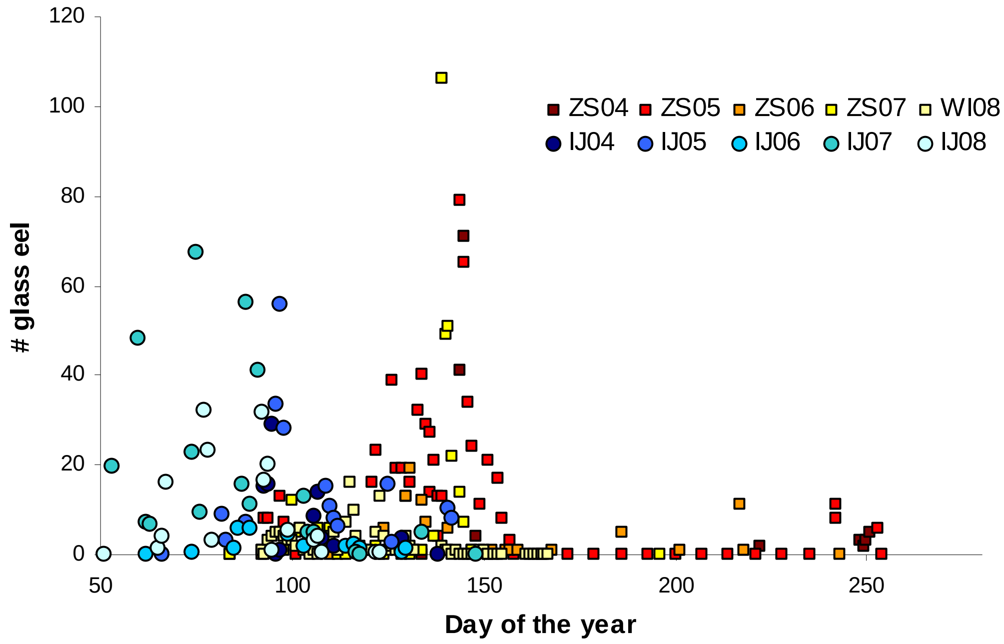

Figure BE.11 Number of glass eels caught per day at the sampling stations in the Yser (IJ) and in the Zeescheldt (ZS) between 2004 and 2008. A different sampling method was used in both stations. In the Zeescheldt glass eels were caught with a hand net, in the Yser using a dipnet.

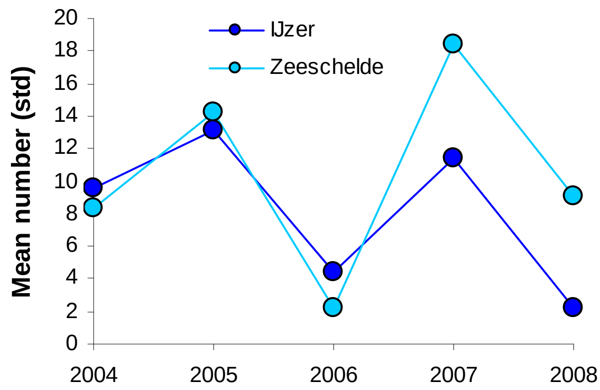

Figure BE.12. Average number of glass eels caught at the sampling stations in the Yser and the Zeescheldt.

BE.G.1 Eel impingement at the power station at Doel on the Lower Scheldt (Scheldt basin)

The Catholic University of Leuven is following the numbers of impinged fish at the nuclear power station of Doel on the Lower Scheldt. The numbers of impinged eels are given in Figure BE.13.

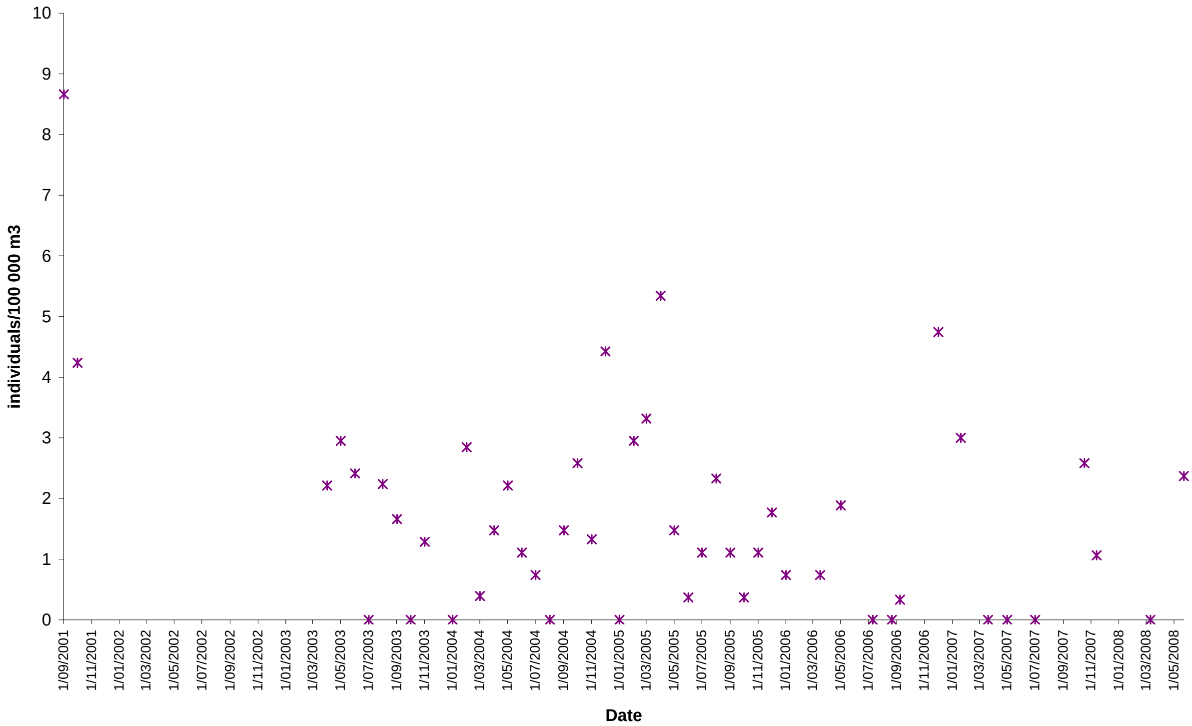

Figure BE.13 Annual and seasonal variation in the number of impinged eels at the power station of Doel (Lower Scheldt, nearby Antwerp). Numbers are expressed as individuals impinged per 100 000 m³ water. Data Katholieke Universiteit Leuven, Laboratory of Animal Diversity and Systematics.

BE.G.2 Silver eel migration study on the river Meuse

Downstream migration of female European silver eel *Anguilla anguilla* was studied in the River Meuse using NEDAP TRAIL® detection stations. Detection stations are distributed on the lower part of the Meuse along the migration route. Female silver eels (N= 31) were captured at different locations in and out of the River Meuse basin, tagged with TRAIL® transponders and translocated in 2007 to the River Berwijn, a small Belgian tributary of the River Meuse, 326 km from the North Sea. From August 2007 till April 2008 13 of the eels (42%) were detected at two or more stations and were supposed to have started their downstream migration. Only two eels (15%) arrived at the North Sea, the others being held up or killed at power stations, caught by fishers or stopped their migration and settled in the river delta. A majority of the eels (58%) did not start their migration and could be located by manual tracking. It was recommended to incorporate protocols to evaluate the proportion of these non-migrants within studies assessing migration success of silver eels. (Verbiest *et al.*, submitted).

BE.G.3 Eel surveys in the Walloon region (Meuse basin)

At the Walloon region scale, the European eel demonstrates recent demographic degradation in the Meuse river basin where the species could still be encountered with fair abundance. Other basins have faced eel stock depletion for a long time because of multiple factors including (**1**) pollution (Scheldt, Sambre), (**2**) obstacles caused by dams (basins of the Chiers, the Semois and the Viroin, upstream Nisramont dam oriental and occidental Ourthe, and the Amblève upstream Coo) and (**3**) the suspension since 1980 of restocking with wild glass eels (from the Yser), yellow, or silver eels obtained from the wild and farmed before release.

On the Meuse, the University of Liège is monitoring the amount of ascending young eels in a fish-pass. From 1992 to 2008 upstream migrating eels were collected in a trap (0.5 cm mesh size) installed at the top of a small pool-type fish-pass at the Visé-Lixhe dam (built in 1980 for navigation purposes and hydropower generation; height: 8.2 m; not equipped with a ship-lock) on the international River Meuse near the Dutch-Belgium border (290 km from the North Sea; width: 200 m; mean annual discharge: 238 $m^3 s^{-1}$; summer water temperature 21–26°C). The trap in the fish-pass is checked continuously (three times a week) over the migration period from March to September each year, except in 1994. A total number of 32 157 eels was caught (biomass 1.955 kg) with a size from 14 cm to 85 cm and a mean value of 31.6 cm corresponding to yellow eels (data up to 2004). The study based on a constant year-to-year sampling effort revealed a regular decrease of the annual catch from a maximum of 5613 fish in 1992 to a minimum of 423 in 2004 (Baras *et al*., 1994; Philippart *et al*., 2004; Philippart and Rimbaud, 2005) (Figure BE.14).

The data for 2005 and 2006 were low: respectively 758 and 559 (Philippart, 2006), whereas 661 eels were caught in 2007 (Philippart, pers. comm.). Only partial data are available for 2008 (until 31/07): 2567 eels were caught. This sudden increase might be explained by the fact that recently (20/12/2007) a fish pass has been opened at the sluice of Borgharen-Maastricht, which allowed passage of eels situated downwards the sluice. But we can not rule out that recruitment of elvers increased (Philippart, pers. comm.).

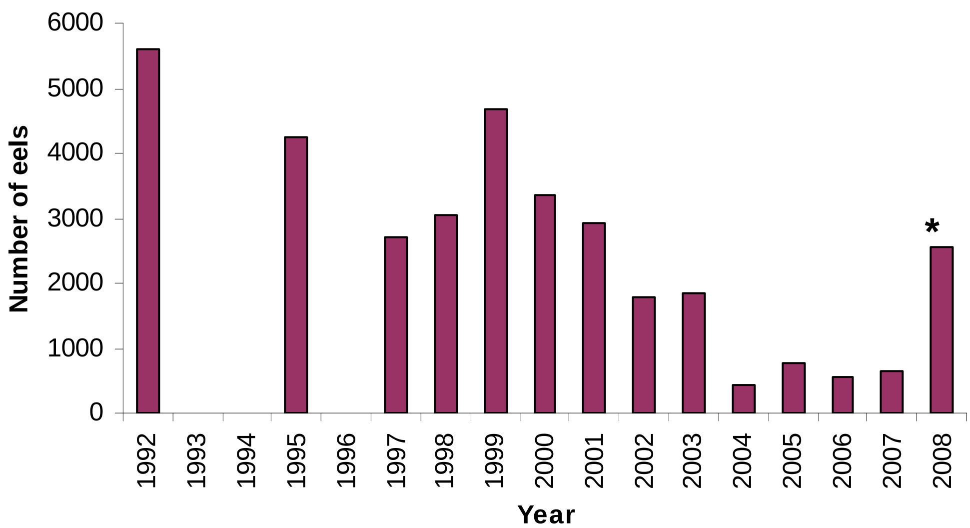

Figure BE.14 Variation in the number of ascending young yellow eels trapped at the fish trap of the Visé-Lixhe dam. Data from University of Liège (J.C. Philippart) in Philippart and Rimbaud, 2005; Philippart, 2006; Philippart, pers. comm. * Data incomplete, catches until 31/07/08.

Scientific samplings of resident eels (counts from the Méhaigne, in Hosdent, from 1985 to 2005; Figure BE.15) and migrating eels (upstream migrating in the Meuse at the Lixhe dam, from 1992 to 2006) demonstrate a clear and critical demographic collapse. This could lead before 2010 to the disruption of recruitment of young individuals at the gates of the Mosan basin in Wallonia, straightly leading for decades to a drastic reduction in continental populations, and eventually, to their extinction within twenty years. No recent data from the Méhaigne were available yet for 2008.

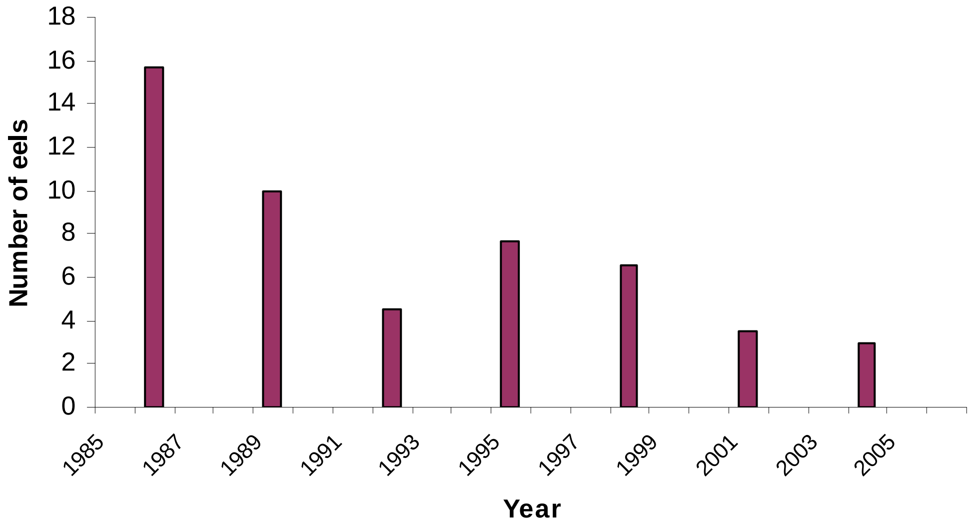

Figure BE.15 Number (x 100) of resident eels sampled by electric fishing in the Méhaigne in Hosdent-Latinne between 1985 and 2005 (Phillipart, 2006).

Table BE.5 Number of yellow eels captured swimming upstream in the fish ladder unit of the Lixhe dam between 1992 and 2006, and number (x 100) of resident eels sampled by electric fishing in the Méhaigne in Hosdent-Latinne between 1985 and 2005 (Phillipart, 2006) and Philippart, pers. comm. * 2008 Data incomplete, catches until 31/07/08.

	MEUSE	MEHAIGNE (X 100)
1985		
1986		1570
1987		
1988		
1989		1000
1990		
1991		
1992	5613	450
1993		
1994		
1995	4240	770
1996		
1997	2706	
1998	3061	660
1999	4664	
2000	3365	
2001	2915	350
2002	1790	
2003	1842	
2004	423	300
2005	758	

2006	559
2007	6619
2008	2567*

BE.H Catch composition by age and length

Age is usually not recorded in Belgium.

Flanders

An extensive database on length and weight is available at INBO, based on surveys with electrofishing and fykenetting. Many data are also available on the Internet at http://vis.milieuinfo.be/

Wallonia

An extensive database on length and weight is available at GIPPA, based on fish stock surveys in Wallonia.

BE.I Other biological sampling

BE.I.1 Length and weight and growth (DCR)

An extensive database on length and weight is available at INBO, based on surveys with electrofishing and fykenetting. Many data are also available on the Internet at http://vis.milieuinfo.be/

Figures BE.16 and BE.17 present the relationship between length and weight ($\log_{10}$-transformed in Figure BE.17) of 11 114 eels sampled in Flanders during surveys between 1995 and 2007.

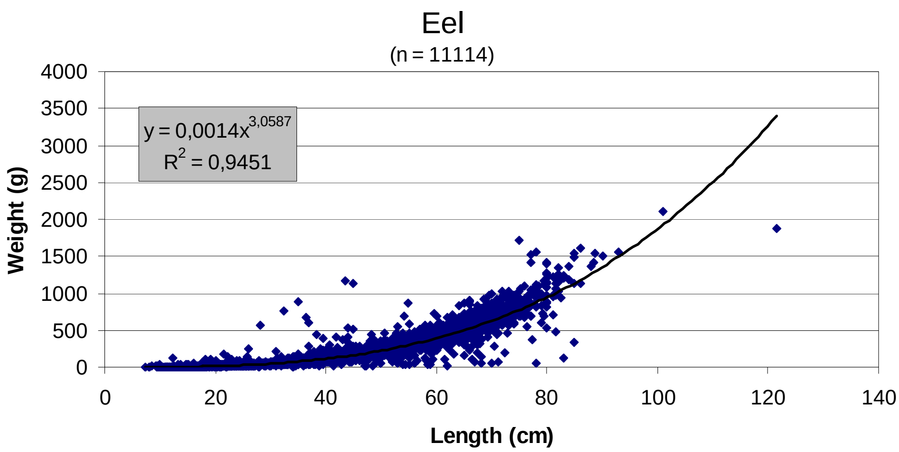

Figure BE.16 Length-weight relation for 11 114 Flemish eels (both sexes) caught between 1995 and 2007 (lengths and weights not corrected for typing/measuring errors).

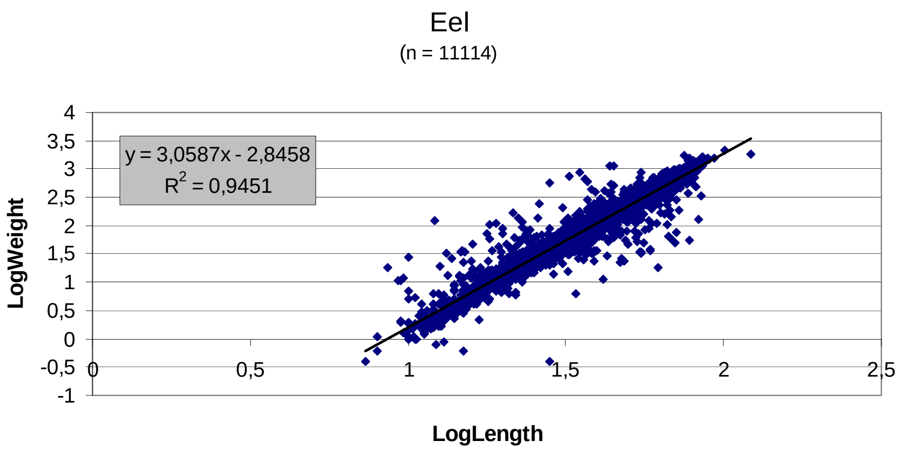

Figure BE.17 Log10-transformed length-weight relation for 11 114 Flemish eels (both sexes) caught between 1995 and 2007 (lengths and weights not corrected for typing/measuring errors).

Growth is studied in a population of eels at lake Weerde, a man made lake, but is not reported yet. In Wallonia length and weight data from scientific surveys is available at GIPPA.

BE.I.2 Parasites

No new information compared to last year's report (cf. Belgian country report 2007).

BE.I.3 Contaminants

Extensive information has already been provided in the WG Eel 2006, and 2007 reports (Belpaire, 2006; Belpaire *et al.*, 2007). Recently, Belpaire, 2008 compiled an overview of research on contaminants in Flanders. We focus hereby on status and trends and on the potential role of contamination in the collapse of the stock.

BE.I.3.1 Status and trends (Belpaire, 2008)

Flanders (INBO) is operating an Eel Pollution Monitoring Network (EPMN) which allows to get a comprehensive overview of the contamination in Flemish waters (and in eels) fully covering the area of Flanders. Within this EPMN a number of contaminants in eel are analysed in a standardized way (Goemans *et al.*, 2003). Because the network is running now for 14 years, and many sites have been sampled twice or more, it becomes possible to draw trends (see last years report for trend figures). The maps and the database VIS allow now to analyse in detail the status and the trends for a specific contaminant, or a group of contaminants. They also allow detailed analysis of status and trends of contamination on a certain spatial scale (site, river, catchment, town, province, region). In VIS these trends can be viewed in reports via predefined queries on the database. Maps have been generated of contamination in eel for ca. 30 PCBs, pesticides and heavy metals (Goemans *et al.*, 2008). As an example the distribution of PCB 156 in eel is represented in Figure BE.18.

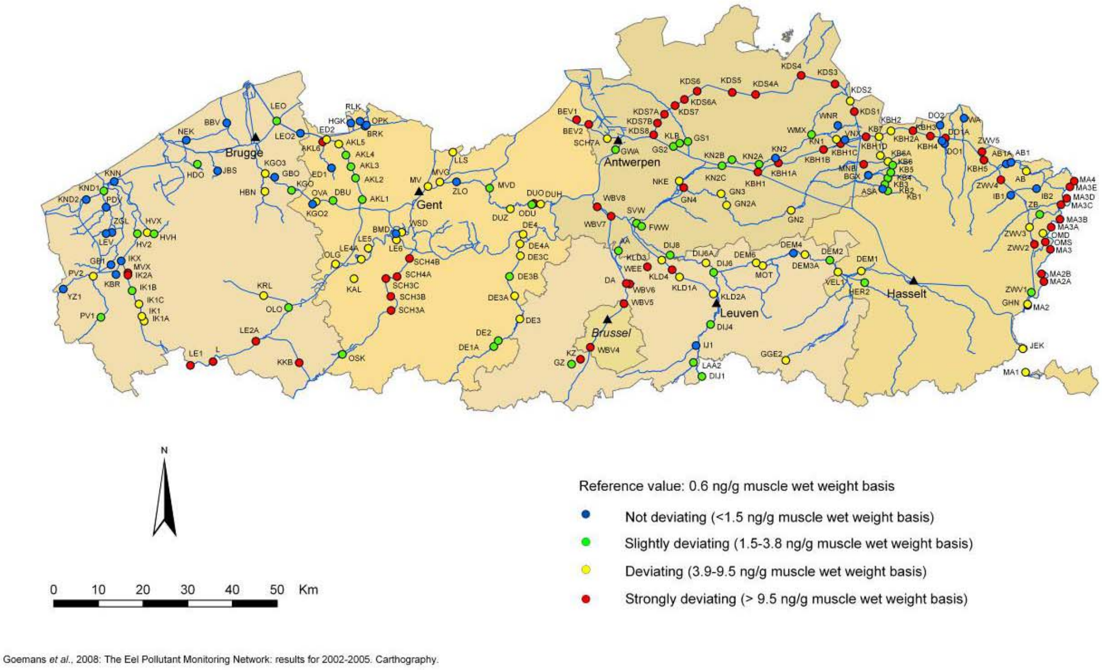

Figure BE.18 Distribution of PCB 156 in yellow eel in Flanders (2002–2005); means on muscle wet weight basis, classified following the deviation from the reference value (Goemans *et al.*, 2008).

The 2006 EU Water Framework Directive has proposed to monitor a selection of priority substances in the aquatic phase, including lipophilic substances. However, there are strong arguments for measuring the latter in biota. Yellow eel is a good candidate because it is widespread, sedentary and accumulates many lipophilic substances in its muscle tissue. Several authors have described the indicative value of measured concentrations, yet few studies have investigated to which extent the spectrum of contaminants present characterizes the local environmental pollution pressure. To evaluate the value of the pollution profile of an eel as a fingerprint of the chemical status of the local environment, two datasets were selected from the Flemish Eel Pollutant Network database, one set from a small catchment area to investigate site-specific profiles, and one from seven large Flemish rivers to investigate river-specific profiles. The pollution profiles of persistent organic pollutants in individual eels along a river (even at distances <5 km) proved to be significantly different. Analysis of pooled contaminant data from multiple sites and sampling years within rivers allows characterization of river-specific chemical pressures. The results highlight the usefulness of eel as a bio-indicator for monitoring pollution with lipophilic chemicals like polychlorinated biphenyls and organochlorine pesticides in rivers. It was concluded that, as such, eel may be used effectively within the monitoring programme for a selection of priority substances referred to in the Water Framework Directive. (Belpaire *et al*., 2008).

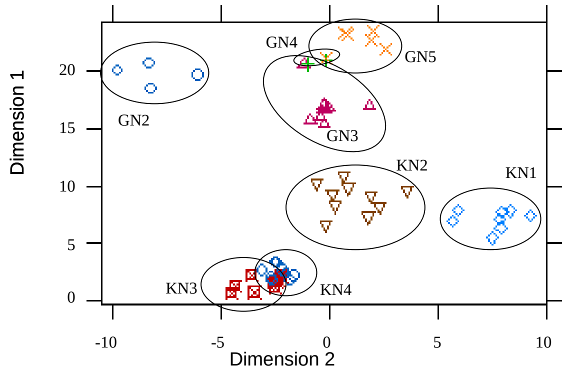

Figure BE.19. Canonical discriminant analysis of eels collected at eight sites in the Grote Nete and Kleine Nete on the basis of their PCB and OCP concentrations (N= 61). Distance between locations varied between 4 and 20 km.

High peaks of some substances in eel tissue confirmed the previously known high pollution load of some specific areas e.g. the high lead and cadmium pollution in the canal Kanaal van Beverlo, historically related to the metallurgy activities. In many cases however, eel analyses revealed unknown environmental problems, like for instance the presence of 1, two-dimensionalibromo-3-chloropropane in eels from two canals (Albertkanaal and Leuvense Vaart) and 1, two-dimensionalichlorobenzene in eels of some sites along the River Leie, indicating some point sources. In a few cases analysis of eels from a specific location has demonstrated unsuspected high pollution levels of several contaminants, this was the case for Lake Weerde, possibly indicating local spilling or dumping of contaminated material. Other compounds measured in eels had distribution patterns which can be explained by specific agricultural or industrial pressures (e.g. lindane in the basins of Yser, Demer and Dijle or HCB in the sub-basin of the Grote Nete). But several contaminants were omnipresent in Flemish eels. BTEX (benzene, toluene, ethylbenzene and the xylenes) compounds were found at all places. This was also the case for PCBs and some very persistent OCPs like DDTs which were banned a long time ago. From the profiles of DDT and derivatives it was concluded that in some river basins, DDT must still be in use (see below). But maybe the most striking and threatening observations are the very high levels of some BFRs measured in eels at several sites along the rivers Leie and Scheldt, peaking at Oudenaarde (River Scheldt). This eel contamination is most likely related to the intensive textile industry from this area.

Eels from different river basins differ in contamination. Belpaire *et al*., 2008 presented PCB and OCP contamination profiles for some basins. Eels from the river Yser are characterized by high OCPs, especially dieldrin and lindane (γ-HCH), and low PCB levels. River Leie reveals a distinctive profile of PCBs, with a large proportion of lower chlorinated congeners. Rivers Dender and Scheldt fingerprints are generally intermediate compared to the other rivers, but demonstrate considerably high PCB levels. River Demer eels usually have high lindane and DDT levels, whereas eels from River Grote Nete are characterized by peaking HCB and high DDT concentrations. In the River Maas, PCB concentrations are peaking, and the PCB profile is totally different from that in the River Leie. It is dominated by the higher chlorinated PCBs. OCP levels in the River Maas eels are low.

Results of measurements of dioxins on eight locations indicate some reason for concern. Dioxin concentration in eel varies considerably between sampling sites, indicating that they are good indicators of local pollution levels. The European Commission has set maximum levels of 4 pg TEQ g^{-1} fresh weight for the sum of dioxins (WHO-

PCDD/F TEQ) and 12 pg TEQ g^{-1} fresh weight for the total-TEQ i.e. the sum of dioxins and dioxin-like PCBs (WHO-PCDD/F-PCB TEQ) in muscle meat of eel and products thereof (Directive 2002/69/EC). Half of the sampling sites demonstrate especially DL-PCB levels exceeding the European consumption level (with a factor 3 on average). The levels of PCDD/FS AND DL-PCBS measured in some sites gave rise to serious concern about the reproduction potential for the eels from these sites. Human consumption of eels, especially in these highly contaminated sites, seems unjustified (Geeraerts *et al*., 2008, in press).

Table BE.6. Overview of the mean length (cm), the mean weight (g) and the muscle lipid content of the eels, the dioxin concentrations (ΣPCDD/F; pg WHO TEQ g^{-1} w.w.), the sum of dioxin-like PCB concentration (ΣDL-PCB; pg WHO TEQ g^{-1} w.w.), and the total-TEQ concentration (ΣPCDD/F and DL-PCB; pg WHO TEQ g^{-1} w.w.) at 8 locations in Flanders (2001–2005) (Geeraerts *et al.*, 2008).

Code	Water	Sampling year	Mean length (cm)	Mean weight (g)	Fat %	ΣPCDD/Fs (pg WHO TEQ g-1 w.w.)	ΣDL-PCBs (pg WHO TEQ g-1 w.w.)	ΣPCDD/F and DL-PCB (pg WHO TEQ g-1 w.w.)	% DL-PCBs of total Σ
COM	Congovaart + lagoon	2001	43.2	162.3	10.64	3.33	138.53	141.86	97.65
IB1	Itterbeek	2005	38.3	109.3	5.49	0.33	1.39	1.72	80.89
KB2	Canal of Beverlo	2005	41.2	110.1	3.58	0.30	2.04	2.35	87.04
KBH1B	Canal Bocholt-Herentals	2002	41.3	115.1	10.19	2.82	81.48	84.30	96.65
KNN	Creek of Nieuwendamme	2002	35.3	77.8	9.96	0.26	1.61	1.87	86.19
KZ	klein Zuunbekken	2002	39.6	107.0	15.01	1.64	23.39	25.03	93.46
ODU	Oude Durme	2002	38.6	99.6	8.93	0.62	3.98	4.60	86.44
WBV6	Willebroekse vaart	2002	39.7	103.1	10.1	0.69	24.04	24.72	97.23

Trend analysis (Maes *et al*., 2008) over the period 1994–2005 indicated that there were significant decreases in the average wet weight concentration of all PCB congeners, nearly all pesticides and four metals. The observed decline of PCBs in eel tissue was in agreement with other studies reporting on time-series of contaminants in fish. PCBs were banned from the EU in 1985 and since then, several time-series have indicated decreasing levels of contamination. Also concentrations of most pesticides decreased significantly over time. This was especially evident for α-HCH and lindane, demonstrating that the ban of lindane in 2002 has positive effects on the accumulation in biota. Similar reductions were modelled for HCB, dieldrin and endrin; however these compounds were banned many years ago. Unexpectedly, concentrations of *p,p'*-DDT increased while at the same time, *p,p'*-DDD and *p,p'*-DDE revealed significant decreases. At first sight, the ratio of DDE over DDT was in all eels analysed >1, suggesting that remaining DDT had not been recently reapplied. However, at some locations in Flanders (Kanaal Dessel Schoten, Handzamevaart and Ieperkanaal) the ratio of DDE over DDT rapidly decreased over a few years by an order of magnitude of three. Such a steep decrease, even if the ratio was higher than one, probably indicates recent application of DDT and reveals that not all stock was depleted. These results, as well as the recent observation that human blood samples, particularly of the juvenile population living outside urban areas, still contain DDT (Schroijen *et al*., 2008) urged regional policy-makers to make a serious attempt in order to collect the remaining stock of banned pesticides. Also for some heavy metals, concentrations decreased in the eel. Especially lead, arsenic, nickel and chromium were notably reduced. The concentration of lead in eel muscle tissue was consistently decreasing between 1994 and 2005, which possibly is related to the gradual changeover from leaded to unleaded fuels and a reduction of industrial emissions. For arsenic, nickel and chromium, the trend may be biased as data were available only since 2000. Cadmium and mercury, however, did not demonstrate decreasing trends and remain common environmental pollutants in the industrialized region of Flanders.

Following the very high levels of BFRs encountered in eels from Oudenaarde, new measurements were carried out in 2006 (Roosens *et al*., 2008). A descending trend in the contamination with BFRs was observed from 2000 to 2006 on this site. For PBDEs, levels have decreased by a factor 35 (26 500 to 780 ng g^{-1} LW), whereas for hexabromocyclododecane (HBCD), the decrease was less conspicuous, (35 000 to 10 000 ng g^{-1} LW). Based on these results we can conclude that in 2006 fish seem to be less exposed to PBDEs than 6 years earlier. This is probably as a consequence of the restriction regarding the use of the penta-BDE technical mixture (since 2004), a better environmental management and a raising awareness concerning PBDEs. However, because there are no restrictions regarding its usage, HBCD can still be detected in large quantities, especially in aquatic environmental samples taken next to industrialized areas, where it is used in specific applications. The slight decrease in the concentrations of HBCDs in eels observed between 2000 and 2006 might indicate that HBCD is slowly being replaced by other BFRs for which no risk assessment is available. BFR levels have decreased in the Oudenaarde area, but still remained higher than in other locations in Flanders. Also compared to several European studies the reported PBDE levels are still one order of magnitude higher in Oudenaarde eels. The textile industry is likely the cause of elevated BFR levels in fish on this part of the river Scheldt, but further studies should be set up to determine the exact origin and how far this contaminated area extends over the whole river.

We may conclude that the results from the Flemish Eel Pollution Monitoring Network allow getting a comprehensive overview of a set of contaminants indicating environmental pressure over Flanders, and they are able to document the temporal evolution of some of these pressures. The intensity of pollution, at least at some sites, may well indicate potential negative effect on the health of these contaminated eels.

BE.I.3.2 Contamination in eel and its role in the collapse of the stock (Belpaire, 2008)

We summarize the main findings of work in this field in the following section and draw some conclusions related to the potential role of contamination in the collapse of the stock.

In the eel, the impacts of contaminants on metabolic functions and on behaviour of the eel are widely divergent and act through various mechanisms (Geeraerts and Belpaire, in prep.). Endocrine disruption seems a widely distributed phenomenon among fresh-water fish. Also in Flanders this was recently documented in a comprehensive study (Berckmans *et al.*, 2007) assessing reproductive functions in Flemish roach (*Rutilus rutilus*). This study demonstrated that in 50% of male roach, testes were feminized. In eel, Versonnen *et al.*, 2004 investigated potential effects of xenoestrogens, and measured plasma vitellogenin (VTG) content in 142 eels sampled at 20 different locations of variable pollution levels. The plasma VTG content of eels was very low, despite a very high internal load of endocrine disrupters. Therefore, no indications were found for estrogenic effects to occur in natural fresh-water eel populations in Flanders. These results suggest that immature yellow European eel might not be the best sentinel species to study the effects of estrogenic compounds on VTG levels of wild fish populations. Most probably, endocrine disrupting effects of pollutants related with reproduction, will only become apparent during the maturing silver eel stage.

Maes *et al.*, 2005a studied the effects of pollutants on the genome of eels with variable metal load. They analysed the relationship between heavy metal bioaccumulation, fitness (condition) and genetic variability. A significant negative correlation between heavy metal pollution load and condition was observed, suggesting an impact of pollution on the health of subadult eels. In general, a reduced genetic variability was observed in strongly polluted eels, as well as a negative correlation between levels of bioaccumulation and allozymatic multi-locus heterozygosity.

Van Campenhout *et al.*, 2008 studied the effect of metal exposure on the accumulation and cytosolic speciation of metals in livers of European eel by measuring metallothioneins (MT) induction. This research was carried out in four sampling sites in Flanders revealing different degrees of heavy metal contamination (Cd, Cu, Ni, Pb and Zn). It was concluded that the metals, rather than other stress factors, are the major factor determining MT induction. The effects of perfluorooctane sulfonic acids (PFOS) in Flemish eels were studied by Hoff *et al.*, 2005, indicating that PFOS induces liver damage.

Geeraerts *et al.*, 2007 analysed our extensive dataset of contaminants by statistical modelling and concluded that PCBs, especially the higher chlorinated ones, and DDTs, have a negative impact on lipid content of the eel. It was further demonstrated that fat stores and condition decreased significantly during the last 15 years in eels in Flanders (Geeraerts *et al.*, 2007) and in The Netherlands (Belpaire *et al.*, 2008), jeopardizing a normal migration and successful reproduction.

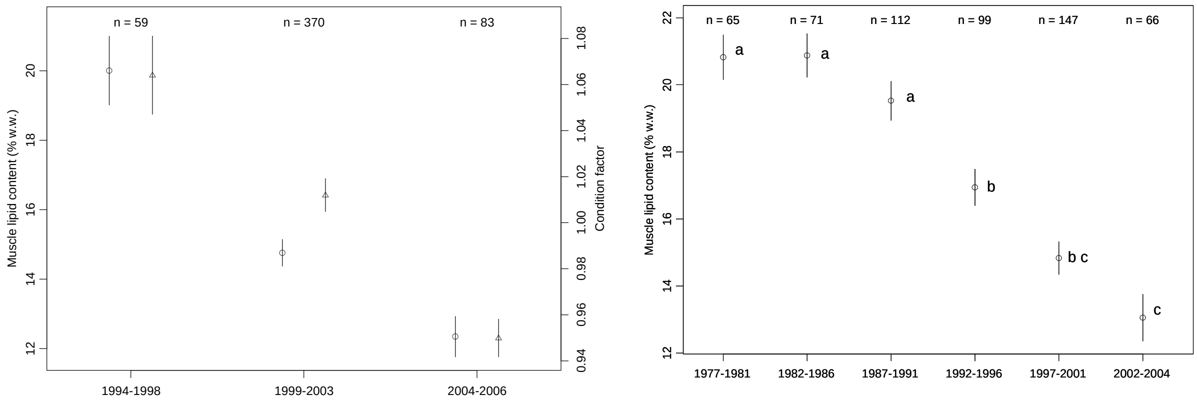

Figure BE.20 Temporal trend in fat contents (% of wet muscle weight) of yellow eels in Belgium (left panel) and The Netherlands (right panel) (means, bars indicating standard errors). The number of sites is indicated. Means of periods with the same letter are not significantly different from each other (Tukey test, 95% simultaneous confidence intervals). For the Belgian eels also condition factor is presented. (Belpaire *et al.*, 2008)

Belpaire, 2008 concluded that pollution is of utmost importance for eel management, and may represent a key element in the search for understanding the causes of the decline of the eel. He postulates that contaminant pressure is a very plausible causative factor for the collapse of the eel stocks and summarizes major arguments and hypotheses to underpin this.

1) Contamination has been demonstrated as the cause of population collapse of many other biota from the 1970s on (e.g. the collapse of several birds of prey in the 1960s as a consequence of DDT).

Many chemicals have been developed and put on the market, simultaneous with the intensification of agricultural and industrial activities during the 1970s. The timing of this increase in the production and release of chemicals may fit with the timing of the decrease in recruitment from 1980 on.

Eels bioaccumulate many chemicals to a very high extent.

The more or less simultaneous decreases in recruitment in the Northern-hemisphere *Anguilla* species, like *A. rostrata* and *A. japonica*, during the last 30 years, is an additional argument endorsing the idea that some new contaminants quickly spreading over the industrialized world, are key elements in the decline.

Many reports have been dealing with direct adverse effects of contamination on individual, population and community level in fish. In eel, many detrimental effects of contaminants on the individual level have been demonstrated, including impact on cellular, tissue and organ level. Also genetic diversity seems to be lowered by pollution pressure.

Considering the high levels of contamination in eels from many areas, endocrine disruption in mature silver eels might be expected, jeopardizing normal reproduction. Dioxin-like contaminants have been reported to hamper normal larval development.

Fat levels in eels have decreased considerably over the past 15 years, suggesting failure of successful migration and reproduction. This decrease is mainly induced by contamination.

Figure BE21 shows a simplified conceptual model of the effects of pollution exposure on the population structure of the European eel. Adapted from Lawrence and Elliott, 2003.

Considering (1) that the effects of contaminants on biota in general and on eel specifically are better known and seem to be of utmost importance for the reproduction success of the species, (2) that the pollution in eels is impressively varying between sites within and between member countries, (3) that the level of pollution in eel in many cases surpasses binding human consumption maximum allowed levels or advisory consumption limits and thus has an effect on fisheries management and regulation, we strongly recommend that at community level initiatives are taken to collate information, to set up comparative monitoring actions, to set up a pan-European database, to set up studies on effects.

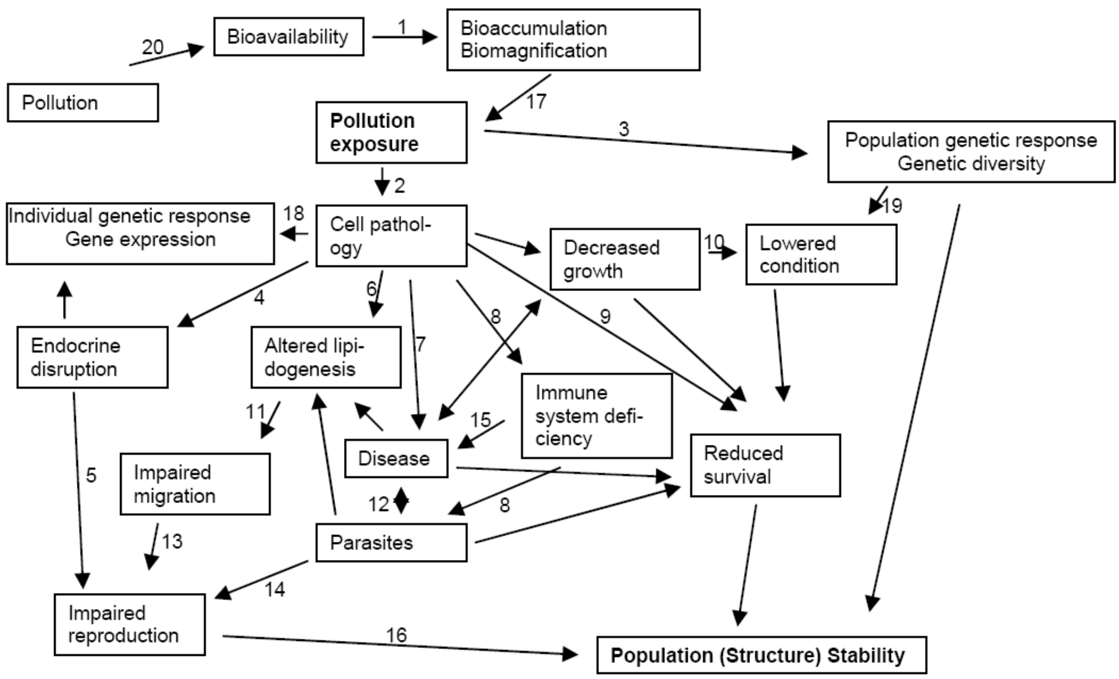

Figure BE.21: A simplified conceptual model of the effects of pollution exposure on the population structure of the European eel, *A. anguilla*. Adapted from Lawrence and Elliott, 2003. Numbers refer to references: (1) Vollestad, 1992; (2) Tuurula and Soivio, 1982; Svobodova *et al.*, 1994; Azzalis *et al.*, 1995; Stohs and Bagghi, 1995; Sanch *et al.*, 1997; Ibuki and Goto, 2002; Pacheco and Santos, 2002; (3) Nigro *et al.*, 2002; Jha, 2004; Maes *et al.*, 2005; Nogueira *et al.*, 2006; (4) McKinney and Waller, 1994; Versonnen *et al.*, 2004; (5) Jobling *et al.*, 2002b; (6) Jimenez and Burtis, 1989; Ceron *et al.*, 1996; Sancho *et al.*, 1998; Fernandez-Vega *et al.*, 1999; Robinet and Feunteun, 2002; Hu *et al.*, 2003; Pierron *et al.*, 2007a; (7) Roche *et al.*, 2002; (8) Sures and Knopf, 2004; Sures, 2006; (9) Sancho *et al.*, 1997; (10) Gony, 1987; (11) Ceron *et al.*, 2003; van den Thillart *et al.*, 2005; (12) Van Ginneken *et al.*, 2005; (13) Johnson *et al.*, 1998; Palstra *et al.*, 2007; (14) Sures, 2006; (15) Van Ginneken *et al.*, 2005; (16) Corsi *et al.*, 2003; (17) Van Campenhout *et al.*, 2008; (18) Ahmad *et al.*, 2006; Maria *et al.*, 2006; (19) Jha, 2004; Maes *et al.*, 2005; (20) Belpaire *et al.*, 2003.

Wallonia

Facing the contamination analyses performed on eels sampled in several waterways in the Walloon region, a Walloon jurisdiction aiming to prohibit consumption of eels fished from Walloon Rivers was published in June 2006 (Walloon Government, 2006).

The health risk associated to the consumption of fish originating in Walloon Rivers was assessed through the study of fish sampled in 61 stations situated on 30 different waterways between 2001 and 2004. The amounts of PCB dioxins and furans encountered in eel tissues were compared with the standard values applied to human health (Thomé *et al*., 2004). These are set to 75 ng g^{-1} fresh weight for PCBs (Royal Order from 6th March 2002 modifying the previous Royal Order (19th May 2000)), establishing maximal dioxin and PCB levels in several foodstuffs. Levels concern PCB congeners (28, 52, 101, 118, 138, 153 and 180) and 12 pg TEQ-WHO g^{-1} (TEQ-WHO or Toxic Equivalents-World Health Organization) of fresh weight for dioxins and furans (European Council regulation of the 29th November 2001).

Eel contamination by dioxins and furans stays in safe levels; encountered values never exceed the 12 pg TEQ-WHO g^{-1} fresh weight.

However, the situation of PCB contamination is far more alarming. Eels reveal PCB concentrations between 40 and 1761 ng g^{-1} fresh weight. Such results are particularly disturbing because they nearly systematically exceed the defined value for human consumption. The highest contamination levels are encountered in the lower Meuse, the Albertkanaal and the Vesdre. It is to be feared that a regular consumption of eel meat should reveal a threat to human health.

BE.I.4 Predators

We refer to last year’s report for data on cormorants. No new data available.

BE.J Other sampling

BE.K Stock assessment

BE.K.1 Stock assessments in Flanders (Yser, Scheldt and Meuse basin)

To examine temporal trends in eel stocks in Flanders an INBO dataset with eel densities from 487 sites in Flanders was used. Each site was fished with electrofishing or fyke fishing during period 1 (1995–2000) and period 2 (2001–2005). Fishing procedures were standardized. From the 487 sites 124 were situated on canals and 363 on running waters.

These data allow quantification of the abundance of eels in Flandrian water bodies, over space and time. Figures BE.22–24 give the distribution and abundance of eels in Flanders (electrofishing data) for 1332 stations, respectively in running waters, canals and polder waters and ponds and lakes (Belpaire *et al*., 2003).

In general, it could be concluded that the number of sites where fish was present increased from 74.7% to 82.5%, given an indication of the general increase in water quality in Flanders.

The same was found for the presence of eel. The number of sites where eel was present increased from 34% in 1995–2000 to 42.5% in 2001–2005. This increase is statistically significant. The increase is mainly as a consequence of an increase in water quality, but also the building of fish ladders had a positive effect on eel colonization. A striking example of the positive evolution in water quality has been the recent report by INBO of eel and other fish on the River Zenne, a river flowing through Brussels, and considered as dead since beginning of 1900.

However the densities of the eel collected both by electrofishing and by fyke fishing are low. Density data even tend to decrease between period 1 and 2. The decrease is significant for the electrofishing data.

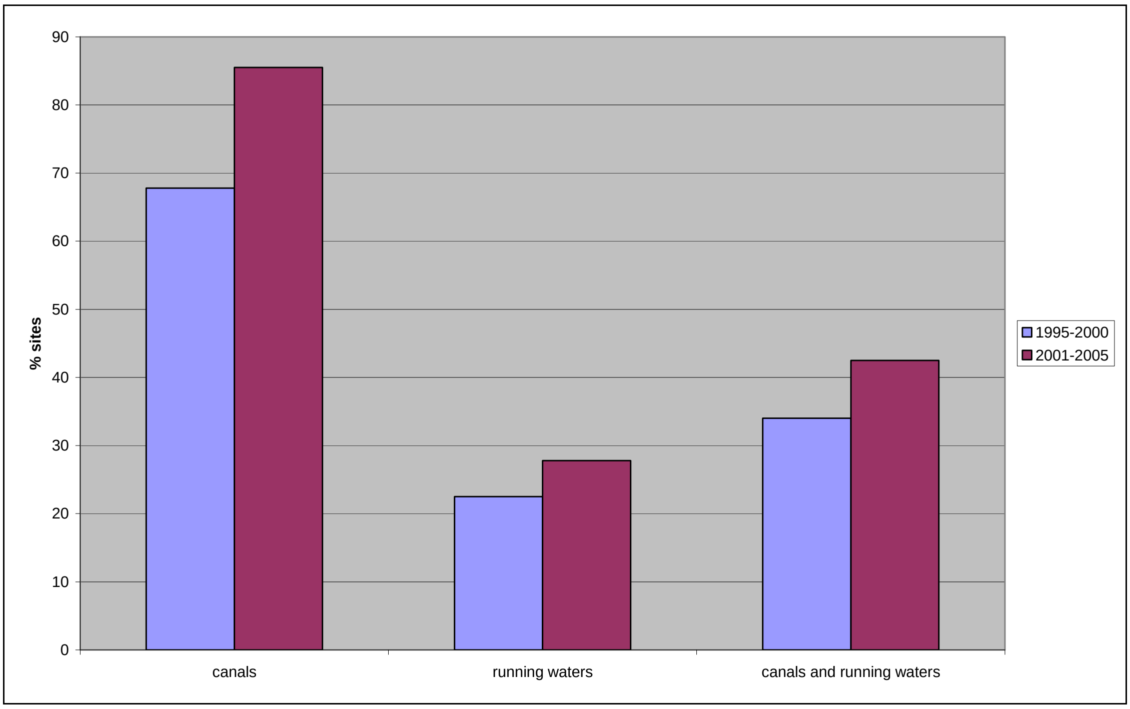

Figure BE.22 Presence of eels from 487 surveys in canals and running water in period 1: 1995–2000 and period 2: 2001–2005 (the same locations were fished in period 1 vs. period 2).

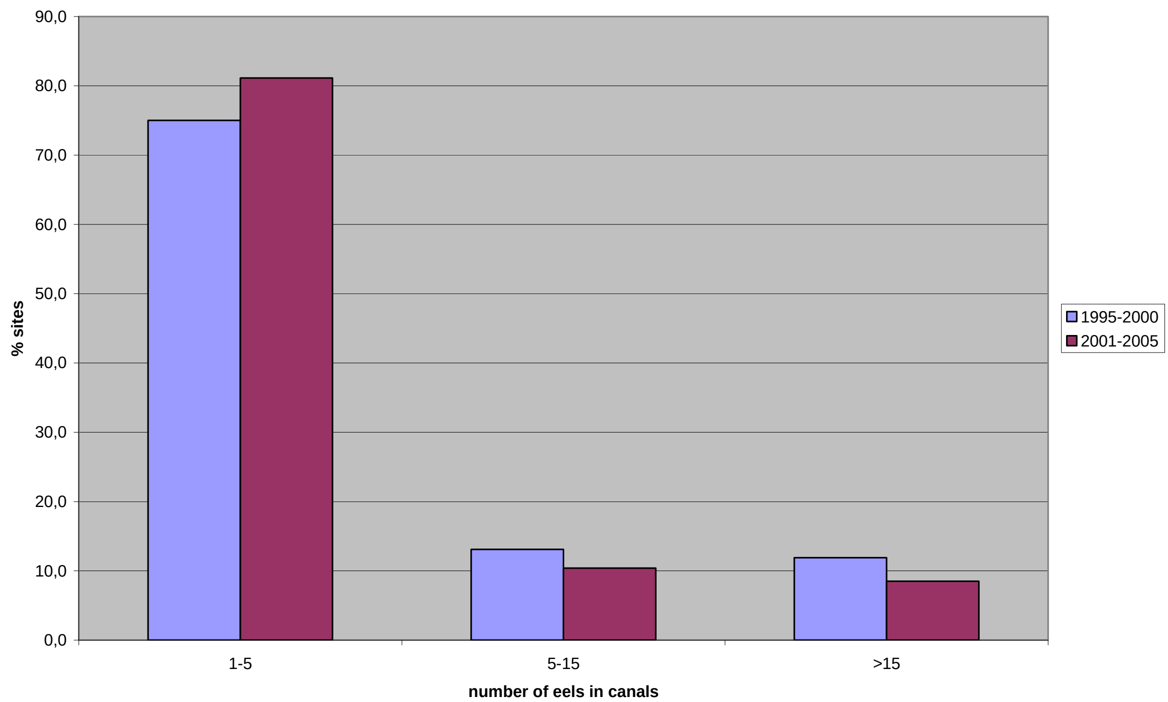

Figure BE.23 Abundance of eels (number of eels/100 m EF and number of eels/fyke/24 h) on sites where eels are present in canals in period 1: 1995–2000 and period 2: 2001–2005 (the same locations were fished in period 1 vs. period 2).

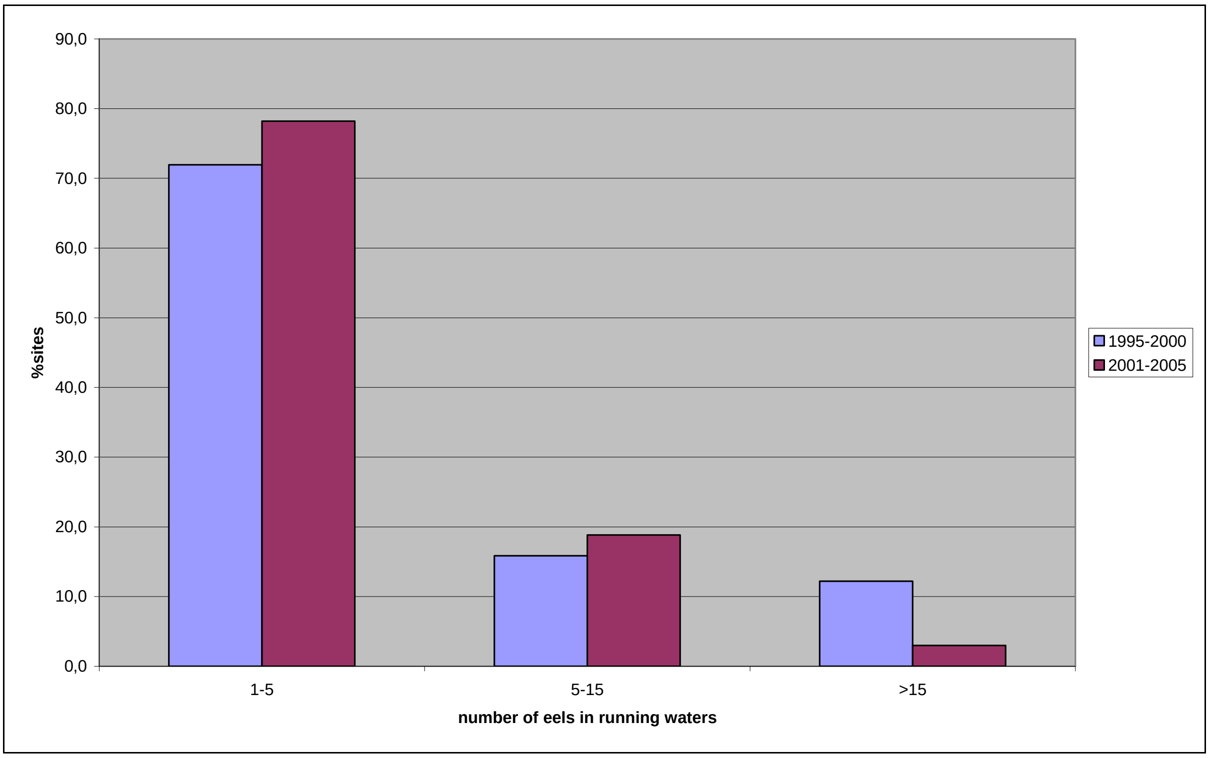

Figure BE.24 Abundance of eels (number of eels/100 m EF and number of eels/fyke/24 h) on sites where eels are present in running water in period 1: 1995–2000 and period 2: 2001–2005 (the same locations were fished in period 1 vs. period 2).

BE.K.2 Stock assessments in Wallonia (Meuse basin)

Fish stock assessments programmes in Wallonian Rivers are carried out by the Centre de Recherche de la Nature, des Forêts et du Bois (CRNFB). Table BE 7 is providing eel catches for 2007.

Table BE.7. Eel catches from fish stock surveys in the Walloon Region in 2007 (Data from the Hydrobiology Database of the CRNFB, contact Thierry Demol for details and survey techniques).

Date	Lmin	Lmax	Kg	number	Water mass	Surf ha	x	y
24.09.07	595	740	4244	7	Noue du Colébi		187 023	100 868
11.09.07	380	570	5950	6	Canal Charleroi Bruxelles	0,11	141 080	142 940
02.05.07			2,092	6	la Meuse	0,05	242 770	156 292
04.09.07	530	790	2,737	5	la Meuse	0,220	201 828	131 780
12.09.07	480	700	2,315	5	la Meuse	0,200	242 770	156 292
16.10.07	580	730	4,37	5	la Lesse	0,523	191 195	100 985
21.09.07	620	900	3,798	4	la Lhomme	0,149	206 852	92 353
01.08.07	575	890	2,384	3	la Mache	0,158	199 990	76 280
10.09.07			0,595	3	la Lys	0,14	50 544	161 281
31.08.07	275	400	0,147	2	la Dendre	0,09	114 126	158 760
03.09.07			0	2	la Meuse	0,22	182 700	100 617
24.07.07	833	833	1,317	1	la Biesme	0,100	165 530	121 610
06.09.07	430	460	0,421	1	l' Escaut	0,13	82 857	134 696
19.09.07	775	775	0,93	1	la Semois	0,441	187 136	61 735

26.09.07	725	725	0,585	1	la Lesse	0,480	204 941	76 782
03.10.07	650	650	0,053	1	la Lienne	0,184	249 480	122 680
07.09.07			0	1	canal ATH BLATON	0,12	109 000	145 520
14.09.07		50	0	1	la Molignée	0,08	184 449	111 948

In the frame of the National Action Plan for eel stock preservation, scientific surveys of eel numbers will be increasingly performed in the coming years.

BE.L Sampling intensity and precision

BE.M Standardisation and harmonization of methodology

BE.M.1 Survey techniques

Flemish region

Glass eel survey techniques

At the Nieuwpoort station the glass eel fishing is starting at the end of February and continues till the beginning of May. Fishing is not carried out every day, but is mainly dependent of weather conditions and tide. Usually there are 20 to 30 fishing nights per season. Fishing is starting ca. 2–3 hours before high tide and is continued until high tide is attained.

The time-series has been achieved by fishing in the ship lock of the Iepersluis at Nieuwpoort. Two to three hours before high tide the outer (sea side) doors of the ship lock are opened to allow glass eel entering the ship lock. A 5 m long steeled dipnet is held vertical from the ship lock quay and pulled forward, just under the surface, for the length of the ship lock. The dipnet has a width of 80 cm and is 60 cm high. Glass eel has been monitored in this way since 1964.

On the Scheldt (see Section BE.G.2) the immigration of glass eels was studied using artificial substrates (Silberschneider, 2001). Substrates were deployed at the outlet of sewage treatment plants and drainage systems in the Zeescheldt and tributaries (Rupel, Lower Nete and Kleine Nete) and were checked once every two days for glass eels.

Data available are daily glass eel catches (kg), date and starting and ending hours of the fishing period. Temperature, tide data and other external factors (weather, etc.) are also recorded. Catches are presented as total annual yield or can be presented as maximum daily catch or mean daily catch. Catch per haul are recorded. The Research Institute for Nature and Forest is keeping up to date a database with the catches.

Yellow eel

Since 1995, INBO runs a fresh-water fish monitoring network consisting of ca. 1500 stations in Flanders. These stations are subject to fish assemblage surveys on regular basis (on average every 2 to 4 year depending of the typology of the station). This network includes all water types, head streams as well as tributaries (stream width ranging from 0.5 m to 40 m), canals, disconnected river meanders, water retaining basins, ponds and lakes, in all of the 3 major basins in Flanders (Yser, Scheldt and Meuse). Techniques used for analysing fish stocks are standardized as much as possible, but can vary with water types. In general electrofishing was used, sometimes completed with additional techniques, mostly fyke fishing. A detailed description of the sampling methodology is given in Table BE.8. All fish are identified, counted and at each station 200 specimens of each species were individually weighed and total length was measured. As much as possible biomass (kg ha^{-1}) and density (individual's ha^{-1}) is calculated. Other data available are number (and weight) of eels per 100 m electrofished river bank length or number (and weight) of eels per fyke per day.

Table BE.8. Description of the techniques used for fish stock assessments in Flandrian water bodies by INBO.

WATERTYPE	TECHNIQUES USED
Running waters <1.5 m	100 m electrofishing with 1 anode
Running waters 1.5–4 m	100 m electrofishing with 2 anodes
Running waters 4–6 m	100 m electrofishing with 3 anodes
Running waters 6–8 m	100 m electrofishing with 4 anodes
Running waters >8 m	Combination of: 500 m boat electrofishing (2 x 250 m on both river banks) fykes and/or gillnets
Closed river arms and ponds Polder drainage systems	Combination of : seine netting boat electrofishing (both river banks) fykes and/or gillnets

Walloon region

No detailed information.

BE.M.2 Sampling commercial catches

Not carried out.

BE.M.3 Sampling

BE.M.4 Age analysis

Not carried out.

BE.M.5 Life stages

See Sections BE.G.1 and G.2 for glass eel, and BE.K.1 and K.2 for yellow eel.

See Verbiest *et al.*, subm. for silver eel.

BE.M.6 Sex determinations

No sex determination.

BE.N Overview, conclusions and recommendations

The national eel management plans is actually being worked out in Belgium. There are major critical points where considerable efforts still have to be made, essentially on water quality and pollution, and on habitat restoration and restoration of the migration possibilities.

New evidence has been presented that contaminants might have an adverse impact on the eel. An alarming decrease in fat levels in yellow eel over the last 15 years was described for Belgium and The Netherlands.

Many pressures have been suggested or demonstrated to negatively impact the eel stock. Maybe these pressures acted in a synergetic way, resulting in the collapse of the stock. Dekker, 2004 suggested that the most likely proximate cause of the collapse in recruitment observed in the European eel after a prolonged period of gradually declining abundance in continental waters is caused by an insufficient quantity of spawners. From the evidence presented under BE.I.3, *we may conclude that not only the quantity, but also the quality of the potential spawners leaving continental waters, is insufficient, and has contributed to the decline of the stock*. Contaminant pressure in continental waters seems to represent a major threat for the European eel stock and will limit the possibilities of restoration of the stock. Hence, we believe that within the (inter)national eel restoration plans, measures to decrease contaminant pressure are an essential issue (Belpaire, 2008).

Considering (1) that the effects of contaminants on biota in general and on eel specifically are better known and seem to be of utmost importance for the reproduction success of the species, (2) that the pollution in eels is impressively varying between sites within and between member countries, (3) that the level of pollution in eel in many cases surpasses binding human consumption maximum allowed levels or advisory consumption limits and thus has an effect on fisheries management and regulation, we strongly recommend that at community level initiatives are taken to collate information, to set up comparative monitoring actions, to set up a pan-European database, to set up studies on effects.

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Report on the eel stock and fishery in Germany 2007

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DE.B Introduction

In Germany, the European eel *Anguilla anguilla* is an important species for both commercial and recreational fisheries.

Germany is a federation consisting of 16 states, all of them having their own fisheries related legislation. The fisheries legislations include regulations, which are relevant to eel, such as minimum size limits or restrictions for fishing gears. In some states, the fisheries managers (fishers or angling clubs) have to prepare a management plan, which is examined by the responsible authorities. However, there is no general obligation to provide statistics on fishing efforts or landings.

Coastal eel fisheries occur in Niedersachsen, Bremen, Hamburg, Schleswig-Holstein and Mecklenburg-Pomerania.

Coastal marine fishing areas for eel fisheries in the North Sea can be divided into the lower courses and estuaries of rivers and the Wadden Sea. In the Baltic Sea there are lower courses of rivers, the inner part of the coast especially in Mecklenburg-Pomerania, called Bodden or Haff, and the outer coast.

The North Sea coastline of Schleswig-Holstein is in total 553 km long, 256 km of which belong to the islands and 297 to the continent. The Baltic Sea coast is 637 km incl. the island of Fehrmarn. The Schleswig-Holstein Wadden Sea has a surface area of about 1700 km^2 (Ministerium für ländliche Räume 2001).

The coastline of Mecklenburg-Pomerania is 1712 km long; 1358 km of it belong to the inner coast and 354 km to the outer coast. There are several isles of different sizes between 17 km^2 (Hiddensee) and 930 km^2 (Rügen). The total surface area of the fishing districts of the inner part is 171 400 ha and 568 000 ha of the outer part; resulting in a total area of 739 400 ha.

Generally the borderline between inland fisheries and marine fisheries is regulated in the respective state fishery legislations. It can be rather narrow to the coast as for smaller rivers like Eider and Stör or rather inland as with the River Elbe, near to the city of Hamburg, or the River Ems close to the city of Papenburg.

The European Water Framework Directive subdivides Germany into 10 separate River Basin Districts (RBD; Figure 1). Six of them are real international RBDs (Rhine, Danube, Elbe, Meuse, Oder, Ems). The two smaller RBDs Schlei/Trave and Eider mainly belong to Germany with only small parts of the catchment area being located in Denmark. Only two RBDs exclusively belong to Germany.

The Rhine is 1320 km long and has a drainage area of about 185 000 km² from which 106 000 km² belong to Germany. The drainage area is shared with Switzerland (28 000 km²), France (23 300 km²), The Netherlands (22 700 km²), Luxemburg (2520 km²), Austria (2400 km²), Belgium (767 km²), Liechstenstein (160 km²) and Italy (70 km²). The Rhine is draining into the North Sea.

The Elbe has a length of 1094 km and a catchment area of 148 268 km². The German part of the catchment area is 97 175 km² and 49 933 km² belong to the Czech Republic. Austria (921 km²) and Poland (239 km²) contribute less than 1% to the drainage area. Important tributaries in the German part of the catchment area are the rivers Havel, Saale, Mulde and Schwarze Elster. The Elbe is also draining into the North Sea.

The Weser is one of the two RBDs which completely belong to Germany. The total drainage area is 48 800 km² (including coastal waters). The Weser itself results from the confluence of the rivers Werra and Fulda. The main tributaries are Werra, Fulda, Diemel, Aller and Leine. The Weser is draining into the North Sea.

The river Ems is also draining into the North Sea. The total drainage area amounts to 18 000 km² which are shared with The Netherlands. About 15 000 km² belong to Germany and 2400 km² to The Netherlands. The rest results from the Ems-Dollart estuary.

The catchment area of the river Meuse (35 000 km²) is shared with The Netherlands, Belgium, France and Luxemburg. The main tributaries in Germany are the rivers Rur (2338 km²), Niers (1382 km²) and Schwalm (273 km²). The Meuse is draining into the North Sea.

With a total catchment of 4701 km², the Eider is a very small RBD. Only a small proportion of it belongs to Denmark. The Eider is draining into the North Sea.

With a catchment area of 122 512 km² (including the Szczecin Lagoon and its tributaries), which is shared by Poland, the Czech Republic and Germany, and a length of 855 km, the Oder is one of the bigger rivers draining into the Baltic Sea. The main part of the drainage area belongs to Poland (87.6 %), whereas the German part is 7987 km² (6.5 %).

The Warnow/Peene RBD includes a total drainage area of 13 600 km². The main rivers in this RBD are Warnow and Peene with catchment areas of 3300 km² and 5100 km², respectively. About 2900 km² coastal waters are also included. Both rivers are draining directly into the Baltic Sea. This RBD belongs exclusively to Germany.

The Schlei/Trave RBD has a drainage area of 6174 km². Besides Schlei and Trave, it consists of some small rivers and streams, which also drain into the Baltic Sea. The Schlei is no running water (river) but a firth of glacial origin. The RBD is also characterized by 51 lakes with areas of more than 50 hectares.

With 807 827 km² (including coastal waters), the drainage area of the Danube is the second largest European river catchment. The river has a length of 2870 km, and 18 countries contribute to the drainage area. The Danube is draining into the Black Sea and does not belong to the natural distribution area of the European eel.

According to the EU Council Regulation 1100/2007, Germany is preparing Eel Management Plans for its River Basin Districts except for the River Danube. The preparation is close to its final stage. During the process of preparing the plans, many data on the waters and on several aspects of the fishery have been collected by the responsible persons in authorities and scientific institutions. However, so far not all of these data have become available for the author of this report. Therefore, this report lacks some detailed information for several RBD’s but these data will become available for the next report (2008).

DE.C Fishing capacity

DE.C.1 Coastal and marine fishery (if relevant to eel)

The statistics of the German fleet (2005) lists 1624 fishing vessels with lengths of less than 12 m in the North Sea and the Baltic Sea. These vessels mainly fish for groundfish and herring and are probably the most relevant part of the fishing fleet with regard to eel. Additionally, there are 109 trawlers of different size fishing in both the North Sea and the Baltic Sea. 26 vessels with lengths of more than 12 m fish with passive gears, e. g. longlines. They may be partly relevant to eel. Most likely, the number of vessels has slightly decreased since 2005.

The Mecklenburg-Pomerania fishers are using hooped fykenets, eel fykenet chains and longlines for eel in the inner coastal waters and fykenet chains and longlines in the outer part.

Fishery on eel in the North Sea part of Schleswig-Holstein is with fykenets only. There is no more trawl fishery. In the lower course of the River Elbe, a stownet fishery exists. In the Baltic Sea Schleswig-Holstein fishers are often part-time fishers. They are using fykenets of different construction, even big sized ones fixed to piles nearly having the size of poundnets. In recent years more and more pipe eel traps are used, because they provide better catches, are cheaper and easier to protect against theft.

Lower Saxony has a small fishery on eel in the lower courses of the rivers Ems, Weser and Elbe. Trawl fishery has been finished some 10 years ago for economic reasons. On the river Ems there is a traditional fixed stow nets fishery (poles), which has been reduced for economic reasons as well. On the rivers Weser and Elbe an anchored stow net fishery exists. Fishery on yellow and silver eel starts in spring with increasing water temperatures and ends in October. During summertime eel baskets are being used additionally.

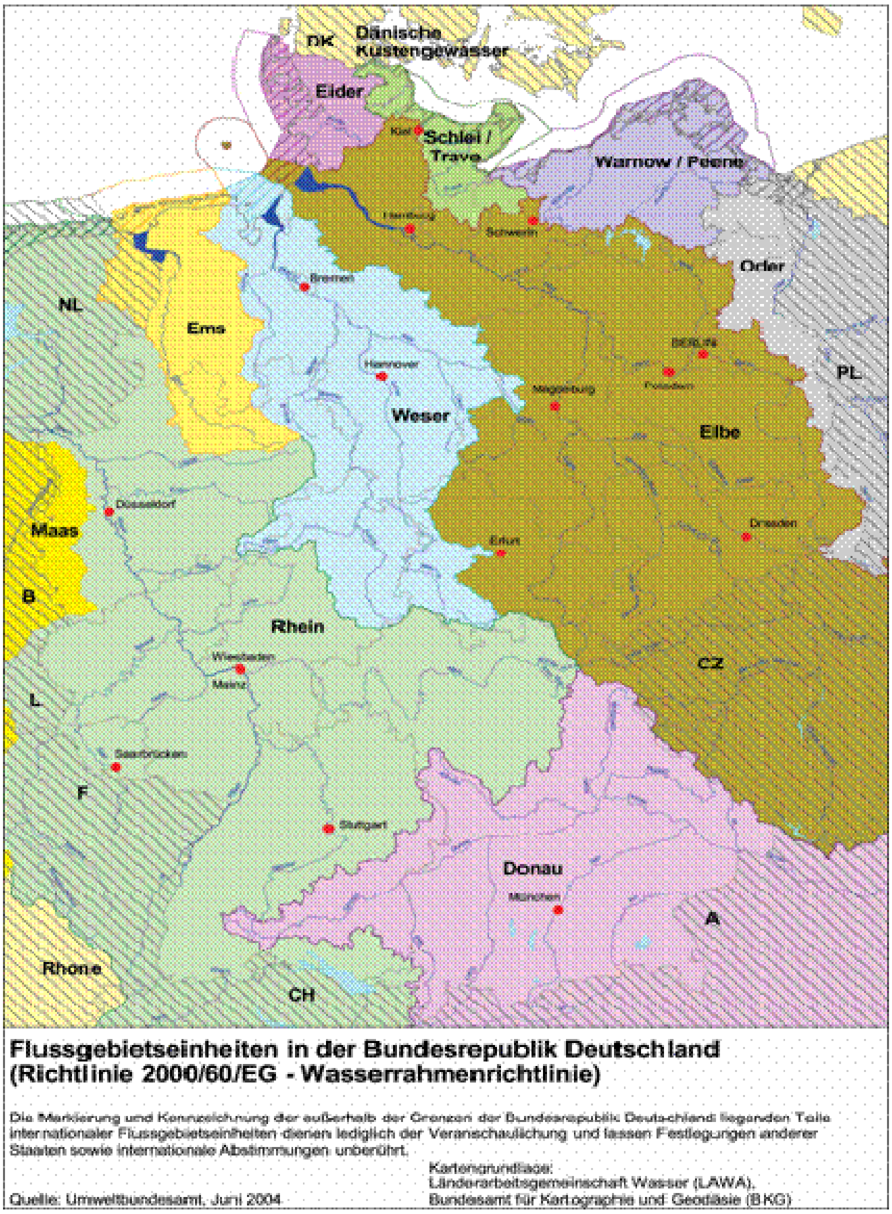

Figure 1 River Basin Districts (RBD) in the Federal Republic of Germany: Eider, Schlei/Trave, Elbe, Warnow/Peene, Oder, Weser, Ems, Rhine, Meuse and Danube.

DE.C.2 Inland fishery

Fishing capacity of inland fisheries is not reported in detail.

The total surface area of German inland waters is 845 305 ha, from which at present 536 777 ha are used for fisheries purposes.

In 2006, about 219 000 ha of lakes and reservoirs and 26 000 ha of rivers were managed by nearly 900 companies (including 478 full commercial fisheries and about 400 semi-professional and hobby fisheries). The total economic yield was about 9.4 million €. Data for 2007 are not yet available but most likely do not differ strongly.

DE.D Fishing effort

Landings from vessels less than 10 m which are landing eel need not to report on logbooks. Instead they are using landings declarations in which there is no record for effort or gear.

Fishing effort is not reported for inland fisheries. However, the EU Council Regulation 1100/2007 requires some more detailed information from the fishers and consequently, the availability of data in this field will improve in the next years.

DE.E Catches and landings

DE.E.1 Coastal fishery

Data on landings of eel from the North Sea and the Baltic Sea have been provided by the relevant bodies of the respective states.

The coastal fishery in Lower Saxony mainly represents fishing activities in the lower reaches and estuaries of rivers by use of stow nets or fykenets.

Schleswig-Holstein reported on trawl fishery in the North Sea around the island of Helgoland during the 1960–1970s. But this fishery ceased in the meantime. Stocking size eel (in Table 1) were exclusively caught in lower parts of the rivers Elbe and Eider. These smaller eels are sold via the *Aalversandstelle* of the German Fisheries Association or directly to lake fishers for restocking of inland waters of this state.

In the Baltic Sea there is no trawl fishery from Schleswig-Holstein vessels for a long time. All landings are from small enterprises at Schlei and Trave. Around the island of Fehmarn and in the Lübeck Bight, catches decreased dramatically during recent years. According to fishers concerned this decrease is at least partly as a consequence of cormorants often sitting on the piles of poundnets and drying their plumage after a successful visit of the catch chambers of the passive gear. During the past five years 2/3 of all poundnets places have been given up as a consequence of a strong decrease of catches.

In the Mecklenburg-Pomeranian part of the Baltic coast, there is still a substantial eel fishery and the catches revealed only a slightly decreasing tendency during the last years.

Table 1 Eel landings from the coastal fishery in North and Baltic Sea by quantities (rounded) and value (transformed in Euro).

	North Sea						Baltic Sea		
Year	Lower Saxony (incl. stocking size eel)		Schleswig-Holstein		Schleswig-Holstein* Stocking size eel		Schleswig-Holstein		Mecklenburg-Pomerania
	t	€	t	€	t	€	t	€	t
1959	83.8	113,706							
1960	50.5	84,143							
1961	47.8	76,854							
1962	66.8	108,019							
1963	55.3	111,128							
1964	56.1	124,742							
1965	56.3	135,596							
1966	67.8	143,672							
1967	92.3	199,788							
1968	102.5	245,202							
1969	85.3	194,871	97.4	313,213			204.5	909.189	
1970	130.3	324,193	94.1	349,148			143.8	682.162	

			North Sea					Baltic Sea		
Year	Lower Saxony (incl. stocking size eel)		Schleswig-Holstein		Schleswig-Holstein* Stocking size eel		Schleswig-Holstein		Mecklenburg-Pomerania
1971	113.9	375,358	130.6	550,216			124.5	679.720	
1972	77.2	71,785	92.3	453,610			146.8	749.918	
1973	77.5	393,541	105.5	510,202			151.2	825.524	
1974	85.9	392,953	113.8	661,990			109.8	679.307	
1975	94.7	509,196	102.6	592,191			123.7	762.290	
1976	104.5	540,277	102.4	599,191			102.6	660.139	
1977	99.3	540,192	135.9	793,559			77.6	546.213	
1978	69.0	432,263	100.7	682,567			62.6	465.377	
1979	81.4	486,924	76.1	569,022			81.6	596.672	
1980	108.9	658,220	73.5	548,177			66.0	474.395	
1981	119.4	787,696	55.4	405,403			75.1	575.250	
1982	107.3	766,437	67.3	502,455			98.3	746.875	
1983	102.9	684,057	72.6	531,814			82.6	636.962	
1984	95.4	617,621	62.2	483,898			51.3	420.048	
1985	65.4	449,844	57.1	442,299			50.4	411.762	
1986	91.7	662,076	39.6	324,351			65.6	564.750	
1987	69.0	485,298	21.0	171,292			57.1	478.490	
1988	45.6	349,384	42.2	363,694			70.1	590.345	
1989	29.3	220,463	31.4	265,244			86.9	751.143	
1990	35.9	283,640	14.7	125,732			82.4	741.405	
1991	24.5	202,558	11.8	94,525			83.5	773.621	
1992	25.7	223,031	6.1	57,957			78.7	701.902	
1993	30.1	227,157	12.8	115,980	1.9	9,690	66.5	624.781	
1994	64.5	492,489	13.3	68,891	10.4	44,146	63.7	567.412	
1995	42.5	322,316	7.7	60,244	3.6	18,496	60.2	542.434	
1996	15.7	135,320	6.3	43,984	3.5	17,850	27.7	267.152	
1997	30.0	238,911	12.0	84,278	3.7	22,452	44.5	417.479	
1998	13.8	114,715	8.5	62,714	3.7	22,289	19.1	186.149	
1999	19.9	161,782	10.5	75,144	6.1	33,233	27.0	254.386	
2000	16.3	141,990	5.7	39,266	5.0	27,756	30.1	284.963	
2001	21.1	186,200	4.7	37,764	4.7	26,266	28.6	278.228	108
2002	35.3	292,198	4.4	38,850	4.0	21,547	28.0	218.217	98
2003	29.8	233,986	4.8	36,067	3.4	19,548	27.4	251.862	93
2004	31.7	246,038	5.4	39,745	4.1		17.3	136.337	94
2005	22.2	198,872	5.0	38,400			17.0	130,560	86
2006	19.1	165,340	4.1	29,247			21.1	141,178	91
2007	23.6	191,278	0.05	388			11.3	67,806	76

*** Catches of stocking size eel result exclusively from the rivers Elbe and Eider (North Sea).**

DE.E.2 Inland fishery

Due to the federal structure of Germany, catches are not reported separately for RBDs but for states (Bundesländer). In the course of the preparation of the EMP's, the data will have to be made available for RBD's, but this information has not become available yet.

A clear decrease in the yellow and silver eel catches (not distinguished) has been observed for more then 10 years (Table 2). However, there has been no further decline since 2003. In 2006, the most important states with regard to eel fisheries were Brandenburg (96 t) and Mecklenburg-Pomerania (51 t). In 2007, the eel catches of the inland fishery were stable with 206 t (even a slight increase was reported).

In the last years, yields of commercial fisheries were reported or estimated from different regions in the range between 0.8 kg/ha (Brämick *et al*., 2007) and 2.9 kg/ha (S. Spratte, pers. comm.). Leuner, 2007 reported a yield of about 6 kg/ha for the river Main (belonging to the Rhine RBD), but this also included catches of recreational fisheries.

Table 2 Development of eel catches from the inland fishery in the last 13 years. Data represent the sum of catches from Bavaria, Berlin, Brandenburg, Mecklenburg-Pomerania, Saxony-Anhalt and Thuringia.

YEAR	EEL CATCHES (T)
1995	369.3
1996	300.2
1997	280.7
1998	251.9
1999	261.0
2000	276.4
2001	239.3
2002	236.9
2003	170.9
2004	168.6
2005	174,4
2006	185,6
2007	206.0

DE.E.3 Aquaculture

Table 3 Production of eel in recirculation systems.

YEAR	PRODUCTION (T)
1995	186
1996	204
1997	221
1998	appr. 260
1999	appr. 400
2000	422
2001	347
2002	381
2003	372
2004	328
2005	329
2006	567
2007	740 (440 t for human consumption and 300 t stocking size eel)

In Germany, the eel is an important species for aquaculture in recirculation systems. With a total production of 740 t in 2007, a clear increase compared to the last years was achieved. This increase was mainly caused by the high demand for pre-grown eels for re-stocking, e. g. for a big pilot project for the enhancement of the spawner stock in the catchment of the river Elbe. There are no other aquaculture techniques used for production of eel.

DE.E.4 Recreational fisheries

The number of anglers is assumed to be approximately 1.5 million.

A study revealed that 6.4 % of anglers most frequently took eel home (Arlinghaus, 2004).

Even though some associations and clubs ask their members for catch reports, there exists no general catch statistics from recreational fisheries. Consequently, the order of magnitude of angler catches is not well known. However, by considering the large number of anglers, it is likely that angler catches of eel contribute considerably to total eel mortality in the fresh waters.

The relative importance of catches of the commercial and the recreational fishery differs according to the conditions in the respective area. Whereas in some regions, angler catches are assumed to be twice as high as the yield of the commercial fishery, the opposite is reported from other regions.

During the process of data collection for the eel management plans, the data basis has improved for some regions and it can be expected that this process will continue. E.g. in Schleswig-Holstein, fisheries managers already have to prepare management plans for their waters including data on catches and stocking. In the course of preparing the draft eel management for the river Elbe, the following data were obtained for waters of the Elbe catchment in Schleswig-Holstein:

Mean annual catch of eel per member of angling club 0.53 kg

Mean annual catch of eel per "active" angler 1.09 kg

At a number of 30 000 anglers in this area, the total eel catch was estimated to 15 t (S. Spratte, pers. comm.).

For anglers in waters of the RBD Schlei/Trave, a mean value of 0.84 kg/angler and year was extracted from a management plan database in Schleswig-Holstein (F. Hartmann, pers. comm.) for the years 2001–2004. It was not distinguished between "active" anglers and "all anglers".

For the Elbe RBD, Brämick *et al.*, 2007 report angler catches of about 0.5 kg/ha.

DE.E.5 Restocking

Restocking of eel is very common in German waters, but as there is no central database for eel stocking, no representative data are available. Earlier data on restocking, in particular from the area of the former GDR and later from the state Brandenburg, have been presented in former reports of the WGEEL (e.g. 2003, R. Knösche).

Some data exist for certain regions or waters and may describe the situation at least roughly (Data from S. Spratte, personal communication). In the Schleswig-Holstein part of the Elbe River basin district, running waters managed by anglers have been stocked with about 75 glass eel equivalents per ha (mean value for this type of waters) during the last years. In lakes in the same area managed by anglers, the stocking density was between 0.08 kg farmed eels per ha and 1.2 kg "Satzaal" (wild-caught eels of ca. 30g per individual) per hectare.

Lakes managed by commercial fishers received about 1.2 kg *Satzaal* per ha (about 210 Glass eel equivalents). From the same area, stocking densities in the middles of the 1990s were about 75–150 Glass eel equivalents. There was usually no re-stocking at the bigger channels (Elbe-Lübeck-Kanal, Kiel channel).

In 2005, approximately 400 000 bootlace eel equivalents were stocked by commercial fishers in the river Havel (Brämick *et al.*, 2006). This results in a mean stocking density of about 13 bootlace eels per hectare for this important tributary of the river Elbe.

At present, there is a project running at the Elbe system (Spawner stock enhancement in the river Elbe, financial support by FIAF) which includes a huge re-stocking programme. For the Elbe system, Brämick *et al.*, 2007 stated that about 20 years ago more than 100 glass eels per hectare had usually been stocked. However, as a consequence of the reduced availability and the strong increase in price, the re-stocking decreased to about 20–40 glass eel equivalents per hectare during the last 15 years. In the course of the present pilot project, the stocking numbers again increased up to 120 glass eel equivalents per hectare (Brämick *et al.*, 2007). It is planned to keep the stocking number stable for the next years.

Even higher stocking densities of about 300 glass eel equivalents per hectare were reported by Leuner, 2007 from the river Main (Rhine RBD).

DE.F Catch per unit of effort

Data on catch per unit of effort are not reported. There is only one long-term series on (silver) eel catches available from a stownet fishery at Gorleben at the river Elbe. During the last years, the cpue data were rather constant and the mean value of the years 2002–2005 were only slightly lower than the mean value of the period) 1966–1980 (see last years report).

DE.G Scientific surveys of the stock

DE.G.1 Recruitment

In the last years, monitoring on immigration and upstream migration of young eels on some locations in Mecklenburg-Pomerania, Schleswig-Holstein and Brandenburg was initiated.

The monitoring stations were established in waters of the RBD's Oder, Warnow/Peene (both Baltic Sea) and Elbe (North Sea).

For a quantitative monitoring of immigrating elvers, eel ladders were installed by the Institute for Inland Fishery Potsdam-Sacrow at four locations, two of them in tributaries to the rivers Elbe and Oder, respectively. The distance of the two locations in the river Elbe from the North Sea coast was 255 km (Löcknitz eel ladder) and 311 km (Havel eel ladder and fykenet), respectively, although the locations in the river Oder were somewhat closer to the Baltic coast (Welse eel ladder 77 km, Finow fykenet 109 km). At all of these spots, upstream migration of elvers is interrupted by dams. Monitoring stations also exist in some smaller rivers (Tanger, Mulde and Jonitzer Mulde).

Based on quantitative catches with a large fykenet, which was installed directly in a fish pass, total numbers of elvers migrating into the river Havel were estimated as 70 000 individuals in 2005 and 43 000 in 2006 (Brämick *et al.*, 2007). Numbers in the river Oder RBD were by far lower (see last years report).

Results are also available from some rivers in Mecklenburg-Pomerania. The data indicate that the numbers of glass eels arriving are very low if compared to former data and that the numbers did not significantly differ during recent years (Lemcke, 2003; Schaarschmidt, 2005; Schaarschmidt *et al.*, 2007; Ubl *et al.*, 2007, Table 4). The mean lengths of the upstream migrating eels were in the range from 11.6 cm (Dove Elbe/Dömitz) to 25.6 cm (Farpener Bach/Alt Farpen; Ubl *et al.*, 2007).

Compared to data from former periods, the recruitment into the Mecklenburg-Pomeranian waters is on a very low level. At the Müritz-Elde-Wasserstraße, the recent catches are about 1.1% compared to the 1950s (Ubl *et al.*, 2007). Similarly, at the Warnow system, the catches are 2% of the catches in the 1950s and only about 0.04% of the 1930s. At the Wallensteingraben, the recent data represent 2% of the catches in the 1950s.

Glass eel and elver monitoring projects have also been initiated in the Kiel Channel (North Sea-Baltic Sea channel, S. Spratte, per. comm.). However, results are not yet available.

Table 4 Comparison of standardized catches of upstream migrating eels 2001–2006 in several rivers in Mecklenburg-Pomerania (number of eels per fishing gear between May and October; Ubl *et al.*, 2007).

Catchment	River	Station	Distance to coast	Gear/Relation	2001	2002	2003	2004	2005	2006	2007
Baltic Sea	Warnow	Bützow	53 km	per eel ladder	37	230	73	56	76	40	35
	Hellbach	Mühle	7 km	per eel ladder	not sampled	25	33	not sampled	not sampled	not sampled	Not sampled
	Wallenstein-graben	Wismar (Mühlenteich)	2 km	per eel ladder	not sampled	not sampled	not sampled	173	153	123	296
	Mühlengrube	Wismar (Ziegenmarkt)	0.1 km	per eel ladder	not sampled	not sampled	not sampled	not sampled	not sampled	17	19
	Uecker	Torgelow (Wehr)	52 km (Oder estuary) or 83 km (Peene estuary)	per eel ladder	not sampled	70	33	---	---	53	32
	Peezer Bach	Straßenbrücke	1.8 km	per eel collector	not sampled	not sampled	not sampled	not sampled	not sampled	---	---
	Plastbach (or Farpener Bach)	Alt Farpen (Stausee/Speicher)	4.8	per eel collector	not sampled	not sampled	not sampled	not sampled	not sampled	2.9	---
	Recknitz	Bad Sülze (Fischpass)	28 km	per eel collector	not sampled	not sampled	not sampled	not sampled	not sampled	---	---
North Sea	Müritz-Elde-Wasserstraße	Dömitz (Fischpass)	224 km	per fykenet	not sampled	5934	2365	3145	2861	3124	2440
				per eel collector	not sampled	not sampled	not sampled	not sampled	not sampled	9	---
	Dove Elbe	Dömitz (Wehr)	224 km	per eel ladder	not sampled	not sampled	1981	676	721	1035	890
				per eel collector	not sampled	not sampled	not sampled	not sampled	not sampled	11	---

DE.G.2 Yellow eel

In the last years, there were no yellow eel surveys in German marine coastal waters. At present it is tried to develop such a system in the coastal waters of the Baltic Sea (*Verein Fisch und Umwelt* for the Institute for Fishery of the LFA Mecklenburg-Pomerania). Basic principle will be the use of 30 eel fykenet chains per 1 ha. The system is in a test stage and no results have become available so far.

In the Kiel Channel, yellow eel monitoring will be conducted in four tributaries by electrofishing starting in 2008 (three times per year). Additionally, large fykenets and trawling catches will be used.

In the Elbe-Lübeck channel, yellow eel monitoring will be done by electrofishing and by the use of a special beach-seine. In both waters, re-stocked eels have been marked with *alicarin red*.

DE.G.3 Silver eel

Generally, there are no long-term data on silver eel stocks and escapement available.

Studies on silver eel escapement have been started at the rivers Elbe (and the tributary Havel) and Warnow. First results are available for the river Havel (Elbe RBD). Recapture rates for tagged eels were 0.1–0.2 % for fykenets. As expected, recapture rates were higher for stow nets with 11–15% in the upper Havel and 2.2% in the river Elbe (further downstream).Based on the results, preliminary estimates for the number of downstream migrating silver eels are 4000 individuals from the upper Havel, and about 300 000 individuals at the middle Elbe (Brämick *et al*., 2007).

A silver eel monitoring will also be started in the Kiel Channel by use of stow nets and comparable gears.

DE.H Catch composition by age and length

There is no information available on composition of commercial catches by age and length.

Germany has not sampled the landings/catches of eel. Due to the Data Collection Regulation which so far related only to marine landings/stocks, a country need not to sample a stock when the average of landings of the last three years is less than 100 t for a stock not under TAC regulation as it is for eel. For each division 4b, 3c and 3d, from where landings have been recorded the averages over the last three years were below 100.

However, the DCR now requires that data on eel fishery have to be sampled also in fresh waters. At present, the programme for 2009 is discussed. First data will be sampled in 2009 and results will become available in 2010.

DE.I Other biological sampling

DE.I.1 Length and weight and growth

Recently, some data on age and growth have been published from waters in Mecklenburg-Pomerania (Simon, 2007). The ageing of the fish was done by otoliths.

Table 5 Results of determination of age and growth of eels from waters in Mecklenburg-Pomerania (Simon, 2007).

Catchment	Water body	N	Age groups	Annual individual growth per year according length back calculation (cm)		
				Min	Mean	Max
North Sea	Müritz-Nationalpark	17	4 to 13	2.3	4.8	8.2
Baltic Sea/Inner coastal waters	Bodstedter Bodden	8	5 to 10	2.6	5.9	10.6
	Grabower Bodden	10	5 to 12	2.8	6.0	10.5
	Greifswalder Bodden	21	4+ to 6+	1.4	5.6	8.7
	Salzhaff	18	5 to 8	2.8	5.8	10.4
	Wieker Bodden	10	5 to 9	3.8	6.2	11.0
Baltic Sea/Outer coastal waters	Adlergrund	8	4+ to 9+	1.3	6.0	9.5
	Arkonasee / Arkonabecken	11	3+ to 12+	1.4	6.0	11.6
	Außenstrand Thiessow	9	4+ to 8+	1.4	5.5	8.6
	Außenstrand Usedom	10	6 to 10	2.9	5.2	9.5
	Künstliches Riff	18	4+ to 9+	1.0	5.4	9.5
	Ostmole Warnemünde	8	6+ to 8+	2.7	5.4	8.0

DE.I.2 Parasites

A monitoring for *Anguillicola crassus* has been established at the rivers Elbe and Weser and Ems (Table 6), which are all important rivers for eel. For this monitoring, commercial fisher collect eel swimbladders from commercial catches on a weekly basis. As a consequence, no data on length or weight of the fish are available.

Generally, the prevalence in eels from German waters appears to be between 50 and 90% (Knösche *et al.*, 2004; Lehmann *et al.*, 2005; Leuner, 2006, 2007; Lehmann *et al.*, 2007).

Lehman *et al.*, 2007 also reported the presence of *Trypanosoma granulosum* in more than 90% of all investigated eels from the Rhine system.

Table 6 Monitoring of infection of eels from the Rivers Weser, Elbe and Ems with *Anguillicola crassus*.

River	Year	N	Prevalence (%)	Abundance	Infection intensity
Weser	2000	982	88.1	7.6	8.7
	2001	969	85.4	5.7	6.6
	2002	916	87.9	5.3	6.0
	2003	957	81.5	4.1	5.1
	2006	980	90.7	5.5	6.1
Elbe	2000	373	83.4	5.3	6.3
	2001	135	88.9	4.7	5.3
	2002	259	87.7	5.7	6.5
	2003	275	86.2	4.3	4.9
	2006	358	89.1	4.4	4.9
	2007*	118	87.3	4.1	4.7

Ems	2000	384	73.7	4.5	6.1
	2002	240	69.2	3.0	4.3

*** preliminary results, not all samples analysed.**

DE.I.3 Contaminants

Concentrations of pollutants/contaminants in the musculature of eels from the river Elbe have been measured by the Elbe River Water Quality Board (ARGE ELBE) in 1999 and 2000 (e. g. ARGE ELBE 2000). Along the entire German length of the Elbe, contaminant levels were measured in excess of the maximum allowable levels. This was particularly evident for HCB (hexachlorobenzene) content. Occasionally, maximum levels were also exceeded for other contaminants, e.g. DDT. The most recent publication from the ARGE Elbe (ARGE ELBE 2008) provides data on concentrations of contaminants for eels from the river Elbe from a location close to the border to the Czech Republic in 2005 and 2006. Concentrations of mercury have remained rather constant (around 0.25 mg/kg wet weight), whereas the values for cadmium revealed a decreasing tendency (<0.008 mg/kg w. w.). Several PCB's had constant levels or a slightly decreasing tendency. Clearly decreasing values were observed for HCB (from 1.8 mg/kg Fat in 2001 to 0.56 mg/kg Fat in 2006). However, HCB-concentrations are still on a critical level.

The data are provided in detail to C. Belpaire and C. Geeraerts for the inclusion into the quality database. The reports from the Elbe River Water Quality Board are available at www.arge-elbe.de.

Concentrations of PCB's and dioxins were clearly below the maximum allowable levels in eels from the Baltic Sea (Bladt, 2007, cited in Karl, 2007). Mean values were 7.4 ng/kg w. w. for dioxin/dl-PCB.

DE.I.4 Predators

Mortality of eel as a consequence of predation by cormorants was estimated by Brämick and Fladung, 2006 for lakes and rivers in Brandenburg. According to the study, 109 t eel (1.4 kg/ha) were annually preyed upon by cormorants. For the period 1990–1999, a mean annual predation of 0.3 kg/ha had been estimated for the same region (Brämick *et al*., 2007). The increase in the most recent period may reflect the increasing numbers of cormorants.

In Bavaria, predation of cormorants on eel was estimated to 17.5 t (Leuner, 2007).

DE.I.5 Diseases

Compared to the last years report, no new data have become available on diseases of eels in German waters.

DE.J Other sampling

Genetic tests on about 3000 eels from Mecklenburg-Pomerania, Brandenburg and Saxony revealed the presence of about 2% *Anguilla rostrata* (Ubl and Frankowski, 2008). Most likely, these individuals had been stocked in the period 1998–2002. In studies on naturally immigrating glass eels and elvers, no individuals of the American eel had been found. To avoid such unintended introductions of alien species, genetic tests will be used in the future, at least in the course of re-stocking programmes.

DE.K Stock assessment

There is no regular stock assessment. Some studies have started on parameters of certain life stages (e.g. recruitment/immigration, silver eel escapement, mortality rates). Some of these results have been presented in other sections, and some results will become available in the course of the studies.

In the course of the preparation of the management plans, a stock model has been developed to describe the stocks and to estimate the escapement of sliver eels from the catchments. It is planned to publish the model in the scientific literature. In the future, the model has to be evaluated by monitoring of the stock and of escapement. If necessary, it will be improved by including new data.

DE.L Sampling intensity and precision

There is no consistent sampling design applied in Germany.

DE.M Standardisation and harmonization of methodology

DE.M.1 Survey techniques

DE.M.2 Sampling commercial catches

DE.M.3 Sampling

DE.M.4 Age analysis

DE.M.5 Life stages

DE.M.6 Sex determinations

DE.N Overview, conclusions and recommendations

The eel is an important species for the German fisheries sector, especially inland and coastal fishery. However, the importance of this sector itself is rather small.

After a clear decrease during the last decades, as a consequence of enormous efforts spent on re-stocking, the catches of eel by the German fisheries now appear to be on a rather stable (but lower) level.

The data basis is still relatively small but in the last years, several projects and studies have been started, which will improve the availability of data on important population parameters in the future.

In Germany, the relevant authorities and institutions work on the preparation of eel management plans according to the EU Council Regulation on eel management. This will also lead to an improved data basis. Furthermore, data collection on eel fisheries is now necessary also in fresh waters in the frame of the DCR. Therefore, starting with 2009 the amount of available and relevant information on eel and eel fishery in Germany will increase.

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Report on the eel stock and fishery in Poland 2008

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PL.B Introduction

PL.B.1 General overview of fisheries

Eel fisheries in Poland occur in lakes, rivers, coastal open waters and two brackish water basins namely Szczecin Lagoon and Vistula Lagoon, however, part of Szczecin Lagoon belongs to Germany and part of Vistula Lagoon belongs to Russia (Figure PL.1). Inland and coastal fisheries are targeted on silver eel and on yellow eel but no data on share of those forms in the catches are available. The total area of inland lakes, reservoirs (over 50 ha) is 2293 km$^{2.}$ In the main stream of Vistula and Odra Rivers and in supporting rivers many dams were constructed, which successfully stopped the upward migrations of eel, as well as other fish species.

Eel fisheries have a long tradition in Poland. Before WW II it was concentrated mainly in inland waters, because Poland had a very small piece of coast available for sea fishery at that time. After WW II, with gaining a broader access to the Baltic (over 500 km of coastal line), the Polish coastal eel fisheries has developed much more and achieved up to 388 tons per year although inland eel fisheries, which also increased substantially its number of lakes, reached up to 1500 tons per year. In the period of 1974–1994 inland catches constituted up to 75% of total yearly Polish catch of eel. Since then dropped very much, almost to the level of coastal catch and recently both fisheries achieve the level of 200–300 tons.

Until the late 1950s Polish eel fisheries based almost exclusively on natural recruitment, later on, extensive restocking mainly with glass eel was carried out in many lakes and both lagoons. This stocking decreased almost to zero in the late 1990s as a consequence of changes in the fishery management and high prices for glass eel. The lack of stockings resulted in very serious decrease of catch, mainly in inland fisheries.

The eel is a non-licensed species in Poland, both in coastal and inland fisheries. All eel fisheries is in private hands and, at the present, there are no organized fishing companies in the coastal fishing, however, in some river districts so called “cooperatives” operate and they are also fishing for eel. There are private fishery farms having also several lakes with eel but most of lakes have a separate owner. There is no solely eel stock and fisheries management in Poland, however, all eel management issues are within hands of the Ministry of Agriculture and Rural Development. Governmental control is limited only to a set of general rules: size limits, gear restrictions, closed seasons and areas. Special protection rules applies to eel fykenet fishing, in Szczecin Lagoon, Pomeranian Bay and Vistula Lagoon, where all fykenets have to be equipped with protection metal “sieves” in the end of bag to allow release of undersized eel. The three Regional Inspectorates of Fisheries, located in Szczecin, Slupsk and Gdynia, are responsible for management, monitoring and surveillance of fisheries at territorial level. In the coastal fisheries landings and effort are registered and reported on obligatory basis as monthly reports (boats up to 8 m) and in the EU-standard log-books (boats 8–10 meters, if they are fishing cod, otherwise only as a monthly reports) Boats over 10 m all have EU-logbooks. There is no obligatory reporting from fishery in lakes and rivers. Polish Anglers Association has some data available but it comes from voluntary reporting by PAA members only. The Inland Fisheries Institute in Olsztyn collects selected inland catch data based on its own sources (mainly questionnaires distributed among lake owners).

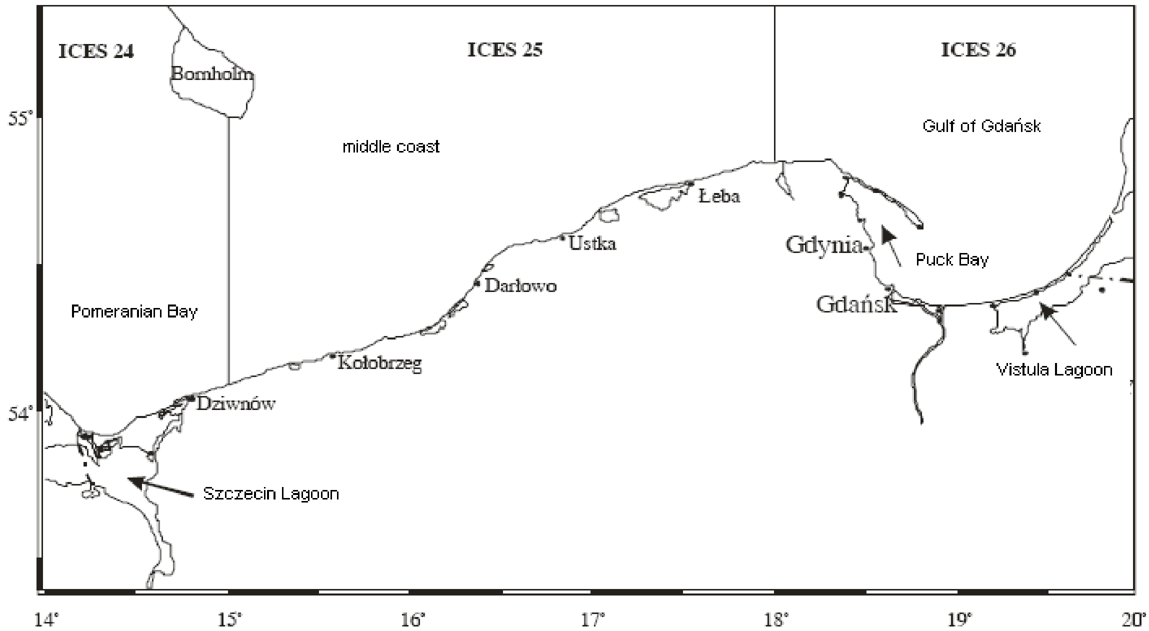

Figure PL.1 The Polish coastal area.

There are five main fishing areas along the Polish Baltic coast (also see Figure PL.1), from all of them landing statistics according to DCR are available since 1994:

1) Szczecin Lagoon; which is influenced first by waters of the Pomeranian Bay, where some fish migrate to feeding grounds then return with the back flow, and second by the waters of Odra River and Swina, Dziwna and Piana Rivers which connect it with the bay (Figure PL.2). Total area of lagoon is 911,8 km^2, of which 457 km^2 is under control of the Polish fishing administration, the rest is under Germany control. The lagoon comprises of several bays, islands, rivers and internal channels. Total exchange of water between the lagoon and bay occurs seven times a year. The lagoon is eutrophic and relatively shallow (mean depth 3,8 m) but along shipping lanes it reaches 11–12 m. In the Polish part of the lagoon approximately 200 fishers with 100 boats operating from 10 harbours reported eel catches in 2007. The main gear used for eel are different types of fykenets and hooks. The Polish highest catch was 447 t in 1967. In 1975–1990 the lagoon was restocked by Poland with an average of 2,5 tons of glass eel per year. The volume of catch is shown in Table PL.F.

Pomeranian Bay; is a broad open area of ca. 6000 km^2, which in part is situated within Polish EEZ (Figure PL.2). Its depth is up to 20 m and means depth is 13

m. The southwest part is under influence of fresh water of rivers: Odra, Piana and Swina. The boat fishing effort in the whole area was "frozen" to the level of 1996. Main gears for eel: hooks ,fykenets. In 2007 there were five boats from three fishing bases reporting eel catches from the area. The volume of catch is shown in Table PL.F.

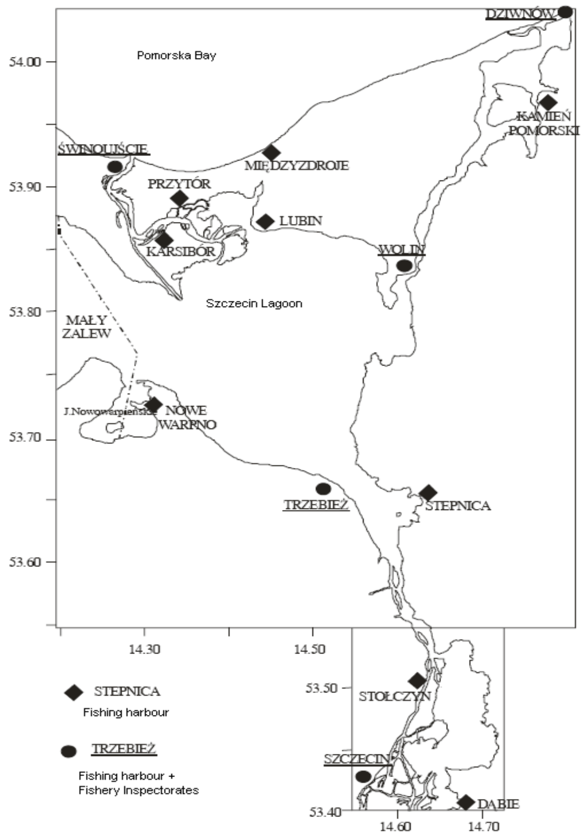

Figure PL.2 Fishing harbours in the Szczecin Lagoon and Pomeranian Bay. (Psuty, 2008).

Open coast (ICES Subarea 25): an open broad belt of coast from 15^0E to 18^0E, with fisheries operating up to 6 mile from the shore and up to depth of 20 m. There are several rivers discharging to the sea; some of them are connected with near-coastal lakes. The eel fishing there has minor importance and its catches dropped from 5 tons in 1954 (Trella, 2000) to 1 tonne recently (Table PL.F). There were eight fishing bases with nine boats reporting eel catches in 2007.

ICES Subarea 26: the Polish waters of Gulf of Gdańsk and some part of waters north of Hel Peninsula, from 18^0E to the Polish-Russian border (without Vistula Lagoon). Salinity ranges from 4–7‰ in the inner part of Puck Bay to 13–14‰ in open coasts. Coastal eel fishing is carried out mainly in shallow waters of Puck Bay and also in coasts on both sides of Vistula River mouth. This area has big tradition in fisheries and has 17 fishing bases with over 100 fishers and 64 boats reporting eel catch in 2006. Yearly eel catch was 118 tons in 1955 (Borowski, 2000) but in the last decade decreased to 9–16 tons (Table PL.F).

Vistula Lagoon-the largest estuarial coastal eutrophic reservoir in the southern Baltic and very important in coastal eel fishing. Total area is 915,5 km^2 out of this 328 km^2 is within Polish borders (Figure PL.3). Total length of the lagoon is 91 km, average width is 9,5 km and mean depth is 2,8 m. The salinity is

0,10‰–1,60‰ during summer and 2,90‰–4,70‰ during autumn. The water has very low transparency (30–90cm). The only one and narrow connection with Baltic Sea is in the Russian part. The highest eel catches of 350–500 tons yearly were recorded in 1926–1940 (Borowski, 2000) but in last decade it decreased from 108 tons in 1996 to 14 tons in 2006 (Table PL.F). There are ca. 90 fishers and 64 boats, reporting eel catches (2007), operating from eight harbours. Fishing gears: fykenets, hooks.

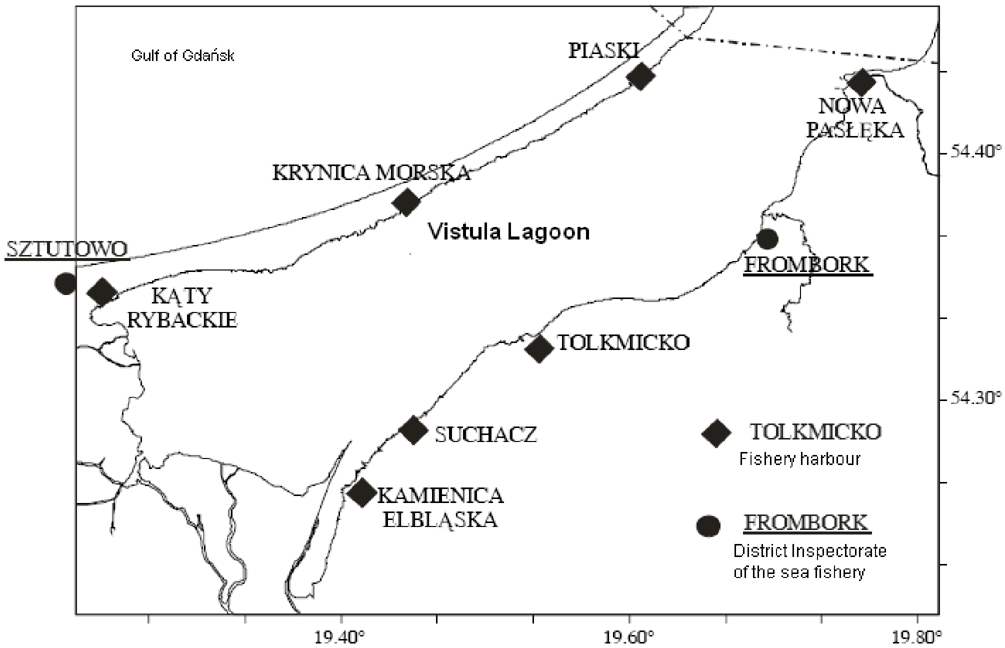

Figure PL.3 Fishing harbours in the Vistula Lagoon. (Psuty, 2008).

PL.B.2 River Basin Districts in Poland

Water Framework Directive separates two RBDs in Poland **(**Figure PL.4):

a) Odra RBD (ORBD) of total area within Polish borders 118 462 km², which includes:

- Odra drainage -118 861 km², out of this 106 057 km² is within Polish borders, 7217 km² within Czech and 5587 km² within Germany borders;
- Szczecin Lagoon of 12 100 km², out of this 2459,2 km² is within Polish borders and 9471,2 km² is within Germany borders;
- drainages of three Pomeranian rivers (Rega, Parseta,Wieprza) of total area 9029 km² , which are discharging to Baltic Sea;
- drainages of other international rivers, present in the Polish territory, of total area of 249,6 km², out of this 239,8 km² is Elbe drainage, 1,3 km² is Danube drainage and 8,5 km² is Ucker River drainage (flowing to Szczecin Lagoon).

b) Vistula RBD (VRBD) of total area within Polish borders 194 223 km², which includes:

- Vistula drainage of total area 199 813,0 km² , out of this 174 087,2 km² is within Polish borders and 25 725,8 km² is outside Polish borders;
- Drainages of Pomeranian rivers discharging to Baltic Sea, with total area of 5965,8 km² ;
- Vistula Lagoon of 915,5 km² with drainage of Pasleka River-2294 km²;
- drainages of other international rivers present in the Polish territory of total area 11 020 km² , out of this drainage of Pregola-7519,8 km², Niemen (Neumunas)-2511,6 km², Dniestr-233,2 km², Danube-381 km², and Swieza River-374,1 km

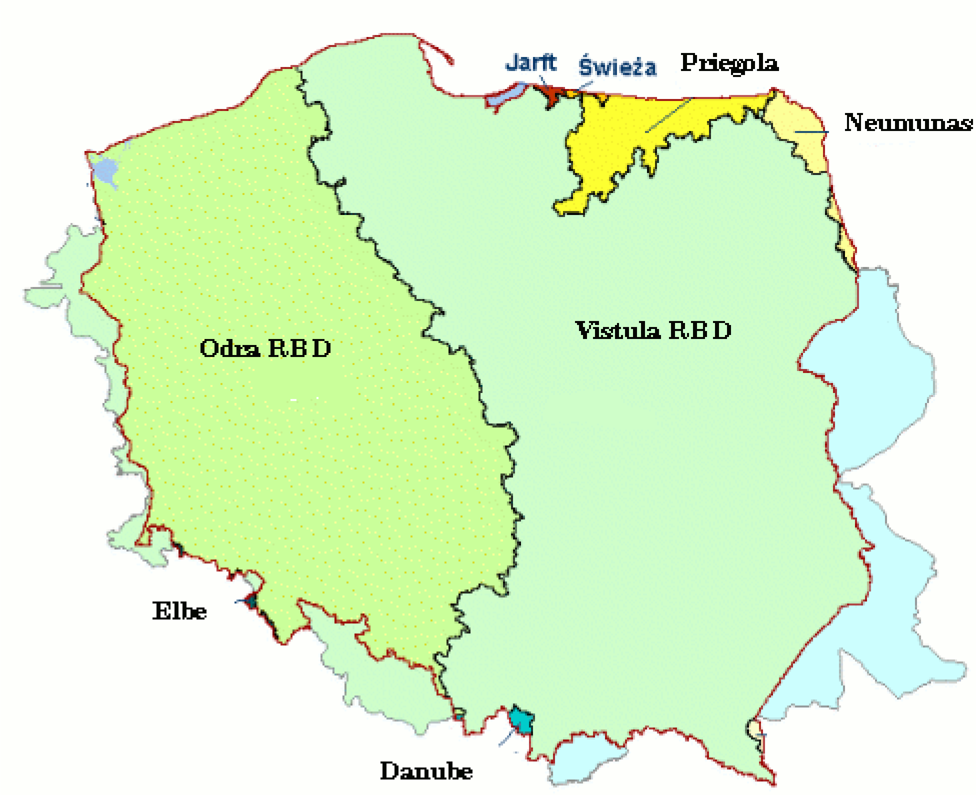

Figure PL.4 River Basin Districts within polish territory.

PL.C and D Fishing capacity and effort

There are no companies organized for coastal fishing eel and every boat owner catch fish on its own. Mean number of fishers and their boats involved in eel fishery from 1948 to 2007 in the lagoons is given in Tables PL.A.–PL.B. Those figures are derived from fisheries database of the District Inspectorates of Sea Fishery. Details on size of individual boats are readily available but nowadays there are no data on numbers of fishers involved.

Total number of boats in register is currently changing as a consequence of implementation of EU programme of reducing fishing capacity. The length of fishing boats ranges from 4 m to 11 m and their age is 6–16 years.

Table PL.A Mean number of fishers, boats and gears used in Vistula Lagoon in the period 1948–2007 (Psuty, 2008).

Years	No. of fishers	No. of boats			No of gears	
		Barkas	Oar boats	Motor boats	Fyke - nets	Hooks
1948–1959	354	34	224	78	8300	200 000
1960–1969	259	11	96	106	13 500	120 000
1970–1979	212	4	72	154	10 000	40 000
1980–1989	249	0	25	206	7200	
1990–1999	253	0	10	214	6000	
2001–2005	-	0	0	117	4500	
2007	-	0	0	64	3072	20 000

Table PL.B Mean number of fishers, boats and gears used in Szczecin lagoon in the period 1948–2007. (Psuty, 2008).

Years	No. Of fishers	No of boats		No of gears			
		Oar boats	Motor boats	Seines	Fyke nets	alhams	Hooks
1948–1959	380	150	170	24	2200	1000	
1960–1969	290	104	133	5	5960	2230	250 000
1970–1979	313	81	151	3	3770	690	190 000
1980–1989	244	61	133	0	3654	540	100 000
1990–1999	230	40	148	0	3520	330	93 000
2001–2005	-	15	135	0	3230	272	80 000
2007	-	-	109	0	2773	184	67 000

Before 1994 data on effort (no of gears and days) were recorded in old database. Since 1994 the number and type of gear used are recorded obligatory in the monthly reports and in the EU-standard logbooks, from where there are retrieved into database of the Ministry. However, the number of days the gears are used is not recorded. Table PL.C presents results of the investigations conducted by SFI of the real fishing effort in the Vistula lagoon.

Table PL.C Values of the fykenets fishing effort in the polish side of the Vistula Lagoon (Psuty, 2008).

Year	No. of boats (licences)	No of fykenets/days
2000	122	328 740
2001	123	290 880
2002	122	233 160
2003	120	160 350
2004	119	149 490
2005	95	125 820
2006	66	81 960
2007	64	73 290

Some provisional information exists on inland fishing effort. This data comes from questionnaires filled by waters owners. Table PL.D presents average proportion of gears used in each river basin district before and after 1985.

Table PL.D Percentage proportion of fishery gears used in inland waters in the relevant period. (Wołos *et al.*, 2008).

	FISHING GEARS					
Period	Fyke nets	Seines	River trapnets	Constant river traps	electro-fishing	longlines
	Vistula River Basin District					
<1985	36	33	19	5	3	4
>1985	44	23	18	3	1	11
	Odra River Basin District					
<1985	16	5	47	1	25	6
>1985	4	2	72	0	15	7
	Pomeranian lakes					
<1985	55	15	12	3	10	5
>1985	93	7	0	0	0	0
	Total area					
<1985	32	27	23	5	8	5
>1985	44	14	27	4	3	8

PL.E Catches and landings

PL.E.1 Restocking

Restocking with glass eel was conducted in Vistula Lagoon (VRBD) during 1970–1988 (mean 1400 kg/year) and in 1988–1994 (mean 167 kg/year) (Borowski, 2000). Restocking in Szczecin Lagoon was conducted in 1975–1991 with mean 1240 kg/year (Borowski *et a*l., 1999). From 2005 restocking re-continued with elvers with aquaculture origin (Netherlands, Germany, Denmark). Table PL.E presents yearly values of re-stocking conducted in the lagoons from 1970 to 2007.

Table PL.E.1 Re-stocking values in both lagoons in the period 1970–2007 (Psuty, 2008).

	Vistula Lagoon		Szczecin Lagoon				Stadium
	kg	ind.	kg	ind.	Mean lenght [cm]	Mean weight [g]	
1970	1630	4 890 000			6.0		
1971	800	2 400 000					
1972	1150	3 450 000			7.0		
1973	800	2 400 000					
1974	2140	6 420 000			10.5		
1975	1600	4 800 000	1000	3 000 000			
1976	1500	4 500 000	1445	4 335 000	6.6		Glass eels
1977	1500	4 500 000	1500	4 500 000	7.5		
1978	1760	5 280 000	1760	5 280 000	7.2	0.3	
1979	2590	7 770 000	2950	7 564 100	7.6	0.39	
1980	1050	3 150 000	3000	7 894 700	7.5	0.38	
1981	2030	6 090 000	675	1 569 700	7.9	0.43	
1982	1630	4 890 000	1690	4 225 000	7.6	0.4	
1983	800	242 000	1700	125 900	20.9	13.5	Elvers
1984	1150	3 450 000	2000	4 444 000	7.9	0.45	
1986	1880	5 640 000	3000	4 838 700	7.2	0.31	
1987	2000	6 000 000	1100	3 437 500	7.3	0.32	
1988	1000	3 000 000	1150	4 259 200	6.3	0.27	
1989	300	900 000					Glass eels
1990			1328	5 533 300	6.8	0.24	
1991	400	1 200 000					
1992	500	1 500 000					
1994	300	900 000					
2005	300	30 000					
2006	839	83 900	840	84 000			Elvers
2007	501	50 100	475	47 500			

Data on inland stocking is still incomplete. Values presented in Figures PL.5–PL.6 come from lakes owners and anglers' societies questionnaires. Due to high glass eel prices, nowadays the most popular material to stock is aquaculture elvers from Western farms (Netherlands, Germany, Denmark). Average stocking values at the beginning of the century fluctuated from 1 to 3 tons of elvers in the total area.

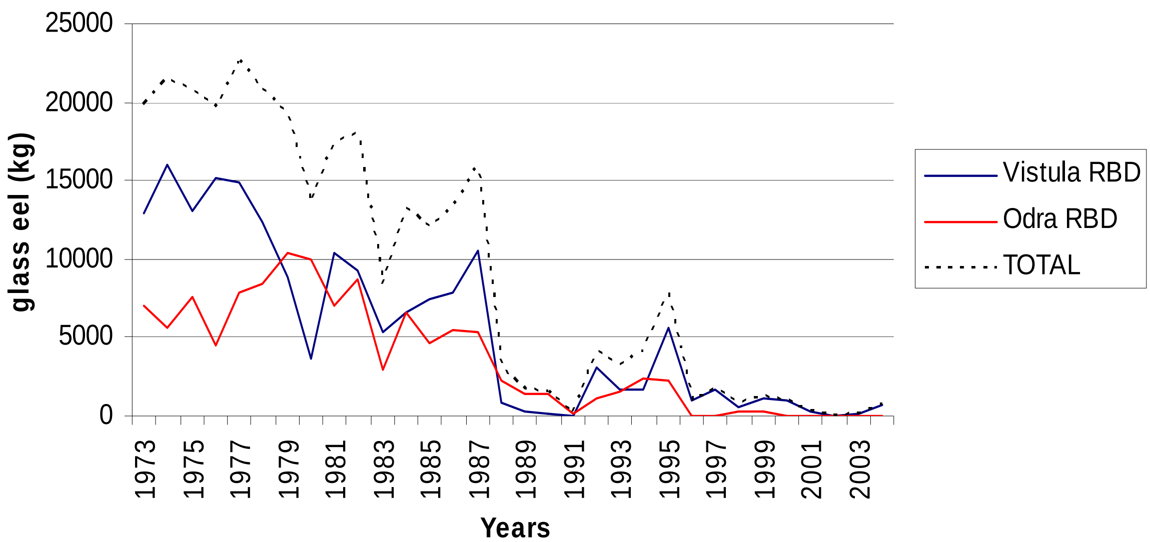

Figure PL.5 Re-stocking of glass eels conducted in inland waters in the period 1973–2004 (data source: Wołos *et al.*, 2008).

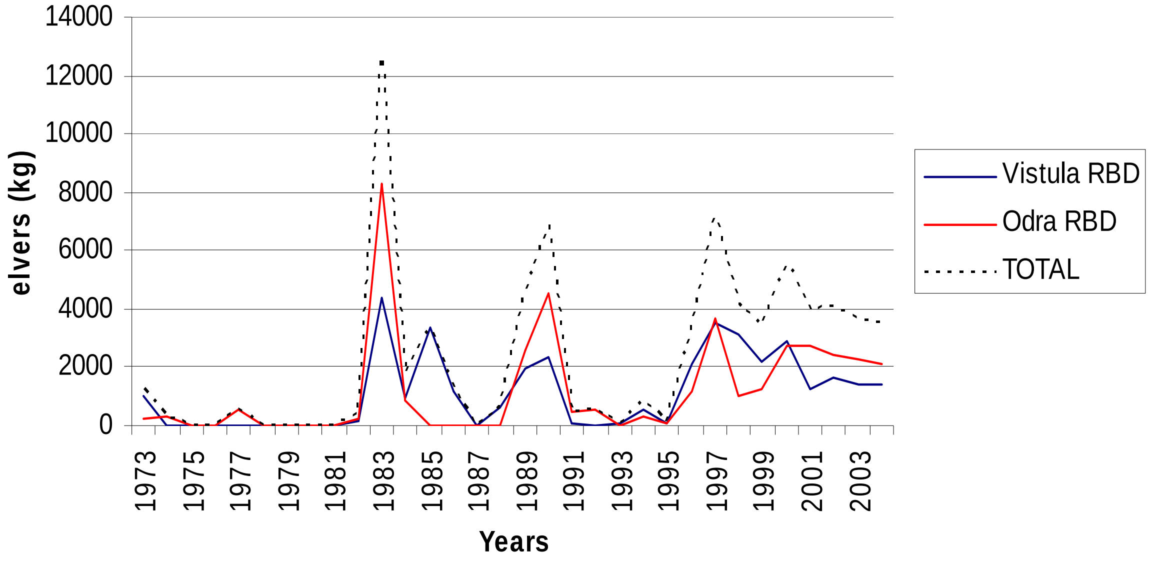

Figure PL.6 Re-stocking of elvers conducted in inland waters in the period 1973–2004 (data source: Wołos *et al.*)

PL.E.2 Catches of yellow and silver eel

Eel fishery in Poland applies mostly to the silver eel and occasionally to the yellow eel. Time series for the coastal eel in 1999–2007 are presented in Table PL.G. In the fishery documents the volume of catch equals to volume of landing. It means that total catch is practically the total landing. The magnitude of unreported catches is probably high, but is difficult to assess. No fishing auction system, except the first one in Ustka, takes place in Poland. The present database in the Ministry has still some errors, also as a consequence of misclassification of species. For inland waters, no obligatory registration of landings exists. The estimates of inland landings are based on other data sources, PAA questionnaires and lake owners' inquiries. Values presented in Figure PL.8.

Table PL.E.2 Polish Baltic coastal eel catch (kg) by area in 1999–2007.

VRBD	1999	2000	2001	2002	2003	2004	2005	2006	2007
East Coast (ICES 26)	16 751	16 290	12 729	14 656	15 213	14 367	14 500	10 900	8769
Vistula Lagoon	100 300	70 155	60 585	34 182	51 472	21 233	21 600	14 200	10 936
TOTAL	117 051	86 445	73 314	48 838	66 685	35 600	36 100	25 100	19 705
ORBD									
Middle Coast (ICES 25)	2855	1712	787	1916	1550	2562	2600	800	1030
Pomeranian Bay	9600	10 800	12 600	12 400	8752	2380	11 100	8900	843
Szczecin Lagoon	92 800	66 200	67 200	58 726	39 162	34 620	26 600	18 300	26 733
TOTAL	105 255	78 712	80 587	73 042	49 464	39 562	40 300	28 000	28 606
GRAND TOTAL	222 306	165 157	153 901	121 880	116 149	75 162	76 400	53 100	48 311

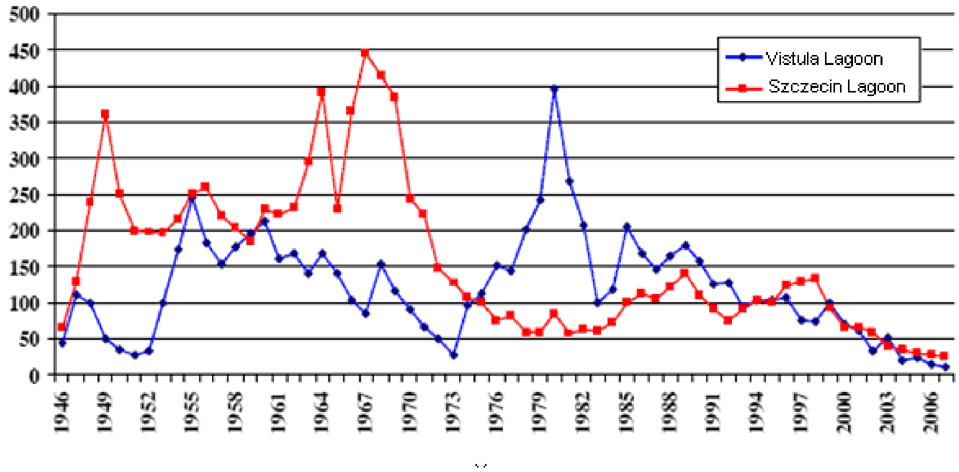

Figure PL.7 Landings of yellow and silver eels in both lagoons in the period 1946–2007 (Psuty, 2008).

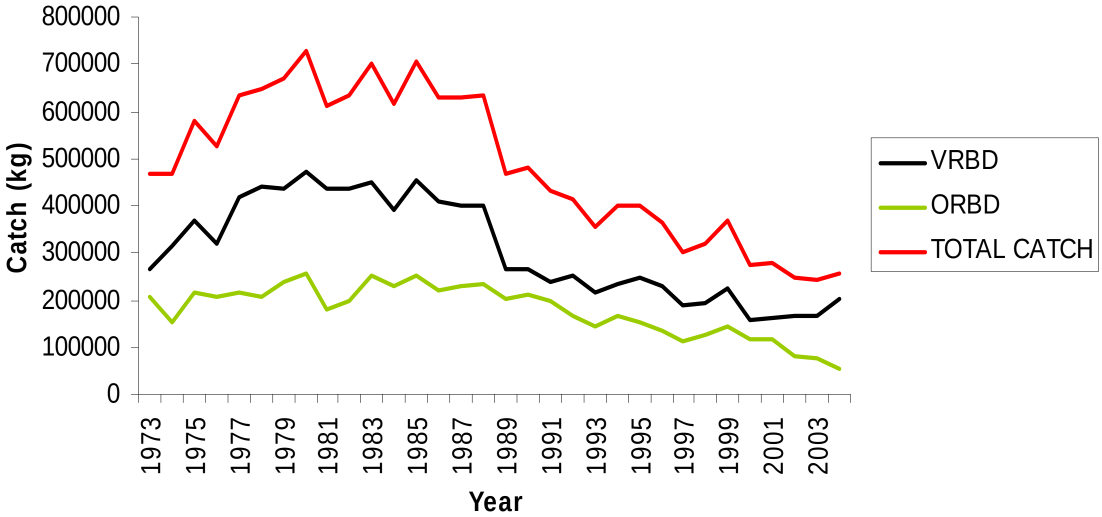

Figure PL.8 Polish eel landings in inland waters in the period 1973–2004 (Wołos *et al.*, 2008).

PL.F Catch per unit of effort

Evaluation of catch per unit of effort was done only for coastal waters. Figure PL.9 present cpue values reported in combined fykenet in the Vistula Lagoon. Negative trend is important and cpue is in the lowest level reported from 1995.

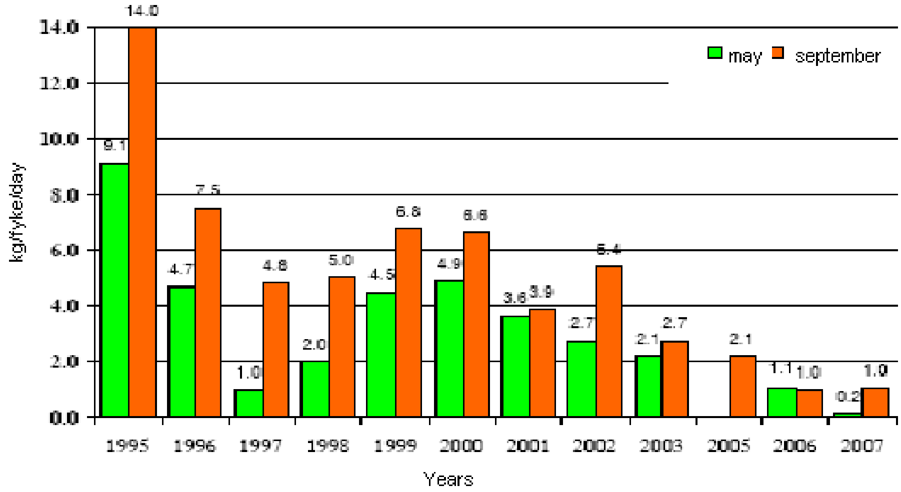

Figure PL.9 Cpue (kg/fykenet/day) values reported in monitoring station in the Vistula lagoon (Psuty, 2008).

PL.G Scientific surveys of the stock

PL.G.1 Results of surveys on ascending young eel into Pomeranian rivers

There are at least seven medium-sized rivers in the Pomeranian region, along the Polish coast, having their outlets open to the Baltic Sea, where glass eel could enter. First surveys on quantity and quality of young eel ascending to those rivers were made by German scientists in 1909–1911 to assess possibility of obtaining young eel for restocking. The results revealed some possibilities; however, it was found not sufficient and not economical comparing to cheap glass eel from the North Sea. After WW II in 1947 similar trials were made by Stankiewicz and later on in 1951, Kaj and Walczak conducted such trials in 16 places in Rega, Prośnica, Wieprza, Słupia and Łupawa rivers. The eel was collected with use of self-catching gears which were set in existing power stations or dams. No bypasses existed in those places. The results revealed that young eel was seen first in rivers on west than on east; moreover, in western rivers the presence of young eel was longer than in eastern rivers. Main flow of eel was noted on Rega River during first decade of May, in Prosnica river-in middle of May and in most eastern river-Słupia in first decade of June. This entire eel was uniform colored and weak pigmented. It was the eel, at first time achieving Polish coast during its voyage from the west. It was found that eel migration to Pomeranian rivers take place all the year-round with a peak in May–June and some eels are up to three years old. No presence of glass eel was found. The length ranged 70–200 mm and weight 0,35–10,7 g with modal length of 70–110 mm.

Data collected in 1998–2005 and 2007–2008 by Polish Angler's Union revealed that ascending young eel in Rega river in 1998–1999 was much smaller (weight 3,7–9,6 g) than in next years (weight 8,1–34,0 g), which can indicate on lack or very small amount of youngest stages.

In Łupawa river similar surveys was made in 1996–1997, 2002 and 2008 in first power station. Results were similar like in other rivers where mean weight of eel was lower in earlier years (8,5–11,6 g) than in last years (15,7–32,2 g).

Results of ascending eel into Pomeranian rivers in years 1951–2008 are presented in Table PL.G.

Table PL.G Results of fishing for ascending eel in Pomeranian rivers in 1951–2008.

River	Year	Month	No of fishing days	Total no of fish caught	Mean no of eel/day	Total weight (g)	Mean weight (g)
Rega	1998	July	4	939	235	6 005	6,4
		August	2	540	270	2 001	3,7
	1999	June	1	198	198	1 700	8,6
		July	3	2593	864	25 008	9,6
		August	2	353	177	2 600	7,4
	2000	June	2	1095	547	10 450	9,5
		July	1	370	370	3 005	8,1
		August	1	310	310	3 600	11,6
		September	1	280	280	3 500	12,5
	2001	June	1	244	244	7 016	28,8
		July	3	2030	677	40 780	20,1
		September	1	420	420	6 000	14,3
	2002	June	1	450	450	9 000	21,4
		July	2	678	339	10 800	15,9
		August	2	1600	800	28 300	17,8
	2003	June	1	480	480	8 000	16,7
		July	1	600	600	10 700	17,8
		August	1	n.d.	n.d.	700	n.d.
	2004	July	1	1135	1135	21 000	18,5
	2005	July	2	210	105	4 000	19,1
	2007	May-June	73	721	9,8	15 000	20,8
	2008	July	2	37	16	1 257	34
Grabowa	1951	May	1	36	36	36,9	1
Wieprza	1951	May	1	30	30	26,1	0,9
		August	1	25	25	26,5	1,1
Słupia	1951	July	1	50	50	75,6	1,5
	2008	July	5	8	1,6	96,2	12
	2008	August	14	28	2	335,8	12
Łupawa	1996	June-July	n.d.	108	n.d.	912,4	8,5
	1997	July–August	n.d.	1956	n.d.	22 651	11,6
	2002	August	n.d.	60	n.d.	634,4	10,6
	2008	July	9	17	1,9	266,1	15,7
	2008	August	1	2	2	64,4	32,2

PL.H Catch composition by age and length

For the Vistula Lagoon samples from commercial fykenets landings have been collected in the years 1969–1976 (Filuk and Olsza, 1978) and 1992–2001. For the Szczecin Lagoon sampling from fykenets was conducted in 1969–1970 and in some years during 1993–2000. After then no measurements were conducted. Samples from longlines catches were collected in the period 1999–2001. During 1996–1998 also length and weight measurements from fykenets in the Puck Bay (part of ICES area 26) were done.

For all eels in the samples length (up to 1 cm) and weight (up to 1–2 g) were determined. In 1969–1970 otoliths from Szczecin Lagoon eels were collected and age readings were carried out in the laboratory. Fish for sampling were acquired directly from fishers in fishing bases located in different parts of the coast.

All length-weight-age sampling was executed by the Sea Fisheries Institute in Gdynia. Having in mind that DCR specifies one sample of 100 eel per 20 tons of landings, the previous level of sampling was sufficient, even in some years much exceeding, for landings obtained. Results of catch composition findings were used in general management advice presented to the Ministry as a part of all-species sampling and fishery expertise.

There is no regular sampling for eel in inland waters; however, scientist of Inland Fishery Institute (IFI) in Olsztyn are collecting length and weight data from some lakes in the Pojezierze Mazurskie and Pomeranian lakes. Data were collected from 60 lakes. In 2007–2008 IFI collected some data for EMP needs:

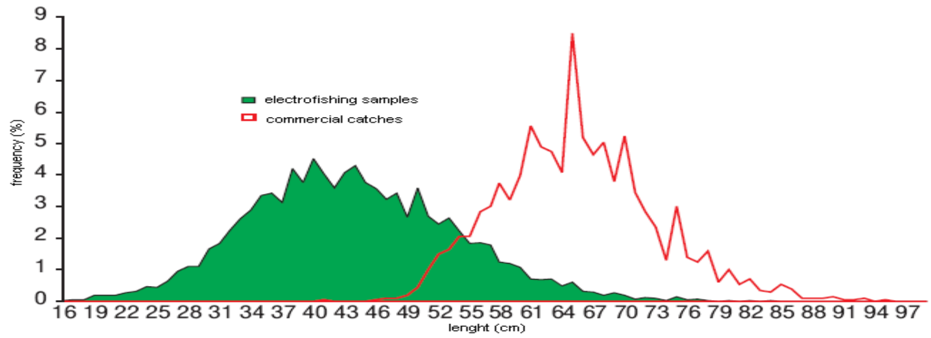

Figure PL.10 Length distribution of eels from inland waters. Data derived from both electrofishing and fishery landings. (Robak, 2008).

Length and age measurements of eel from commercial catches are yearly conducted by SFI on DCR basis. All stages are included:

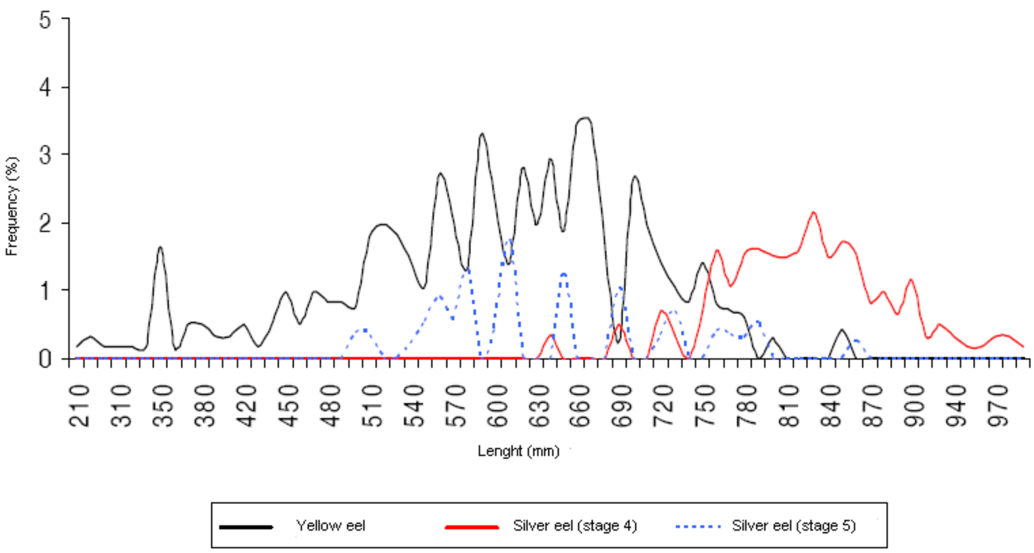

Figure PL.11 Length distribution of yellow and silver eels from the Vistula Lagoon.

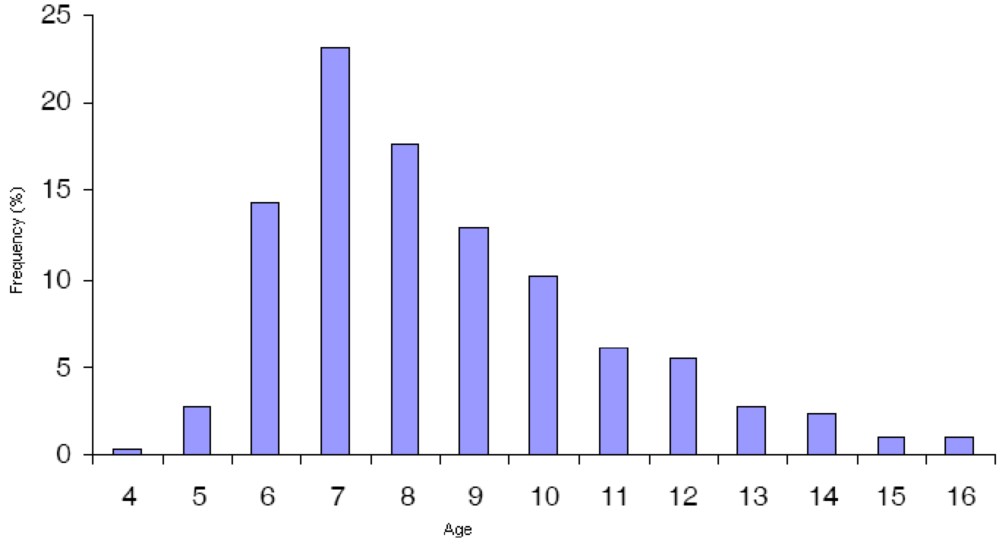

Figure PL.12 Age distribution of yellow and silver eels from the Vistula Lagoon.

PL.I Other biological sampling

PL.I.1 Length and weight and growth (DCR)

Beside length, weight and age measurements requested by DCR regulation, stage determination was done (silvering index).

PL.I.2 Quality of eels

In 2008 research on several factors influencing quality of eel was made in Certified Laboratory of the Sea Fisheries Institute in Gdynia (Usydus Z., Szlinder-Richert J., 2008.)

Samples of eel were collected during autumn 2007 and spring 2008 in Vistula Lagoon and Szczecin Lagoon. Number and size of fish collected are in Table PL.I.

Table PL.I Samples of eel collected in 2007 and 2008 for quality of eel examinations.

Code of sample	Year	Month	Place of catch	Length range [cm]
WTN/1/08	2007	X	Vistula Lagoon	46–59
WTN/2/08	2007	X	Vistula Lagoon	76–86
WTN/3/08	2008	IV	Vistula Lagoon	50–60
WTN/4/08	2008	IV	Vistula Lagoon	67–74
WTN/5/08	2008	IV	Vistula Lagoon	74–89
WTN/6/08	2008	IV	Szczecin Lagoon	54–64
WTN/7/08	2008	IV	Szczecin Lagoon	71–83

In the laboratory chemical examinations were made on:

- fat contents,
- dioxins, furans and dl-PCBs
- heavy metals: Cd, Pb, As, Cr, Ni, Hg.

Results of heavy metals and PCDD/F and dl-PCBs were compared to maximum allowable values obligatory in UE and described in Regulation (EC) 18881/2006 and assessed to classes described by Belpaire and Goemans, 2007. The results were also compared to maximal values given in FAO Fisheries Circular No 825 (1989).

Resulting data of those all examinations were supplied to ICES WGEEL database.

Fat contents

Values of fat contents ranged from 15,1% to 31,4% with mean 15,1% ±5,46. There was observed slight tendency to increase fat contents with increase of eel length.

Heavy metals contents

It was found that presence of all heavy metals, of which contents in the food is limited in UE countries, was much lower in eel tissue comparing to allowed levels given in EU regulations.

The maximum contents of those metals in eel ranged from 2% (Cd) to 22,5% (Hg) of allowed values. In case of Ca, Pb and Cr all samples were classified as Class I, according to as Class II, and according to Ni and Hg as Class I or II.

PCBs contents

It was found that according to majority of indicative congeners, all samples were of class I or class II. According to sum of six indicative PCBs six of seven samples were qualified as class I. Comparing results to very restrictive German regulations it was found that in none of samples allowed limits were not achieved.

Results of eel samples were also compared to samples from herring, sprat, flounder, cod and salmon. Sum of seven indicative PCBs expressed as μg/kg of tissue in case of eel was comparable to those of salmon and higher in case of rest of species.

Chloroorganic pesticides

For HCB four of seven samples were classified as class I and 3 others as class II. In case of ∑DDT 4 samples were classified as class I, two as class II and one as class IV. None of samples exceeded limits of ∑DDT 4 and HCB given in FAO Fisheries Circular No 825 (1989).

Dioxin-like –PCBs

In all samples the dominating congener among non-*orto* PCBs was congener penta-PCB 126, which revealed highest toxicity in that group, and dominating congener among mono-*orto* PCBs was congener 118.

Dioxin/furans (PCDD/Fs)

In most of samples concentration of PCDF was twofold higher than PCDD concentration, except sample no WTN1, where both concentrations were similar. In none of samples was found exceeding of limits PCDD/F nor sum of PCDD/F and dl-PCBs.

In all samples highest share of total toxicity constituted non-*orto* PCBs and that share was of 40–50% depending on sample.

Parasites occurrence

The most recent data on occurrence of parasite *Anguillicola crassus* in eel of Polish waters was collected in 2007–2008, however, some earlier data are also presented.

Data were collected and calculated according to three categories:

- Prevalence-proportion between infested eel and number of eel in sample,
- Mean intensity of infection-mean number of parasites per one infected eel,
- Density-mean number of parasites per one eel in sample.

The range of prevalence varied from 0,0 in Szczecin Lagoon in 1971 to 100,0 in Lake Łebsko (2001, 2004).

Intensity of infection varied from 0,0 in Szczecin Lagoon in 1971 to 14,6 in Lake Łebsko (2007).

The density varied between 0,0 in Szczecin Lagoon (1971) to 9,4 in Lake Jamno (2007).

In 2007–2008 total of 168 samples of eel were collected from 15 places of rivers, lakes and lagoons in both RBD's, namely Vistula and Odra. Those samples were examined on presence of viruses EVEX, AgHV-1, VHS, IHN, SVC and IPN. All examinations were made in Department of Pathology and Immunology of Inland Fisheries Institute in Olsztyn.

In none of samples was found presence of above pathogen viruses.

PL.I.3 Predators

There are studies being carried out on the black cormorant pressure on the coastal and inland waters ichthyofauna. Eel contributed from 1,9% to 2,4% in weight of cormorants food from Gulf of Gdańsk in 1998 and 1999 respectively (Bzoma, 2004). In most cases one or two eels on average weight 300 g and length 56 cm were found in eel food. Total amount of eel eaten from Vistula Lagoon is estimated for 52 tons/year on average, during 1998–2000. Nowadays as a consequence of low density, eel is rarely found in cormorants pellets. In 2007 and 2008 in the largest polish breeding colony in Kąty Rybackie only four eels vs. 23 000 other species were found in pellets. It means that total consumption fluctuate about 1 tonne of eels yearly in the Vistula Lagoon.

PL.K Stock assessment

Landing statistics and effort data are reported to the Ministry of Agriculture through Inspectorates of Fisheries. Data on length-and-age sampling are presented every year to the Ministry and fisheries authorities in the form of research reports of the Sea Fisheries Institute.

The other data collected although doing the research is being used for cognitive aims as well as for planning and prognosis actions connected with running a rational fisheries management.

Recommendations on minimum size, effort reduction, closed periods and areas for eel in the Vistula Lagoon were presented by Borowski, 2000. In the 1997 calculations of the von Bertalanffy growth equation parameters were based on a complete set of tag recoveries, as well as on recoveries from particular tagging experiments and the biomass of the eel population of the Vistula Lagoon was estimated based on the catch curve (Borowski *et al.*, 1997).

Nowadays stock assessment is still in calculations as a consequence of new requirements from EMP.

PL.M Standardisation and harmonization of methodology

PL.M.1 Sampling commercial catches

In the coastal waters in 2007 samples were collected mainly from landings in three fishery harbours. Total length was measured with accuracy of 1 cm and weight of 1 g. All samples were taken to SFI laboratory.

PL.M.2 Age analysis

Age analysis is conducted in SFI laboratory. Age is calculated based on number of growth interval rings, which are visible as dark rings, clearly differing from light protein matrix, on the surface of otolith. (Moriarty, 1983; Campana, 1992; Campana and Jones, 1992; Lecomte-Finiger, 1992; Tzeng *et.al.*, 1994). Two methods of preparation are used. More common: broken and burnt, and less common: sectioned and stained. Thin sections are cut using a high-speed "Acutom-50" saw with a diamond blade.

PL.M.3 Life stages

Life stage is determined using a method described in "EELREP" final report. The silver index is based on the following external body measurements: total body length (L), bodyweight (W), pectoral fin length (FL), and mean eye diameter (MD) which is calculated according to: MD= (vertical eye diameter + horizontal eye diameter)/2.

PL.M.4 Sex determinations

The sex of eel is defined macroscopic according to established schema of ovary and core building.

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Report on the eel stock and fishery in Denmark 2008

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DK.B.Eel and eel fisheries

The eel is present all along the 7500 km Danish coastline, except on the open North Sea coast in Jutland. In inland waters eels may be found naturally or stocked in ponds, lakes and streams. The fishery is concentrated in the southern and eastern parts of Denmark here the silver eel is exploited during the spawning migration while passing through the Danish straits heading to the North Sea. These fisheries catch the migrating eel by poundnets out to the 10+ meter depth line. Throughout the country, in shallow Fjords, Bays, Lagoons and Inland waters, a combined yellow and silver eel fishery takes place. Most of the catch ca. 97% is reported from saline areas suggesting that catches in fresh water are smaller and more fragmented recreational fisheries.

Current management of the eel stock aims to secure local yield and by a set of general and local rules regarding minimum legal size, mesh size, etc. The fresh-water legislation ensures free movement of local stock by enforcing eel passes at migration barriers. No licences are given explicit to eel fishing but professional fisher has a licence to fish. Catch data are reported to the directorate of fisheries by the trade and processing companies. Three different groups exploit the eel. These are: 1) Professional fisher with a licence; either fulltime or part time fishers. 2) Recreational fishers with a licence and 3) land owners without a licence. Only catches from the professional fishers are known. In this report, where possible, data are separated in River Basin Districts.

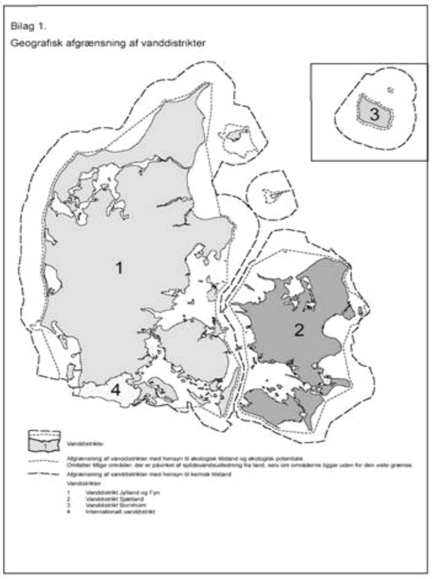


Figure DK.B. River Basin Districts in Denmark defined by the Water Framework Directive.

DK.C. Fishing capacity

The available figure of capacity is the number of boats that have landed eel. At present about 500 boats (Table DK.C) are operating in marine areas. The number of professional fishers in inland waters is very limited less than five boats are registered.

Table DK.C. Number of fishing boats that have landed eel in fresh and salt water. (Source: Directorate of fisheries).

YEAR	NO OF EEL FISHING BOATS	
	Marine	Fresh
2001	604	-
2002	590	-
2003	578	5
2004	562	3
2005	503	3
2006	507	4
2007		

DK.D. Fishing effort

The Pound net fishery is concentrated in the southern and eastern parts of Denmark (BRD 2). The number and position of poundnets are in some areas known but again in others no exact figure is available. The number of poundnets registered in year 2004 was 2124, however this figure is probably not all active gear (Pers. com. Lasse Aufeldt) a more realistic figure is <1000 poundnet. The number of larger fykenet (Pole fykenet) used by recreational fishers is shown in Table DK.E. Eels are also caught by longlines and bottom trawl but no record is available.

In fresh water landowners/stakeholders have an ancient privilege to operate eel traps fixed at the outlet of a lake or mill pond. Currently there are 87 of these eel traps.

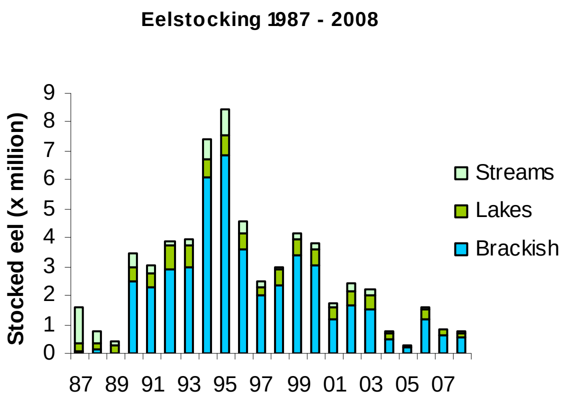
DK.E. Catches and landings

DK. E.1 Catch of glass eel

Catch of glass eel in Denmark took place between 1971 and 1990 at Vidaa and Ballum sluices in the Wadden Sea. There has been no glass eel fishery since 1990.

DK.E.2 Restocking

Restocking has taken place for many decades, by landowners in inland waters where recruitment of young eel, was limited or absent, because of distance to the ocean or migration barriers. From mid 1960s to the end of the 1980s a number of licenses were given to sell young eels for restocking. These eels were captured at pass traps and glass eels at the sluices in the Wadden Sea. This is now forbidden as a consequence of the low recruitment. Since 1988 a restocking programme has been financed by the Danish government and the eel fishers. From 1994 the restocking programme has been financed solely by the recreational license fee. The eels stocked today are imported, as glass eels mostly from France. They are grown to a weight of 2–5 grammes in heated culture before they are stocked. The amount stocked has been decreasing during the last years because the price for stocked eel increased dramatically in the same period. Figure DK.E.2.



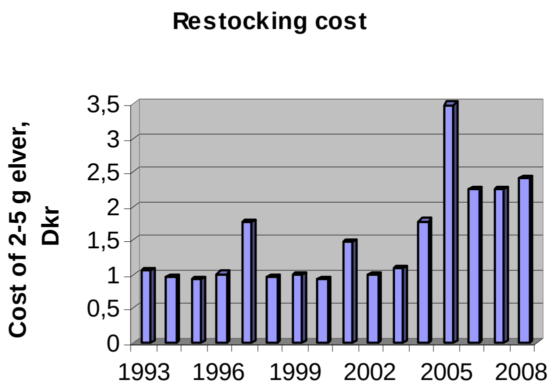


Figure and Table DK.E.2. Restocking of elvers (2–5g) in marine and fresh waters from 1987–2008. Numbers stocked in (millions) and cost per stocked eel.

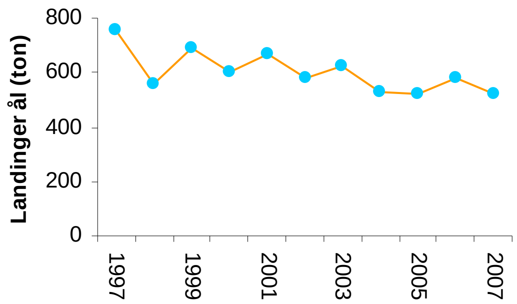
Year	Marine	Lake	River	Total	Year	Marine	Lake	River	Total
1987	0.07	0.26	1.26	1.58	1998	2.35	0.53	0.1	2.98
1988	0.11	0.24	0.4	0.75	1999	3.38	0.56	0.18	4.12
1989	0	0.24	0.17	0.42	2000	3.02	0.55	0.25	3.83
1990	2.46	0.49	0.51	3.47	2001	1.2	0.38	0.12	1.7
1991	2.3	0.44	0.32	3.06	2002	1.66	0.47	0.3	2.43
1992	2.94	0.81	0.11	3.86	2003	1.54	0.49	0.22	2.24
1993	2.97	0.76	0.23	3.96	2004	0.52	0.18	0.06	0.75
1994	6.12	0.61	0.67	7.4	2005	0.24	0.06	0	0.3
1995	6.83	0.72	0.9	8.44	2006	1.15	0.35	0.1	1.6
1996	3.58	0.58	0.44	4.6	2007	0.59	0.21	0.02	0.83

1997	2.02	0.29	0.22	2.53	2008	0.52	0.19	0.04	0.75

DK.E.3. Catch of yellow and silver eel in marine and salt water

Marine and fresh-water catches

The annual catches of yellow and silver eels during the last decade have been fairly constant (Table DK.E). There is a trend that relatively more silver than yellow are being captured, suggesting yellow eels are less exploited now a days.

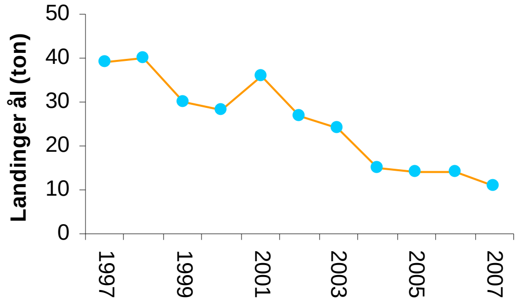


År	Silver	Yellow	Total
1997	375	383	758
1998	306	251	557
1999	380	307	687
2000	382	218	600
2001	446	225	671
2002	365	217	582
2003	437	188	625
2004	343	187	531
2005	372	149	520
2006	427	154	581
2007	411	115	526

Figure and Table DK.E.3. Annual catch in (tonne) separated into yellow and silver eel during the last decade 1997–2006 (Source: Fisheries Directorate).

Freshwater catches

The annual catches in fresh water have been decreasing relatively more than marine catches during the last 10 years. The fresh-water catch is 2–3 % of the marine catch.



Year	Silver	Yellow	Total
1997	-	-	39
1998	-	-	40
1999	-	-	30
2000	4	24	28
2001	2	34	36
2002	5	27	27
2003	2	21	24
2004	4	12	15
2005	3	10	14
2006	7	8	14
2007	5	6	11

Figure and Table DK.E.4. Catch of yellow and silver eel in fresh water (Source: Fisheries Directorate and DFU).

DK.E.4 Aquaculture

Aquaculture production in Denmark started in 1984. The production takes place at indoor, heated aquaculture systems. Annual production is ca. 2000 tonne.

Table DK.E.4. Aquaculture production (1984–2007). (source: C. Graver).

Year	Production units	Production [tonne]	Year	Production units	Production [tonne]
1984	??	18	1996	28	1568
1985	30	40	1997	30	1913
1986	30	200	1998	28	2483
1987	30	240	1999	27	2718
1988	32	195	2000	25	2674
1989	40	430	2001	17	2000
1990	47	586	2002	16	1880
1991	43	866	2003	13	2050
1992	41	748	2004	9	1500
1993	35	782	2005	9	1700
1994	30	1034	2006	9	1900
1995	29	1324	2007	9	1900

DK.E.5. Recreational fishers

The number of licences sold to recreational fishers was 33 615 in 2005 and has been quite stable for the last seven years (www.fd.dk). The recreational fishers are not allowed to sell their catch and the catch is not recorded. The number of gear allowed to fish with, is one large fyke (Pole fyke) and five small summer fykes! A questionnaire among the recreational fishers in 1997 demonstrated that 56% of all recreational fishers catch eels. Based on the information given in the questionnaire it was estimated that in 1997 they caught 200 tonnes, equivalent to 26% of the official catch. Assuming this relation to total landing hold, each licence landed 7 kg (50–70 eel) in 2004 equivalent to a recreational catch of 138 tonnes.

Table DK.E.5. Estimated number of recreational eel fishers, estimated catch, and number of gear registered in the directorate of fisheries in the year 2004.

River Basin District	Recreational eel fishers, estimated, no	Catch, kg	Pole-fyke (Pæleruse)
1	11 181	82 249	448
2	7260	53 406	264
3	327	2406	0
4	-	-	-
Total	18 768	138 060	712

DK.F. Catch per unit of effort in commercial landings

There are no official cpue-data available. The only records available are from the fishers. These records are available because the fishers count the number of eels caught by each poundnet. There has been no attempt to collect cpue data from the fishers. Below is data from one fisher (N.E. Jensen) who has been fishing on the same spot and same depth for many years in Fakse Bugt (Øresund, RDB no. 2). These data demonstrate that cpue has been increasing during the last two decades. We speculate if this may be interpreted as a result of decreasing number of poundnets on the migration route and thus fewer eels caught (decrease in fishing mortality) on the way out of the Baltic and in the Danish Sound.

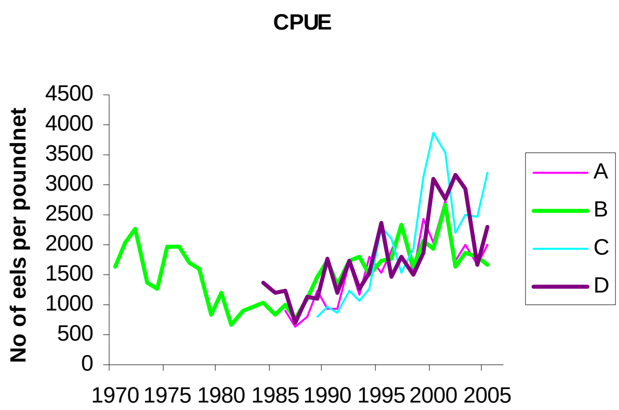


Figure DK.F. Annual catches (in number) of silver eels per poundnet (A.D) in Faxe Bugt, RDB 2 (55⁰, 10′;12⁰ 8′). All the eels are females with an average weight per eel of ca. 800 gramme (Pers. com. N.E. Jensen) Fishing depth of poundnet A and C = 5,3 meter; B and D = 8 meter.

DK.G. Scientific surveys of the stock

DK.G.1 Recruitment surveys of glass eel and ascending yellow eel

The recruitment of young eels to Danish fresh water is currently monitored in pass traps at Harte hydropower stations in river Kolding Å and at Tange hydropower station in river Guden Å. Both rivers empty into Kattegat on the east coast of Jutland. On the west coast of Jutland no passive trapping facilities are available. Here the recruitment is monitored by annual population surveys (electro fishing four sections 2–4 times a year) in a brook by the Wadden Sea. The method used is sampling by during the year Vester Vedsted brook). Further details in Pedersen, 2002.

Table DK.G: Recruitment monitoring of young eel at pass traps and electrofishing.

Year	Tange	Harte	Vester Vedsted brook Density eel/m2		Year	Tange	Harte	Vester Vedsted brook Density eel/m2	
	Kg	Kg	Mean	Max (season)		Kg	Kg	Mean	Max (season)
1967		500			1988	252	253	-	-
1968		200			1989	354	145	-	-
1969		175			1990	367	101	-	-
1970		235			1991	434	44	-	-
1971		59			1992	53	40	-	-
1973		117			1993	93	26	-	-
1974		212			1994	312	35	-	-
1975		325			1995	83	23	2,6	2,6
1976		91			1996	56	6	4,6	6,8
1977		386			1997	390	9	0,7	1
1978		334			1998	29	18	0,3	0,4
1979		291	2,8	6,5	1999	346	15	0,4	0,5
1980	93	522	7	13	2000	88	18	0,6	0,7
1981	187	279	7,8	13	2001	239	11	0,6	0,8
1982	257	239	-	-	2002	278	17	0,5	0,6
1983	146	164	-	-	2003	260	9	0,6	0,7
1984	84	172	-	-	2004	246	9	0,3	0,4
1985	315	446	-	-	2005	88	7	0,5	0,5
1986	676	260	-	-	2006	123	7	0,3	0,7
1987	145	105	-	-	2007	62	7	0.4	0.5

DK.G.2 Stock surveys, yellow eel

All Danish streams are electrofished every seventh year in BRD (1,2,3,4) to determine trout stocks and the need for restocking trout. During this evaluation all fish species are recorded and the number of eels observed during the survey is included in the final report. The information on eel is semi quantitative or just qualitative. These data seem to be of little value!

DK.G.3 Silver eel

In the small Roskilde Fjord (BRD 2) a catch and recapture survey with tagged silver eel has taken place during autumn 1998, 2001–2004. The silver eels are tagged with Carlin tags and released in the inner parts of the fjord. On reported recapture, a fee per tag is given to the fisher. The F-values are minimum values but reflecting a high level of fishery mortality on silver eels in this area.

Table DK.G.3 Catch-recapture experiment with Carlin tagged silver eel during 1998, 2001–2004.

Date of release	Stage	Tagged no	Recaptured no	F %
30.09.1998	Silver	500	189	37,8
09.08.2001	Half silver	300	25	8,3
07.10.2002	Silver	400	68	17,0
19.09.2003	Silver	500	159	31,8
20.09.2004	Silver	500	135	27,0

DK.H. Catch composition by age and length

Only a few sporadic datasets of old age are available.

DK.I Other biological sampling

DK I.3 Parasites

Anguillicola

The swimbladder worm *Anguillicola crassus* introduced to Europe from the far east at the beginning of the 1980s was discovered in Danish wild eels in 1986. Since 1988 a monitoring programme on the abundance of the *anguillicola,* in the eel population in different fresh and brackish water bodies has been continued annually. Data from 2006 in Table DK.I.1.

Table DK.I.1 Analyses of *anguillicola* 2006.

Location	ppt	Coordinates	Year	Total	Infected	Prevalence	Intensity			Abundance
				N	n	%	Mean	Stdv	Max	
Arresø	0	55,59N;11,57E	2006	107	61	57,0	3,4	3,1	14	2,3
Isefjord	18	55,50N:11,50E	2006	101	30	29,7	3,1	3,1	11	0,9
Ringk. Fj.	5–10	55,55N:08,20E	2006	60	38	63,3	6,3	5,2	24	4,0

DK.I.4. Contaminants

There are few surveys and mostly of older date. Recent data for PFAS and organotin-compounds in the aquatic environment extracted from report by Strand *et al*., 2007 and unpublished data from Århus Amt, 2003 see Appendix. A.

DK.I.5 Predators

Cormorants

The number of Cormorants is estimated throughout the country every year by the Ministry of Environment. Cormorant's predation on flatfish, trout, salmon (smolt) and eels have been studied using various tagging methods e.g. floy tags, coded wire tags and radio tags in Ringkøbing Fjord (BRD 1; 55,55'N:08,20'E). In a study of cormorant predation eel 10 163 eels (10 grammes) were coded wire tagged and released in Ringkøbing Fjord in 2003. In the same year 5734 regurgitate were analysed and 21 coded wire tags were found. From these data it was estimated that 43% of the tagged eels were eaten by the cormorants. However, the cormorant do not eat many eels as the frequency of occurrence of otolliths found in regurgitate in 2005 was only 0,12% (Sonnesen, 2007) suggesting that eels are not important as food in Rinkøbing Fjord.

Recent work from Hirsholmene (57,29'N;10.37'E) a cormorant colony in Kattegat suggested that of 350 regurgitate eel otoholiths occurred with a frequency of 0,3% (Poul Hald, 2007).

DK. N. Summary of the report

The fishing capacity about boats landing eel have been reduced from ca. 600 boats to ca. 500 boats during the last five years. No exact data for the current effort are available but the effort in poundnets in use has without been markedly reduced. The marine fishers claim that cpue have not changed negatively over several years and an example of increase in cpue is provided. During the last 10 years the total catches in the marine areas have been fairly constant ca. 500–600 tonne. In fresh water reported catch has decreased from ca. 40 tonne to ca. 15 tonne during the last 10 years. Restocking costs have increased by 100% over the last four years and therefore enhancement by restocking has been reduced equally. Eel production in aquaculture is ca. 2000 tons of eel per year. Recruitment surveys of glass eel and ascending yellow eel indicate a continuously low recruitment.

DK.O. Literature references

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Sonnesen P. 2007. Skarvens prædation omkring Ringkøbing Fjord-en undersøgelse af sammenhænge mellem fødevalg og fiskebestandenes sammensætning. Pp 76 and attachments.

Strand, J., Bossi, R., Sortkjær, O., Landkildehus, F. and Larsen, M.M. 2007. PFAS og organotinforbindelser i punktkilder og det akvatiske miljø NOVANA screeningsundersøgelse. DMU rapport nr. 608 (http://www2.dmu.dk/Pub/FR608.pdf).

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Appendix A On contaminants

Appendix1: Unpublished data from Århus county 2003

Station (Århus Amt 2003)	Lyngbyg.Å	Lyngbyg.Å	Giber Å 1A	Giber Å 2A	
Fisk	Ål	Ål	Ål	Ål	
Dato					
Matrice	muskel	muskel	muskel	muskel	
	03-0581-1*	03-0581-2*	03-0582	03-0583	Enhed
Prøvens vægt (g ww)	2,19	1,74	1,55	1,92	g
Fedt procent (%)	27,68	24,23	26,06	28,24	%
CB-28	0,54	0,54	< 0,38	< 0,38	µg/kg vv
CB-31	< 0,37	< 0,37	< 0,37	< 0,37	µg/kg vv
CB-44	0,42	0,42	0,41	0,45	µg/kg vv
CB-49	0,30	0,34	0,34	0,30	µg/kg vv
CB-52	2,72	2,68	2,86	3,81	µg/kg vv
CB-99	2,58	2,52	2,31	2,70	µg/kg vv
CB-101	3,61	3,57	8,79	12,38	µg/kg vv
CB-105	2,98	3,03	2,93	4,05	µg/kg vv
CB-110	3,81	3,85	4,79	7,28	µg/kg vv
CB-118	6,21	6,31	6,93	9,48	µg/kg vv
CB-128	1,81	1,83	2,89	4,52	µg/kg vv
CB-138	10,77	10,90	20,60	32,50	µg/kg vv
CB-149	5,14	5,17	14,38	22,89	µg/kg vv
CB-151	1,05	1,06	2,24	2,93	µg/kg vv
CB-153	16,55	16,53	30,57	45,42	µg/kg vv
CB-156	1,14	1,14	1,85	3,21	µg/kg vv
CB-170	2,14	2,15	5,45	9,32	µg/kg vv
CB-180	5,13	5,26	12,67	21,06	µg/kg vv
CB-187	5,27	5,33	13,63	23,61	µg/kg vv
CB-194	0,43	0,45	1,03	1,48	µg/kg vv
CB-209	< 0,31	< 0,31	< 0,31	< 0,31	µg/kg vv
Alfa-HCH	1,44	1,52	3,48	3,84	µg/kg vv
beta-HCH	0,41	0,73	0,89	0,70	µg/kg vv
gamma-HCH	1,63	1,60	2,64	2,52	µg/kg vv
HCB	13,38	13,70	33,22	69,30	µg/kg vv
o'p-DDE	0,86	0,87	0,77	0,91	µg/kg vv
o'p-DDT	0,73	0,67	4,38	3,38	µg/kg vv
p'p'-DDD	7,04	6,82	11,64	10,25	µg/kg vv
p'p-DDE	33,40	34,69	49,76	42,84	µg/kg vv
p'p-DDT	9,09	9,11	16,95	21,62	µg/kg vv
TNC	2,83	2,83	2,00	1,96	µg/kg vv
Recovery					
CB-40 (%)	96,0	95,8	97,3	96,2	%

Station (Århus Amt 2003)	Lyngbyg.Å	Lyngbyg.Å	Giber Å 1A	Giber Å 2A	
Brommerede flammehæmmere					
PBDE-17	0,09	0,16	< 0,08	0,08	µg/kg vv
PBDE-28	0,14	0,38	0,19	0,20	µg/kg vv
PBDE-49	0,28	0,29	0,19	0,23	µg/kg vv
PBDE-47	6,48	6,83	3,57	4,04	µg/kg vv
PBDE-66	0,10	0,11	< 0,08	0,11	µg/kg vv
PBDE-100	2,13	1,86	1,53	2,27	µg/kg vv
PBDE-99	0,71	0,59	0,37	0,40	µg/kg vv
PBDE-85	< 0,06	< 0,07	< 0,08	< 0,06	µg/kg vv
PBDE-154	0,26	0,17	0,14	0,23	µg/kg vv
PBDE-153	0,38	0,28	0,22	0,36	µg/kg vv
PBDE-183	< 0,29	< 0,36	< 0,40	< 0,32	µg/kg vv
Recovery PBDE (%)	106	97	107	97	µg/kg vv

Appendix 2

Analyses from Brabrand sø in 1998 mussel tissue on eel pool of 6 individuals. Erichsen *et al.*, 2000.

sum PCB	0.33 mg/kg tørstof
sum DDT/DDE/DDD	0.1 mg/kg tørstof
sum PAH	0.59 mg/kg tørstof

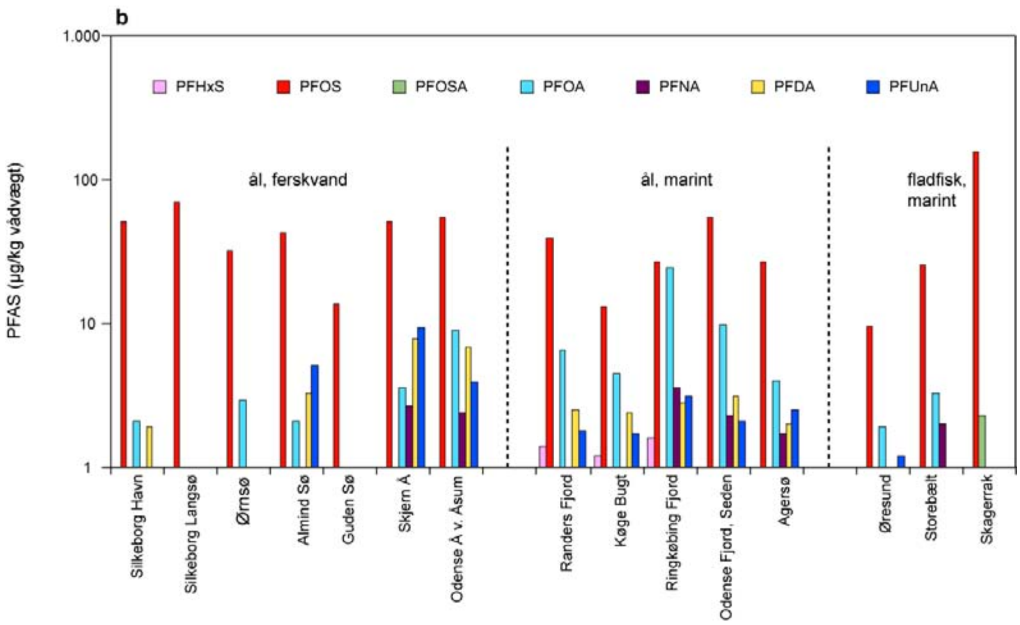

Figure PFAS concentration wet weight in eel (ål) and flatfish (fladfisk) in fresh water (ferskvand) and marine (marint) waters from fish liver.

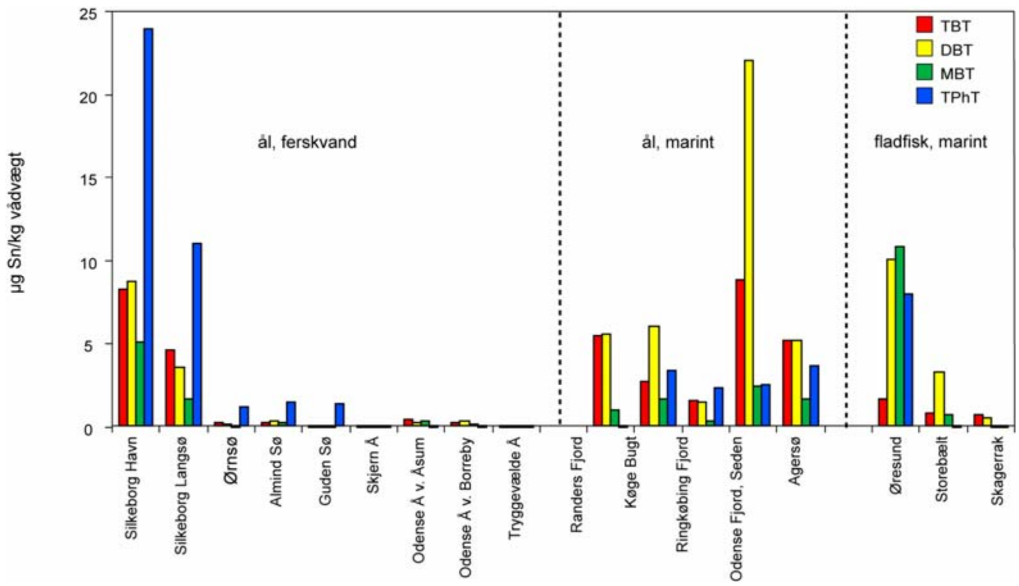

Figure PFAS concentration wet weight (vådvægt) in eel (ål) and flatfish (fladfisk) in fresh water (ferskvand) and marine (marint) waters from fish lever.

Appendix 3

Data for PFAS in fresh water.

LAB-ID	FISK, LEVER (µG/KG VÅDVÆGT)	PFHXS	PFOS	PFOSA	PFOA	PFNA	PFDA	PFUNA
04-0700	Odense Å v. Åsum, ål	<0,8	54,5	<0,5	8,9	2,4	6,9	3,9
04-0679	Skjern Å, ål	<0,8	51,6	<0,5	3,6	2,7	7,9	9,4
04-0680	Silkeborg Havn, ål	<0,8	51,1	<0,5	2,1	<1,4	1,9	<0,7
04-0683	Silkeborg Langsø, ål	<0,8	70,1	<0,5	<1,2	<1,4	<0,8	<0,7
04-0682	Ørnsø, ål	<0,8	31,7	<0,5	2,9	<1,4	<0,8	<0,7
04-0681	Almind Sø, ål	<0,8	42,3	<0,5	2,1	<1,4	3,3	5,1
04-0684	Guden Sø, ål	<0,8	13,7	<0,5	<1,2	<1,4	<0,8	<0,7
04-0314	Randers Fjord, ål	1,4	39,5	<0,5	6,5	<1,4	2,5	1,8
04-0315	Køge Bugt, ål	1,2	13,1	<0,5	4,5	<1,4	2,4	1,7
04-0316	Ringkøbing Fjord, ål	1,6	26,5	<0,5	24,5	3,6	2,8	3,1
04-0467	Odense Fjord, Seden Strand, ål	<0,8	54,3	<0,5	9,8	2,3	3,1	2,1
04-0816	Agersø, ål	<0,8	26,8	<0,5	4,0	1,7	2,0	2,5
04-0632	Øresund, Nivå Bugt, skrubbe	<0,8	9,5	<0,5	1,9	<1,4	<0,8	1,2
04-0633	Storebælt, Agersø, skrubbe	<0,8	25,4	<0,5	3,3	2,0	<0,8	<0,7
04-0634	Skagerrak, Hirtshals, rødspætte	<0,8	156,0	2,3	<1,2	<1,4	<0,8	<0,7
LAB-ID	SEDIMENT, FERSKVAND (µG/KG TØRSTOF)	PFHXS	PFOS	PFOSA	PFOA	PFNA	PFDA	PFUNA
04-0623	Guden Sø (TS: 33.6% , GT:25.0%)	<0,7	<1,0	<0,9	<0,4	<0,7	<1,0	<1,7
04-0624	Ørn Sø (TS: 24,7% , GT: 18,3%)	<0,7	<1,0	<0,9	<0,4	<0,7	<1,0	<1,7
04-0625	Silkeborg Langsø (TS:27,7%, GT:28,7%)	<0,7	<1,0	<0,9	<0,4	<0,7	<1,0	<1,7
04-0626	Almind Sø (TS: 28,2% , GT: 25,5%)	<0,7	<1,0	<0,9	<0,4	<0,7	<1,0	<1,7
04-0678	Silkeborg Havn (TS: 63,8% , GT: 3,0%)	<0,7	<1,0	<0,9	<0,4	<0,7	<1,0	<1,7
04-0698	Odense Å (TS: 14.7% , GT: 24,4%)	<0,7	<1,0	<0,9	<0,4	<0,7	<1,0	<1,7
04-0699	Skjern Å (TS: 61,1% , GT: 3,4%)	<0,7	<1,0	<0,9	<0,4	<0,7	<1,0	<1,7
04-0284	Tryggevælde Å (TS: 20,1% , GT: 15,0%)	<0,7	<1,0	<0,9	<0,4	<0,7	<1,0	<1,7
LAB-ID	MUSLINGER, MARINT (µG/KG VÅDVÆGT)	PFHXS	PFOS	PFOSA	PFOA	PFNA	PFDA	PFUNA
04-0317	Odense Fjord	<0,8	<0,2	<0,5	<1,2	<1,4	<0,8	<0,7
04-0320	Nivå Bugt, Øresund	<0,8	<0,2	<0,5	<1,2	<1,4	<0,8	<0,7
04-0323	Agersø, Storebælt	<0,8	<0,2	<0,5	<1,2	<1,4	<0,8	<0,7
04-0332	Køge Bugt,	<0,8	<0,2	<0,5	<1,2	<1,4	<0,8	<0,7
04-0335	Randers Fjord	<0,8	<0,2	<0,5	<1,2	<1,4	<0,8	<0,7
04-0346	Ringkøbing Fjord	<0,8	<0,2	<0,5	<1,2	<1,4	<0,8	<0,7
04-0407	Anholt, Kattegat	<0,8	<0,2	<0,5	<1,2	<1,4	<0,8	<0,7
04-0658	Bornholm, Østersø	<0,8	<0,2	<0,5	<1,2	<1,4	<0,8	<0,7
04-0671	Lønstrup, Skagerrak	<0,8	<0,2	<0,5	<1,2	<1,4	<0,8	<0,7
LAB-ID	SEDIMENT, MARINT (µG/KG TØRSTOF)	PFHXS	PFOS	PFOSA	PFOA	PFNA	PFDA	PFUNA
00-1992	Randers Fjord	<0,7	<1,0	<0,9	<0,4	<0,7	<1,0	<1,7
00-2006	Ringkøbing Fjord	<0,7	<1,0	<0,9	<0,4	<0,7	<1,0	<1,7
00-2063	Odense Fjord	<0,7	<1,0	<0,9	<0,4	<0,7	<1,0	<1,7
04-0179	Anholt, Kattegat	<0,7	<1,0	<0,9	<0,4	<0,7	<1,0	<1,7

04-0183	Bornholm, Østersø	<0,7	<1,0	<0,9	<0,4	<0,7	<1,0	<1,7
04-0190	Agersø, Storebælt	<0,7	<1,0	<0,9	<0,4	<0,7	<1,0	<1,7
04-0203	Nivå Bugt, Øresund	<0,7	<1,0	<0,9	<0,4	<0,7	<1,0	<1,7
04-0206	Lønstrup, Skagerrak	<0,7	<1,0	<0,9	<0,4	<0,7	<1,0	<1,7

PFHxS: perfluorohexane sulfonate; PFOS: perfluorooctane sulfonate; PFOSA: perfluorooctane sulfonamide;

PFOA: perfluorooctanoic acid; PFNA: perfluorononanoic acid; PFDA: perfluorodecanoic acid; PFUnA: perfluoroundecanoic acid, TS: tørstof; GT:glødetab.

Data for organotin in fish and fresh-water sediment.

LAB-ID	FISK, LEVER (µG SN/KG VÅDVÆGT)	TBT	DBT	MBT	TPHT	DPHT	MPHT	TOCT	DOCT	MOCT
04-0700	Odense Å v. Åsum, ål	0,5	0,3	0,4	<0,5	<0,3	<0,2	<0,5	<0,5	<0,3
04-0701	Odense Å v. Borreby, ål	0,3	0,4	0,2	<1	<0,5	<0,2	<1	<0,5	<0,3
04-0679	Skjern Å, ål	<0,2	<0,2	<0,2	<0,5	<0,3	<0,2	<0,5	<0,5	<0,3
04-0680	Silkeborg Havn, ål	8,3	8,7	5,1	24	3,2	1,9	<0,5	<0,5	<0,3
04-0683	Silkeborg Langsø, ål	4,7	3,6	1,7	11	2,0	0,6	<0,5	<0,5	<0,3
04-0682	Ørnsø, ål	0,3	0,2	<0,2	1,2	<0,3	<0,2	<0,5	<0,5	<0,3
04-0681	Almind Sø, ål	0,3	0,4	0,3	1,5	0,5	0,3	<0,5	<0,5	<0,3
04-0684	Guden Sø, ål	<0,2	<0,2	<0,2	1,4	<0,3	<0,2	<0,5	<0,5	<0,3
04-0284	Tryggevælde Å, ål	<0,2	<0,2	<0,2	<0,5	<0,3	<0,2	<0,5	<0,5	<0,3
04-0314	Randers Fjord, ål	5,5	5,6	1,0	<0,5	<0,3	<0,2	<0,5	<0,5	<0,3
04-0315	Køge Bugt, ål	2,8	6,1	1,7	3,4	<0,3	<0,2	<0,5	<0,5	<0,3
04-0316	Ringkøbing Fjord, ål	1,6	1,5	0,4	2,4	<0,3	<0,2	<0,5	<0,5	<0,3
04-0467	Odense Fjord, Seden Strand, ål	8,8	22,1	2,5	2,6	<0,3	<0,2	<0,5	<0,5	<0,3
04-0816	Agersø, ål	5,2	5,2	1,7	3,7	<0,3	<0,2	<0,5	<0,5	<0,3
04-0632	Øresund, Nivå Bugt, skrubbe	1,7	10,1	10,8	8,0	0,9	1,0	<0,5	<0,5	<0,3
04-0633	Storebælt, Agersø, skrubbe	0,9	3,3	0,8	<1	<0,5	<0,2	<1	<0,5	<0,3
04-0634	Skagerrak, Hirtshals, rødspætte	0,8	0,6	<0,5	<1	<0,5	<0,2	<1	<0,5	<0,3
LAB-ID	SEDIMENT, FERSKVAND (µG SN/KG TØRSTOF)	TBT	DBT	MBT	TPHT	DPHT	MPHT	TOCT	DOCT	MOCT
04-0623	Guden Sø (TS: 33,6% , GT:25,0%)	<2	<2	<4	<10	<5	<5	<5	<4	<4
04-0624	Ørnsø (TS: 24,7% , GT: 18,3%)	<1	<1	<1	<5	<4	<4	<5	<4	<4
04-0625	Silkeborg Langsø (TS:27,7%, GT:28,7%)	21	13	<3	<5	<4	<4	<5	<4	<4
04-0626	Almind Sø (TS: 28,2% , GT: 25,5%)	<2	<5	<4	<10	<5	<5	<5	<5	<4
04-0678	Silkeborg Havn (TS: 63,8% , GT: 3,0%)	6,1	3,4	<2	<1	<1	<1	<1	<1	<1
04-0698	Odense Å(TS: 14,7% , GT: 24,4%)	6,6	10	7,3	<1	<1	<1	<1	<1	<1
04-0699	Skjern Å (TS: 61,1% , GT: 3,4%)	<0,5	<0,5	<0,5	<2	<2	<2	<2	<2	<2
04-0284	Tryggevælde Å (TS: 20,1% , GT: 15,0%)	<1	<1	<2	<3	<1	<1	<3	<1	<1

TBT: Tributyltin; DBT: Dibutyltin; MBT: Monobutyltin; TPhT: Triphenyltin; DPhT: Diphenyltin; MPhT: monophenyltin; TocT: Trioctyltin; DocT: Dioctyltin; MocT: Monooctyltin; TS: tørstof; GT: glødetab.

Report on the eel stock and fishery in the Netherlands 2008

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Reporting Period: This report was completed in August 2008, and contains data up to 2007 and recruitment data for 2008.

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NL.B Introduction

NL.B.1 Status of this report

In 2002 (ICES 2003), the EIFAC/ICES Working Group on eels recommended that member countries should report annually on trends in their local populations and fisheries to the Working Group. In 2003 (ICES 2004), detailed data reports per country were annexed to the working group report, which have subsequently been updated, refined and restructured to match the set-up of the EU Data Collection Regulation. FAO/ICES (2007) is the most recent version. This report on the status of and trend in the eel stock in the Netherlands updates the information presented before.

NL.B.2 General overview of fisheries

Eel fisheries in the Netherlands occur in coastal waters, estuaries, larger and smaller lakes, rivers, polders, etc. The total fishery involves just over 200 companies, with an estimated total catch of nearly 1000 tonnes. Management of eel stock and fisheries has been an integral part of the long tradition in manipulating water courses (polder construction, river straightening, ditches and canals, etc.). Governmental control of the fishery is restricted to on the one hand a set of general rules (gear restrictions, size restrictions, for course fish: closed seasons), and on the other hand site-specific licensing. Within the licensed fishing area, and obeying the general rules, fishers are currently free to execute the fishery in whatever way they want. There is no existing general registration of fishing efforts or landings required. In recent years, licensees in state-owned waters are obliged to participate in so-called Fish Stock Management Committees [‘Visstand Beheer Commissies’ VBC,], in which commercial fisheries, sports fisheries and water managers are represented. The VBC is responsible for the development of a regional Fish Stock Management Plans. The Management Plans are currently not subject to general objectives or quality criteria.

NL.B.3 Spatial subdivision of the territory

The fishing areas can be categorized into five groups (see also Figure NL.1):

The Waddensea; 53ºN 5ºE; 2591 km^2. This is an estuarine-like area, shielded from the North Sea by a series of islands. The inflow of seawater at the western side mainly consists of the outflow of the river Rhine, which explains the estuarine character of the Waddensea. The fishery in the Waddensea is permitted to license holders and assigns specific fishing sites to individual licensees. Fishing gears include fykenets and poundnets; the traditional use of eel pots is in rapid decline. The fishery in the Waddensea is obliged to apply standard EU fishing logbooks. Landings statistics are therefore available from 1995 onwards; <50 tons per year.

Lake IJsselmeer; 52º40'N 5º25'E; now 1820 km^2. Lake IJsselmeer is a shallow, eutrophic fresh-water lake, which was reclaimed from the Waddensea in 1932 by a dike (Afsluitdijk), substituting the estuarine area known as the Zuiderzee. The surface of the lake was stepwise reduced by land reclamation, from an original 3470 km^2 in 1932, to just 1820 km^2 since 1967. In preparation for further land reclamation, a dam was built in 1976, dividing the lake into two compartments of 1200 and 620 km^2, respectively, but no further reclamation has actually taken place. In managing the fisheries, the two lake compartments have been treated as a single management unit. The discharge of the river IJssel into the larger compartment (at 52º35'N 5º50'E, average 7 km^3 per annum, coming from the River Rhine) is sluiced through the Afsluitdijk into the Waddensea at low tide, by passive fall. Fishing gears include standard and summer fykenets, eel boxes and longlines; trawling was banned in 1970. Licensed fishers are not spatially restricted within the lake, but the number of gears is controlled by a gear-tagging system. The registered landings at the auctions are assumed to cover some 80% of the actual total.

Main rivers; 180 km^2 of water surface. The Rivers Rhine and Meuse flow from Germany and Belgium respectively, and constitute a network of dividing and joining river branches in the Netherlands. Traditional eel fisheries in the rivers have declined tremendously during the 20th century, but following water rehabilitation measures in the last decades is now slowly increasing. The traditional fishery used stow nets for silver eel, but fykenet fisheries for yellow and silver eel now dominates. Individual fishers are licensed for specific river stretches, where they execute the sole fishing right. No registration of efforts or landings is required.

Zeeland; 965 km^2. In the Southwest, the Rivers Rhine, Meuse and Scheldt (Belgium) discharge into the North Sea in a complicated network of river branches, lagoon-like waters and estuaries. Following a major storm catastrophe in 1953, most of these waters have been (partially) closed off from the North Sea, sometimes turning them into fresh water. Fishing is licensed to individual fishers, mostly spatially restricted. Fishing gears are dominated by fykenets. Management is partially based on marine, partly on fresh-water legislation.

Remaining waters; inland 1340 km^2. This comprises 636 km^2 of lakes (average surface: 12.5 km^2); 386 km^2 of canals (> 6 m wide, 27 590 km total length); 289 km^2 of ditches (< 6 m wide, 144 605 km total length); and 28 km^2 of smaller rivers (all estimates based on areas less than 1 m above sea level, 55% of the total surface; see Tien and Dekker, 2004 for details). Traditional fisheries are based on fykenetting and hook and line. Individual licenses permit fisheries in spatially restricted areas, usually comprising a few lakes or canal sections, and the joining ditches. Only the spatial limitation is registered. Eight small companies operating scattered along the North Sea coast have been added to this category.

The Water Framework Directive subdivides the Netherlands into four separate River Basin Districts, all of which extend beyond our borders. These are:

a) the River Ems (Eems), 53º20'N 7º10'E (=river mouth), shared with Germany. This RBD includes the northeastern Province Groningen, and the eastern part of Province Drente. Drainage area: 18 000 km^2, of which 2400 km^2 are in the Netherlands.

b) the River Rhine (Rijn), 52º00'N 4º10'E, shared with Germany, Luxemburg, France, Switzerland, Austria, Liechtenstein. Drainage area: 185 000 km^2, of which 25 000 km^2 in the Netherlands, which is the major part of the country.

c) the River Meuse (Maas), 51º55'N 4º00'E, shared with Belgium, Luxemburg, France and Germany. Drainage area: 35 000 km^2, of which 8000 km^2 are in the Netherlands.

d) the River Scheldt (Schelde), 51º30'N 3º25'E, shared with Belgium and France. Most of the southwestern Province Zeeland used to belong to this RBD, but water reclamation has changed the situation dramatically. Drainage area: 22 000 km^2, of which 1860 km^2 are in the Netherlands.

Within the Netherlands, all rivers tend to intertwine and confluent. Rivers Rhine and Meuse have a complete anastomosis at several places, although a large part of the outflow of the River Meuse is now redirected through former outlets of the River Scheldt. Additionally, the coastal areas in front of the different RBDs constitute a confluent zone. Consequently, sharp boundaries between the RBDs cannot be made-neither on a practical nor on a juridical basis. In the following, we will subdivide the national data on eel stock and fisheries by drainage area on a preliminary assumption that water surfaces and fishing companies are approximately equally distributed over the total surface, and thus, totals can be split up over RBDs proportionally to surface areas.

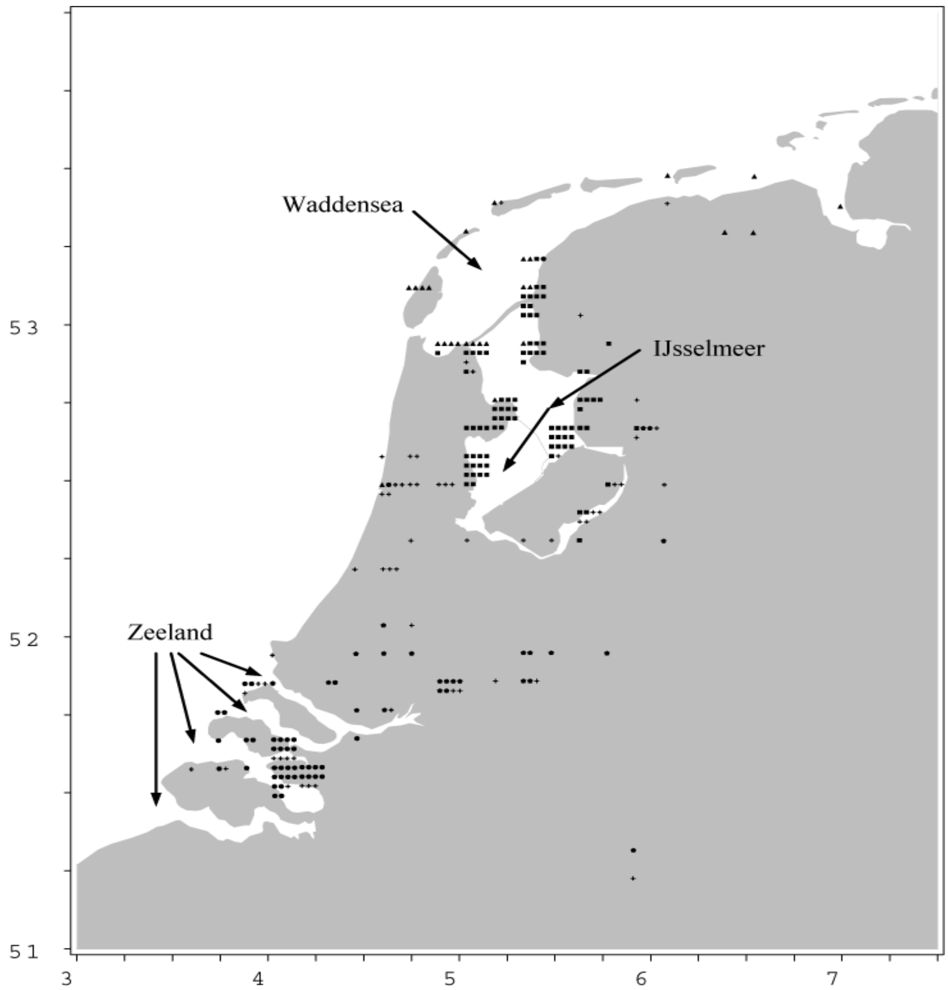


Figure NL.1 Distribution of eel fishery companies in the Netherlands (2005). Home addresses of companies have been grouped in a 10*10 km grid. Within each grid cell, individuals are listed in artificially created rows. Symbols indicate the fishing areas: ▲ Waddensea; ■ IJsselmeer; ⬟ Rivers; ⬣ Zeeland; + Others.

Table NL.a Overview of water surface, number of commercial companies and their annual landings (2004), by fishing area. Estimates in Italics have been broken down by RBD, assuming that catches are proportional to the number of fishing companies.

		Surface	Number of	Estimated landings (t)		Data source
Area	RBD	(km2)	companies	yellow eel	silver eel	
Waddensea	Rhine	2591	25	37	-	EU logbooks
	Ems	38	2	3	-	EU logbooks
IJsselmeer	Rhine	1820	85†	240	40	Auction statistics
Rivers	Rhine	120	21	46	91	Informed guess
	Meuse	60	2	4	9	Informed guess
Zeeland	Meuse	535	43	75	?	(EU logbooks)
	Scheldt	428	0	0		
Others	Rhine	900	56	222	133	Informed guess
	Ems	86	2?	9	5	Informed guess
	Meuse	288	1?	4	2	Informed guess

	Scheldt	67	0		
Sum		6528	237	640	280

† 85 licenses, owned by 68 companies.

NL.C Fishing capacity

Table NL.a lists the number of fishing companies having a specific eel fishing license, by fishing area. Most licenses are linked to a specific ship. For marine waters and Lake IJsselmeer, a register of ships is kept, but for the other waters, no central registration of the ships being used is available. Registration of the number of gears owned or employed is lacking. For Lake IJsselmeer, a maximum number of gears per company is enforced (authenticated tags are attached to individual gears), but the actual usage is often much lower, among others because restrictions apply on the combinations of types of fishing gears (e.g. no fykenets and gillnets should be operated concurrently, because perch and pikeperch are the target species of the gillnetting, although landing perch and pikeperch from fykenets is prohibited).

NL.D Fishing effort

For most of the country, fishing capacity is unknown. In areas where fishing capacity is known, no record is kept of the actual usage of fishing gears. Consequently, no information is available on fishing effort. For Lake IJsselmeer, an estimate of the number of gears actually used is available for the years 1970–1988 (Dekker, 1991). In the mid 1980s, the number of fykenets was capped, and reduced by 40% in 1989. In 1992, the number of eel boxes was counted, and capped. Subsequently, the caps have been lowered further in several steps, the latest being a buy-out in 2006. Because the number of companies has reduced at the same time, the nominal fishing effort per company has not reduced at the same rate, and underutilization of the nominal effort probably still exists. The effort in the longline fishery is not restricted, other than by the number of licenses.

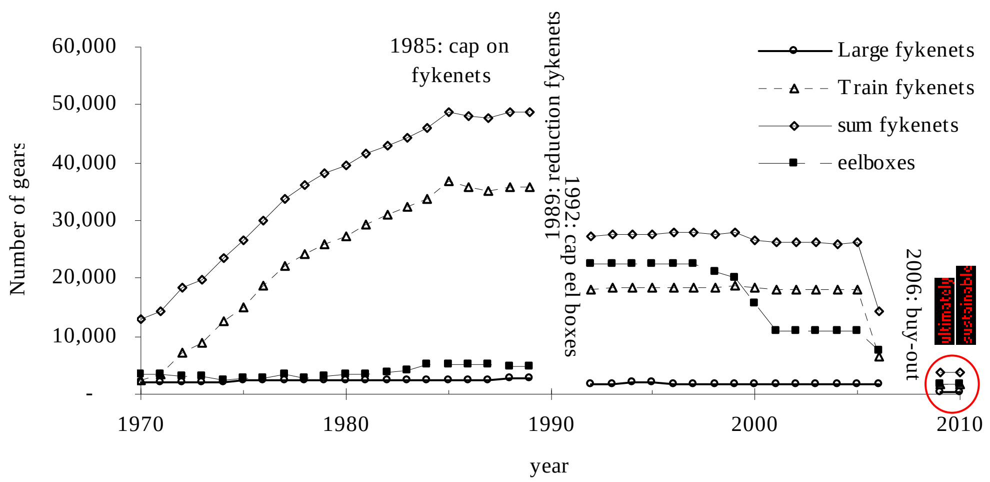


Figure NL.2 Trends in the nominal number of fishing gear employed in the eel fishery on Lake IJsselmeer. Information before 1989 is based on a voluntary inquiry in 1989 (Dekker, 1991); after 1992, the licensed number of gear is shown. The reduction in-between is realistic.

For the years 2009–2010, the maximal effort level that would lead to an ultimate recovery of the eel stock is tentatively indicated.

NL.E Catches and landings; restocking; aquaculture

NL.E.1 Catches and landings, commercial fisheries

NL.E.1.1 Catches and landings from marine waters

Catches and landings in marine waters are registered in EU logbooks, but these do not allow for a break down by RBD. Registrations are available for the years since 1995. Up to 2001, ships with a total length (LOA) ≥15 m were obliged to report all their eel catches, but smaller ones were not; since 2001, ships with a total length ≥10 m are obliged to report their eel catches, if their landings per day exceeded 50 kg per species. That is: in 2001 the number of ships potentially reporting rose, but the actual reporting per ship declined. This change in the regulations was partly driven by changing practices, and vice versa. In practice, the abrupt change in the regulations in 2001 led to a gradually changing reporting practice, before and after 2001. Overall, the number of ships reporting in a year declined from 130 before 2001 to 59 thereafter, although the average landing per ship increased from 230 kg/ship/year before 2001 to 436 kg/ship/year thereafter.

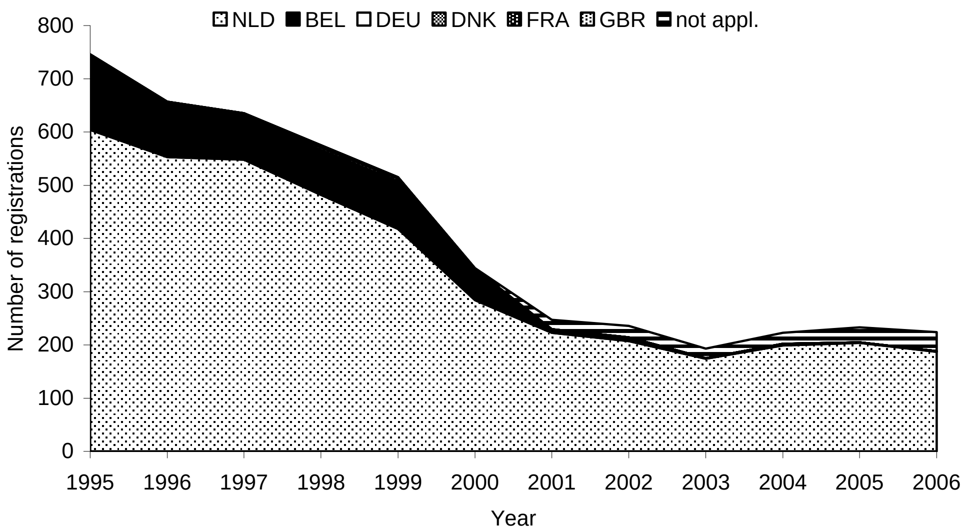


Figure NL.3 Time trend in the number of registered eel landings from marine waters in Dutch harbours by country of origin of the ship.

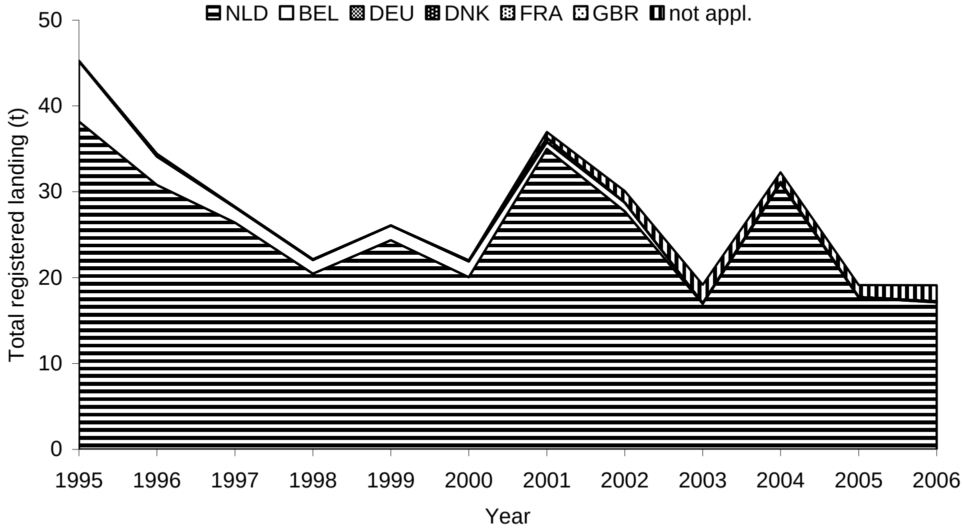


Figure NL.4 Time trend in the total registered landings from marine waters in Dutch harbours by country of origin of the ship.

Nearly 40% of the landings stems from fykenets, recorded as "Miscellaneous gear" or "not applicable". For these fishers, the eel catches is a target species. 50% of the landings stems from bottom trawls (main target is flat fish) and shrimp trawls, for which eels represents a bycatch. The highest monthly catch is recorded from a midwater otter trawl. This concerns a single data record only. It seems likely, that this is a recording error, but over the years there are seven records of (considerable) eel catches from midwater trawls in total.

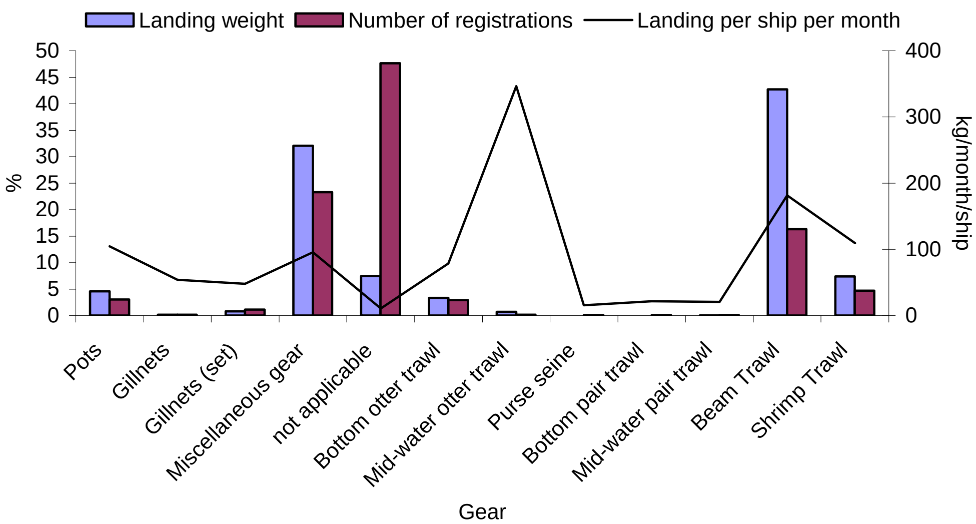


Figure NL.5 Breakdown of eel landings by fishing gear. The categories "Miscellaneous gear" and "not applicable" presumably represent fykenet catches.

The available dataset has a temporal resolution of month and year. Consequently, the effect of the change in daily exemptions in 2001 can not be analysed in full detail. Figure NL.7 shows the cumulative frequency distribution of monthly catches per ship by year. Monthly landings per ship range from 1 kg to just over 6 tons per ship per month. Despite the exemption for daily catches below 50 kg in 2001, the landing per ship per month declines over the years. Median registered landings per ship per month were 1124 kg before 2001 and 344 kg thereafter, corresponding to an average daily landing of 56 resp. 17 kg. Strict application of the exemption (obligation to report landings of 50 kg per species per day, corresponding to 1000 kg/month) would result in loss of information on 50% of the registered landings in the years before 2001, and 80% thereafter (and more than that of the total landings, registered and unregistered), and all information would be lost in the two most recent years.

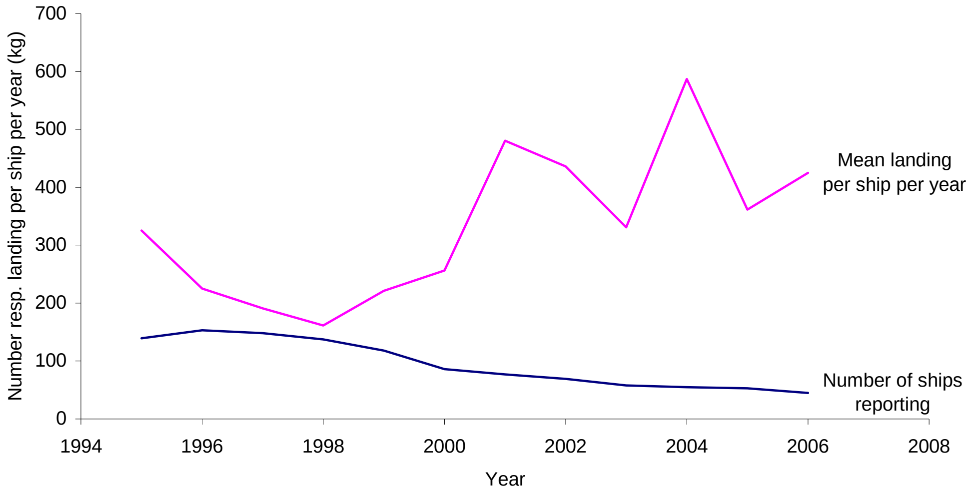


Figure NL.6 Time trend in the number of ships reporting, and the average reported landing per ship per year.

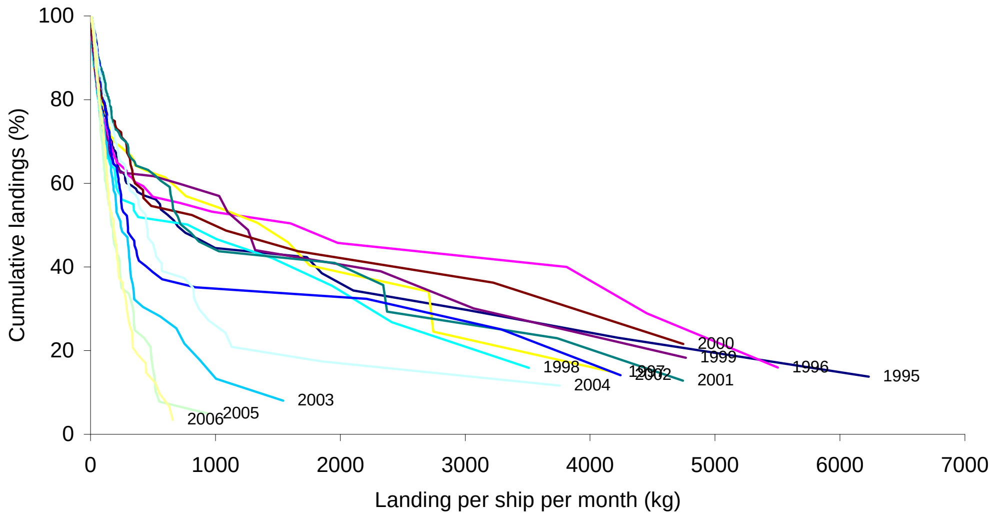
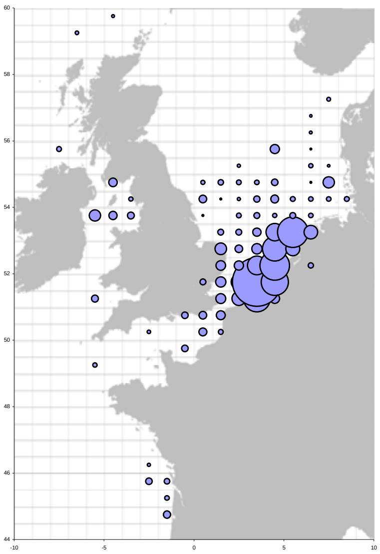


Figure NL.7 Cumulative frequency distribution of the landings per ship per month and year.

Recorded landings of eel from marine waters in Dutch harbours are coming from fishing areas along the Dutch coast, from the Irish Sea, north of Scotland, the English Channel, the Bay of Biscay, the German Bight and the southern North Sea. The major part of the landings (96%) comes from Dutch coastal areas, predominantly the Wadden Sea and the Zeeland area. Over the years, the dominance of Zeeland landings increases.



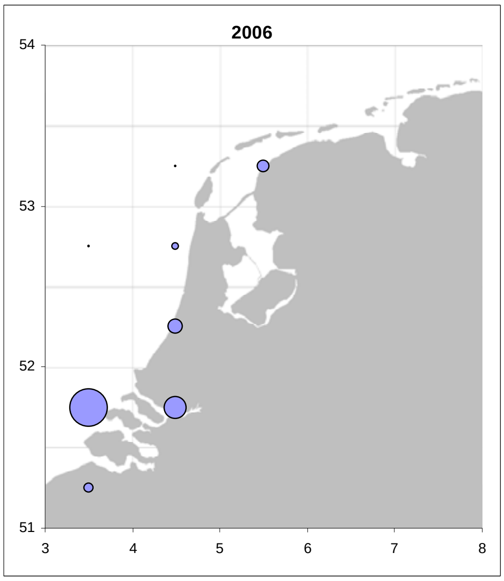


Figure NL.8 Spatial distribution of registered eel landings from marine waters in Dutch harbours. The area of each symbol depicts <u>the square root of the landings</u> per ICES rectangle, summed over the available data years (the radius thus corresponds to the fourth root of the landings).

Figure NL.9 Spatial distribution of registered eel landings in ICES rectangles adjacent to the Dutch coast (96% of the total). The area of each symbol is proportional to the landings (the radius to the second root of the landings).

A preliminary estimate of recreational catches in marine waters is presented in Table NL.c, below.

NL.E.1.2 Catches and landings from Lake IJsselmeer

For Lake IJsselmeer, statistics from the auctions around Lake IJsselmeer are now kept by the Fish Board (Table NL.b); before 1994, the government kept statistics. These statistics are broken down by species, month, harbour and main fishing gear; the quality of this information has deteriorated considerably over the past decade, as a consequence of misclassification of catches, and the trading of eel from other areas at the IJsselmeer auctions.

Table NL.b Landings in tons per year, from the auctions around Lake IJsselmeer, Rhine RBD. Only landings recorded at the auctions are included; other landings are assumed to represent a minor and constant fraction. Figures in italics are suspect, as a consequence of misclassification of catches and trade from areas outside Lake IJsselmeer at the IJsselmeer auctions.

DECADE YEAR	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
0	324	620	1157	838	3205	4152	2999	1112	641	472	368
1	387	988	989	941	4563	3661	2460	853	701	573	381
2	514	720	900	1048	3464	3979	1443	857	820	548	353
3	564	679	742	2125	1021	3107	1618	823	914	293	279
4	586	921	846	2688	1845	2085	2068	841	681	330	245

5	415	1285	965	1907	2668	1651	2309	1000	666	354	234
6	406	973	879	2405	3492	1817	2339	1172	729	301	230
7	526	1280	763	3595	4502	2510	2484	783	512	285	130
8	453	1111	877	2588	4750	2677	2222	719	437	323	
9	516	1026	1033	2108	3873	3412	2241	510	525	332	

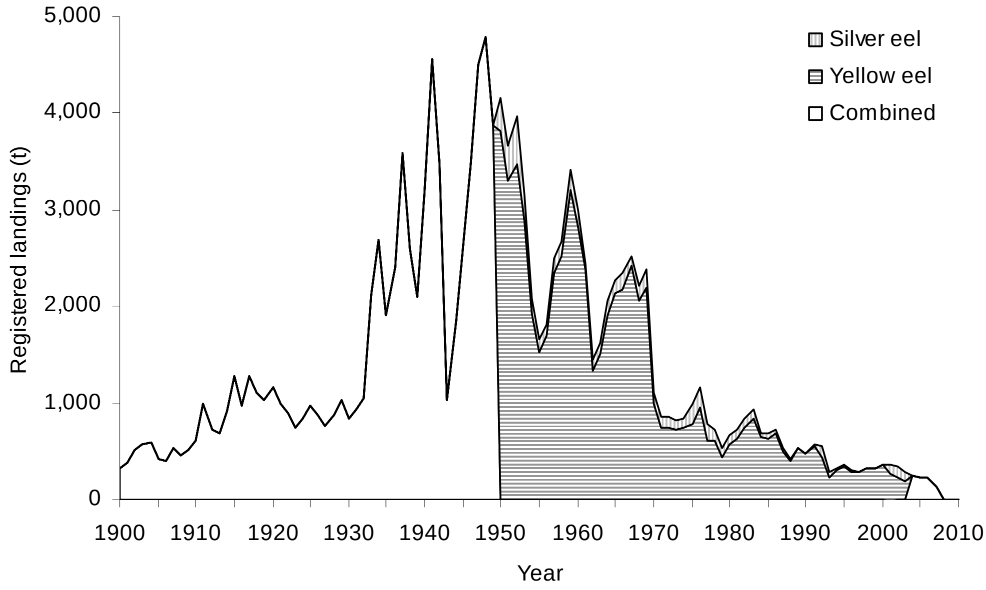


Figure NL.10 Time trend in the landings from Lake IJsselmeer.

NL.E.1.3 Catches and landings from inland waters outside Lake IJsselmeer

For the inland areas outside Lake IJsselmeer, no detailed records of catches and landings are available. Dekker, 1998 gave a rough estimate, which was subsequently refined on the basis of new information, and personal communication with individual fishers and their organizations. The resulting figures (Table NL.a) probably give a reasonable estimate of the actual landings, but obviously do not allow for an analysis of time-trends. Overall, only one-third of the total landings are accurately documented.

NL.E.2 Catches and landings, recreational fisheries

Recreational catches of eel are not systematically recorded, and the order of magnitude is not well known. Inquiries related to angler licensing indicate that 350 000 out of 913 000 male anglers fish for eels (in 2003); 57 500 of them take eels back home, in an average annual quantity of 18 specimens, approx. 1 kg per capita per annum. The number of female anglers is much lower, but not exactly reported. The total quantity of eels taken home has recently been analysed (Vriese, Klein Breteler, Kroes and Spierts, 2008), coming to an order of magnitude of 200–400 t per annum. Circumstantial evidence indicates that the true figure is probably close to the lower bound of 200 t.

Additionally, some 1000 individuals are licensed for recreational use of 2 fykenets per license in coastal waters. Assuming 50 fishing days per year, and a daily catch of 0.5 kg per fyke, their catch will be in the order of 25 t.

A preliminary breakdown of catches by the type of fishers is given in Table NL.c.

Table NL.c Breakdown of commercial and recreational fishing and landings by the type of fisher. Data from Vriese *et al.*, 2008; Dekker *et al.*, 2008 and guestimates.

	Individual catch kg/year	Number of individuals	Total catch tonne/year
Full time commercial	7700	100	770
Part time commercial	1000	150	150
Poaching	?	?	?
Recreational (small fykes)	25	1000	25
Sniggklers†	2.650	3773	10
Eel anglers	0.863	95 000	82
Other anglers	0.100	1 000 000	100
Non-anglers		15 898 977	
Totals		17 000 000	> 1,227

† Translation: sniggle=peur.

In summer 2008, the prime organization of recreational fishers (Sport Visserij Nederland) has announced a voluntary ban on eel landing from 2009 onwards. According to this decision, no eel should be taken, though catch-and-return will remain allowed. This is a voluntary restriction, not translated into law.

NL.E.3 Restocking

Glass eel and young yellow eel are used for re-stocking inland waters since time immemorial, mostly by local action of stakeholders. Although a minimum legal size for capture, holding and transport of eels is set in a byelaw, the existing practice of short-range transports has never been prosecuted. Since World War II, the Organisation for the Improvement of Inland Fisheries OVB has organized a re-stocking programme, importing glass eels from France and England, and buying yellow eel from commercial fishers fishing in the Waddensea.

Data on re-stocking quantities are listed in table NL.c.

In recent years, the OVB has merged with the major anglers organization, and subsequently handed over the glass eel importing to the Organisation of Professional Fishermen CvB. Information on recent glass eel imports was made available by the CvB. Restocking of young eel is no longer organized centrally, although trade of small eels (undersized) still occurs. The listed estimates are probably a minimum, not including unregistered trade. Because the government does not keep track of imports and re-stockings anymore, it is not known anymore whether re-stocking has been practised by other parties.

In the earlier decades, young yellow eels were derived from fisheries for wild eel in the Wadden Sea; in recent years, the catches in the Wadden Sea have dropped to almost nothing, and young yellow eels are derived from the aquaculture industry, i.e. eels derived from imported glass eel (England, France).

Table NL.c Re-stocking of glass eel and young yellow eel in the Netherlands, in millions re-stocked†.

Decade	1940		1950		1960		1970		1980		1990		2000	
Year	Glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel
0			5.1	1.6	21.1	0.4	19.0	0.2	24.8	1.0	6.1	0.0	2.8	1.0
1			10.2	1.3	21.0	0.6	17.0	0.3	22.3	0.7	1.9	0.0	0.9	0.1
2			16.9	1.2	19.8	0.4	16.1	0.4	17.2	0.7	3.5	0.0	1.6	0.1
3			21.9	0.8	23.2	0.1	13.6	0.5	14.1	0.7	3.8	0.2	1.6	0.1
4			10.5	0.7	20.0	0.3	24.4	0.5	16.6	0.7	6.2	0.0	0.3	0.1
5			16.5	0.9	22.5	0.5	14.4	0.5	11.8	0.8	4.8	0.0	0.1	0
6	7.3		23.1	0.7	8.9	1.1	18.0	0.5	10.5	0.7	1.8	0.2	0.582	0
7	7.6	1.6	19.0	0.8	6.9	1.2	25.8	0.6	7.9	0.4	2.3	0.4	0.216	0
8	1.9	2.0	16.9	0.8	17.0	1.0	27.7	0.8	8.4	0.3	2.5	0.6	0	0.230
9	10.5	1.4	20.1	0.7	2.7	0.0	30.6	0.8	6.8	0.1	2.9	1.2		

†Conversion from weight into numbers: it was assumed that there are 3000 glass eels per kg, resp. 30 young yellow eels per kg.

NL.E.4 Aquaculture

Different sources reported slightly diverging results for the Dutch aquaculture industry (Table NL.d).

Table NL.d Aquaculture production in the Netherlands, as reported by different sources.

Aquaculture production (tons/year)	Data source			
	FEAP	wgeel2003	FAO Fishstat	Nevevi
1985		20	20	
1986		100	100	
1987		200	200	100
1988		200	200	300
1989		350	350	200
1990		550	500	600
1991		520	550	900
1992		1250	520	1100
1993		1487	1250	1300
1994		1535	1487	1450
1995		2800	1535	1540
1996	1800	2443	2800	2800
1997	1800	3250	2443	2450
1998	3250	3800	2634	3250
1999	3800	4000	3228	3500
2000	4000	3800	3700	3800
2001	4000	3228	4000	4000
2002	4000		3868	4000
2003			4200	4200
2004			4500	4500
2005			4000	4500
2006				4200
2007				4000
2008				?? 3600

Nevevi is the national organization of fish farmers; one would expect their own estimates to be the best.

NL.F Catch per unit of effort

Data on catch per unit of effort are only available within the framework of a stock monitoring programme in State controlled waters. Starting in 1993, the fish assemblage in the main rivers and linked waters (see Figure NL.11) has been monitored, by means of logbook registration of commercial catch and bycatch, in a restricted number of fykenets (four large fykenets or two pairs of summer fykenets per location), mostly on a weekly basis. For eel, the number of yellow eels and silver eels caught is recorded. Results demonstrate a slowly declining trend over the years, but the year-to-year and site-to-site variation is considerable. There is no formal application of these data in eel fisheries management, but the results have frequently been quoted in the debate on the status of the eel stock.

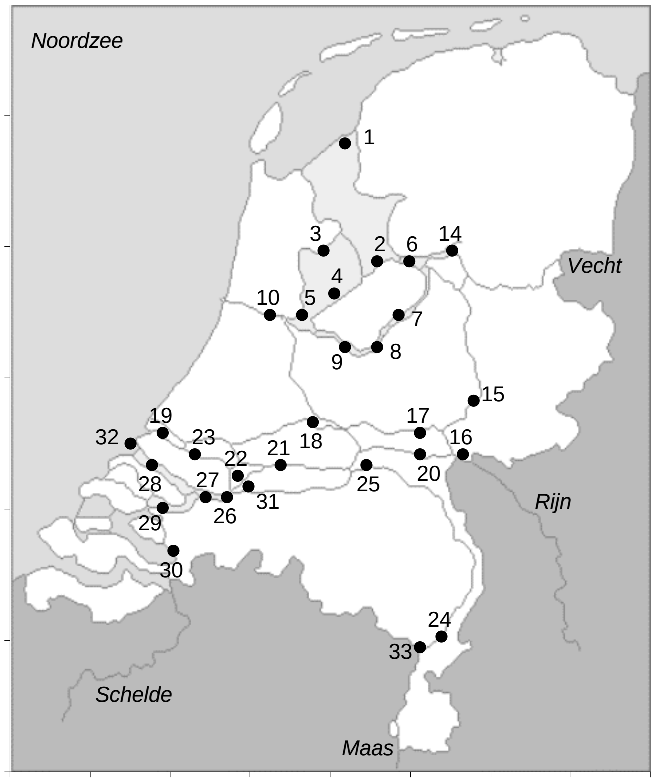


Figure NL.11 Sampling sites for the four fyke monitoring of commercial catches and bycatch.

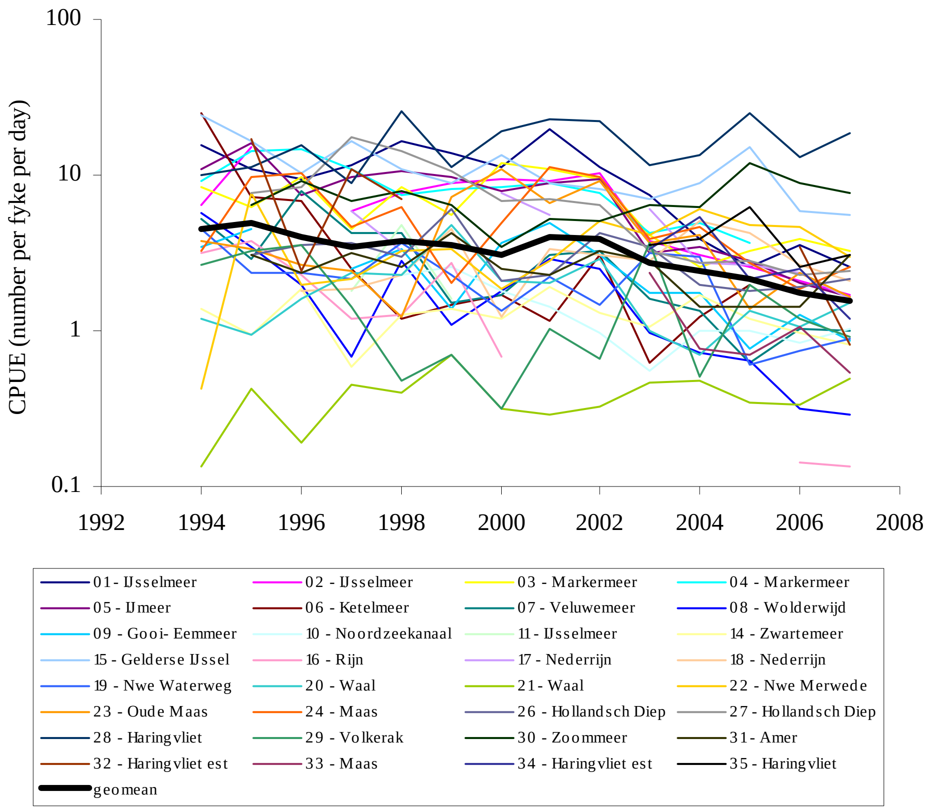


Figure NL.12 Time trends in the four fyke monitoring of commercial eel catches per sampling site. The geometric mean has been calculated for the available data in each year.

NL.G Scientific surveys of the stock

NL.G.1 Recruitment surveys

Recruitment of glass eel in Dutch waters is monitored at Den Oever and 11 other sites along the coast (see Dekker, 2002 for a full description).

2008 is the lowest season on record, though 2006 was just a bit more. Immigration in 2008 started a bit earlier than on average, and ended early May; the season was definitely not as early as the poor 2006 season. The glass eels had a low total length, in the same order as in recent years (Figure NL.14).

The data at the other sites (Figure NL.15) confirm the overall trend, though individual series may deviate.

Table NL.f Number of glass eel caught per lift net haul in Den Oever. All observations in a year have been corrected for time of day and month of sampling, and averaged.

Decade Year	1930	1940	1950	1960	1970	1980	1990	2000
0		17.36	8.34	29.45	53.67	37.73	4.63	2.10
1		15.19	17.11	50.54	23.78	31.72	1.40	0.70
2		24.50	109.68	117.95	42.56	20.00	3.76	1.38
3		16.05	17.88	168.81	30.35	13.36	3.75	1.87
4		46.93	26.85	52.73	35.51	17.91	6.12	1.88

5		19.05	37.12	109.57	46.09	18.61	8.50	1.02
6		7.73	9.76	26.35	37.66	19.70	9.65	0.43
7		7.60	21.71	40.16	84.32	7.65	15.46	1.35
8	20.62	6.55	70.90	27.47	53.54	5.62	2.77	0.36
9	46.29	6.46	38.83	23.59	74.46	3.90	4.10	

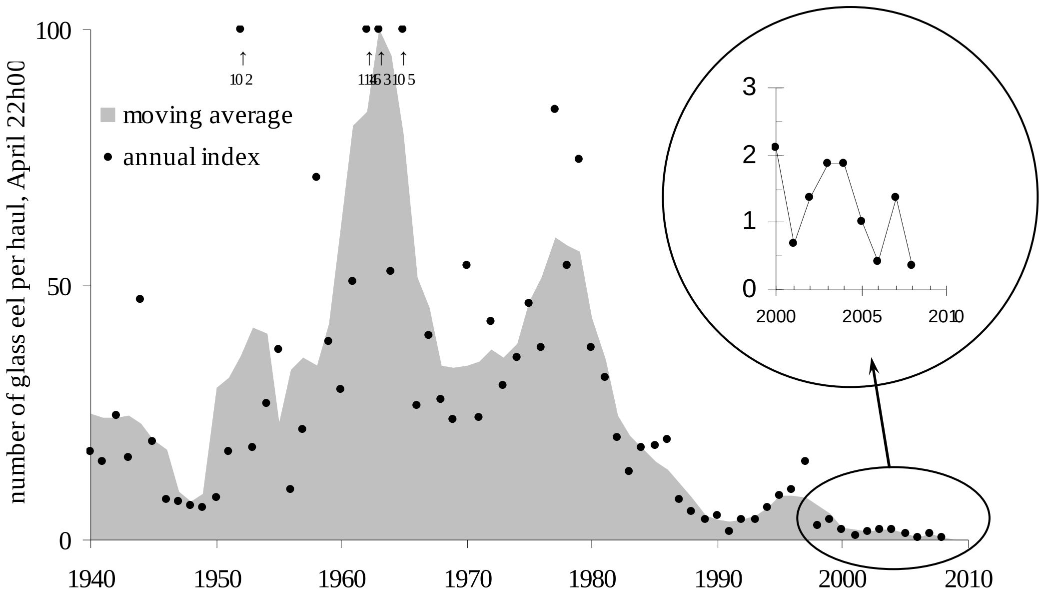


Figure NL.13 Time trend in the glass eel survey at Den Oever.

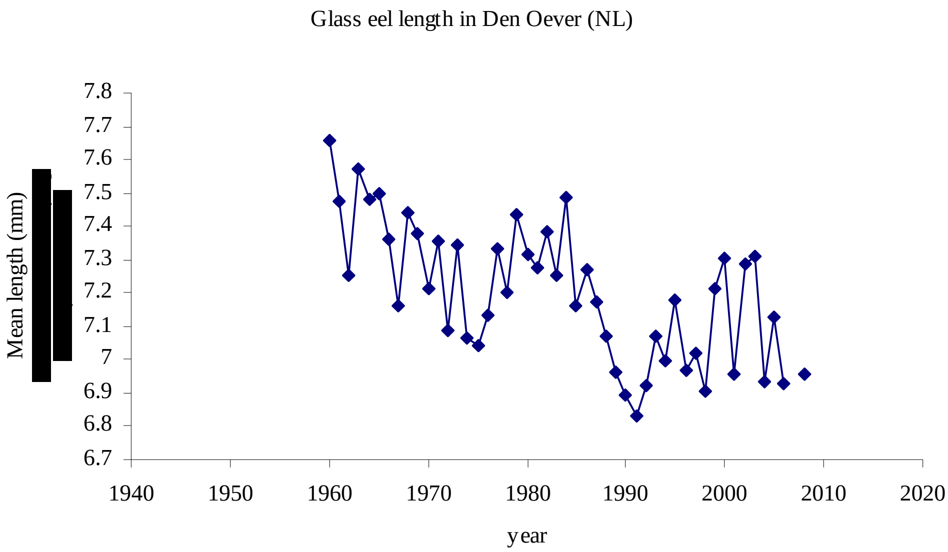


Figure NL.14 Time trend of the length of the glass eel sampled in Den Oever. The measurements have been corrected for the date of sampling within the season, and for the average timing of each season within each year. (Data for 2006 currently unavailable).

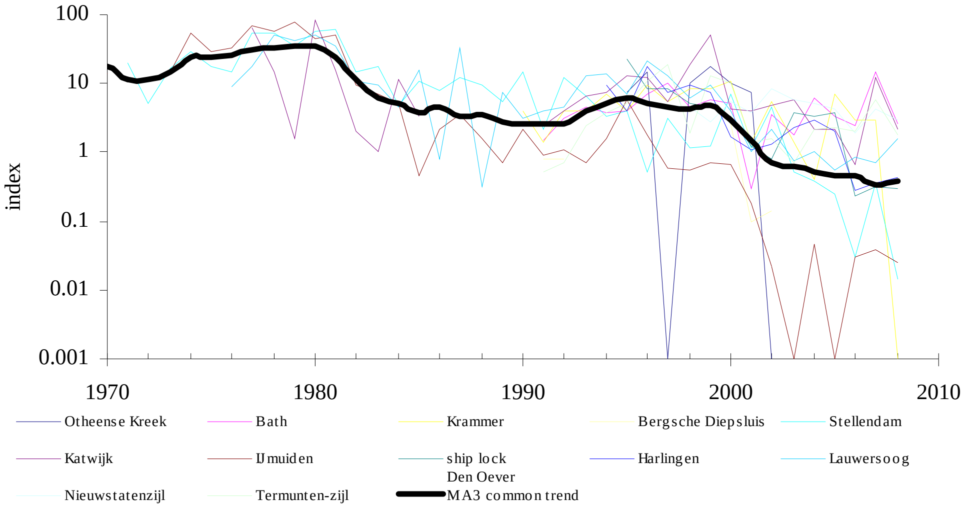


Figure NL.15 Long-term trends in the glass eel catches in the experimental fisheries at various places along the Dutch coast.

Table NL.g Annual indices of glass eel recruitment at places in the Netherlands, other than Den Oever. Annual indices are expressed as the mean catch per lift net haul, at whatever time in the night. Most hauls are made in the evening, just in the dark.

	Otheense Kreek	Bath	Krammer	Bergsche Diepsluis	Stellendam	Katwijk	IJmuiden	ship lock Den Oever	Harlingen	Lauwersoog	Nieuwstatenzijl	Termunten-zijl
Year / RBD	Scheldt	Scheldt	Meuse	Meuse	Meuse	Rhine	Rhine	Rhine	Rhine	Rhine	Ems	Ems
1969							47.30					
1970							31.50					
1971					15.40							
1972					4.10							
1973					13.10		32.80					
1974					22.80		119.30					
1975					13.90		66.80					
1976					11.30		73.10			14.40		
1977					42.10	130.25	159.20			28.40		
1978					42.10	30.23	131.70			83.90		
1979					27.30	3.23	176.00			66.20		
1980					45.10	171.60	101.50			80.30		
1981					47.30	31.65	113.90			55.10		
1982					11.30	4.13	20.80			17.40		
1983					14.30	2.10	15.60			15.10		
1984					3.80	23.62	11.40			7.10		
1985					8.70	6.67	1.00			25.20		
1986					6.40		4.70			1.30		
1987					9.80	14.00	7.70			52.00		
1988					7.60		3.50			0.50		
1989					4.40	3.67	1.60			12.10		
1990			0.30		11.30		4.70			5.00		
1991		5.90	0.10	1.41	1.70	5.10	2.00			6.30		0.30
1992		12.30	0.30	1.38	9.90	8.20	2.50		14.80	7.30		0.40
1993		17.50	0.30		5.20	13.50	1.60			20.80		1.40
1994		14.60	0.50	7.94	2.70	15.10	3.60		16.00	22.50		2.20
1995	0.50	15.70	0.30		3.20	27.10	13.10	27.80	6.80	11.60		3.00
1996	1.00	26.80	0.70		0.40	25.40	4.00	10.20	29.70	34.40	24.00	6.00
1997	0.00	40.40	0.40	33.33	2.50	10.90	1.30	10.20	12.40	20.90	21.00	10.60
1998	0.70	18.30	0.60		0.90	38.80	1.20	6.50	15.40	9.90	19.90	1.10
1999	1.20	23.10	0.60		1.00	101.30	1.60	5.60	12.70	15.10	11.80	7.50
2000	0.70	20.10	0.80	4.36	5.60	8.80	1.50	4.00	2.80	6.60	23.30	5.70
2001	0.50	(1.2†)	0.10	0.17	0.90	8.10	0.40	1.50	1.80	1.70	16.10	0.80
2002	0.00	13.60	0.40	0.25	3.70	9.80	0.05	1.00	2.20	3.40	35.30	0.90
2003	0.00	7.00	0.10		0.40	11.80	0.00	4.70	3.80	1.20	25.50	0.40
2004	0.00	(24.9†)	0.03		0.30	4.50	0.11	4.10	(4.9†)	1.70	21.70	1.20
2005	0.00	13.40	0.50		0.20	4.40	0.00	4.60	3.30	0.90	18.20	1.30
2006	0.00	9.70	0.21		0.02	1.33	0.07	0.28	0.48	1.39	8.33	1.13
2007‡	0.00	55.86	0.22		0.29	24.77	0.09	0.38	0.59	1.13	18.11	3.26
2008	0.00	10.49	0.00	3.91	0.01	4.31	0.06	0.38	0.71	2.54	12.36	1.00

† Sampling only took place in part of the season.

‡ Very early season (warm spring), sampling stopped early (start of May) --> low number of empty samples.

NL.G.2 Yellow eel stock surveys

NL.G.2.1 Yellow eel stock surveys in Lake IJsselmeer

Figure NL.16 presents the trends in cpue for the yellow eel surveys in Lake IJsselmeer, using the electrified trawl. The long-term trend in this survey has been analysed by Dekker, 2004a, in a wider setting, using more sources of information. In that long-term analysis, a smooth function over the years was fitted to the data. Figure NL.16 presents the raw data per year.

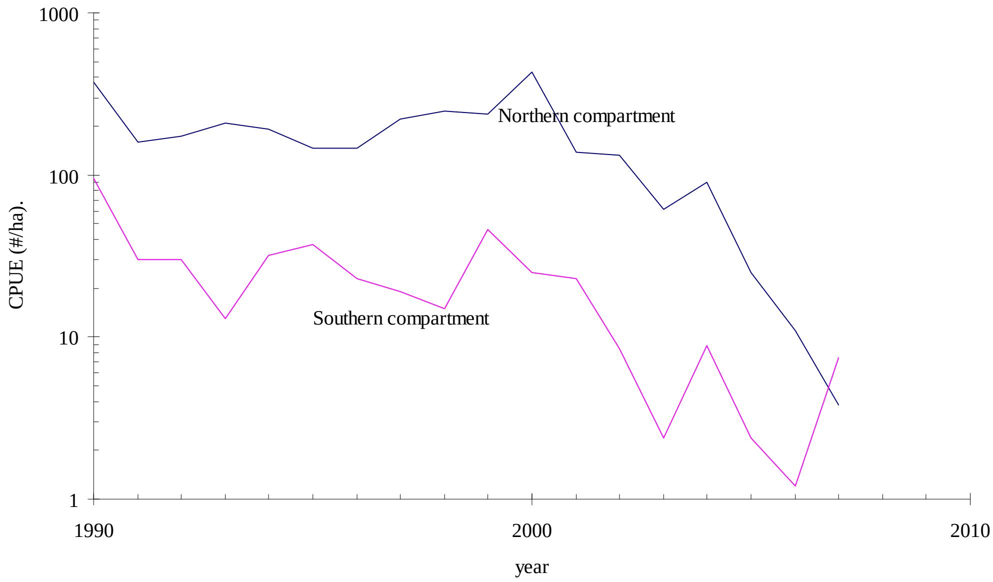


Figure NL.16 Cpue trends in Lake IJsselmeer stock surveys, in number per hectare swept-area, using the electrified trawl. Note: The northern and southern compartments are separated by a dyke.

NL.G.2.2 Yellow eel stock surveys in the Main Rivers

Figure NL.17 presents the trends in the Main Rivers survey, for the common trawl and the hand-held electric dipnet, for the main stream, the shore area, and the oxbow and other adjacent waters separately. None of these series demonstrates a clear upward or downward trend.

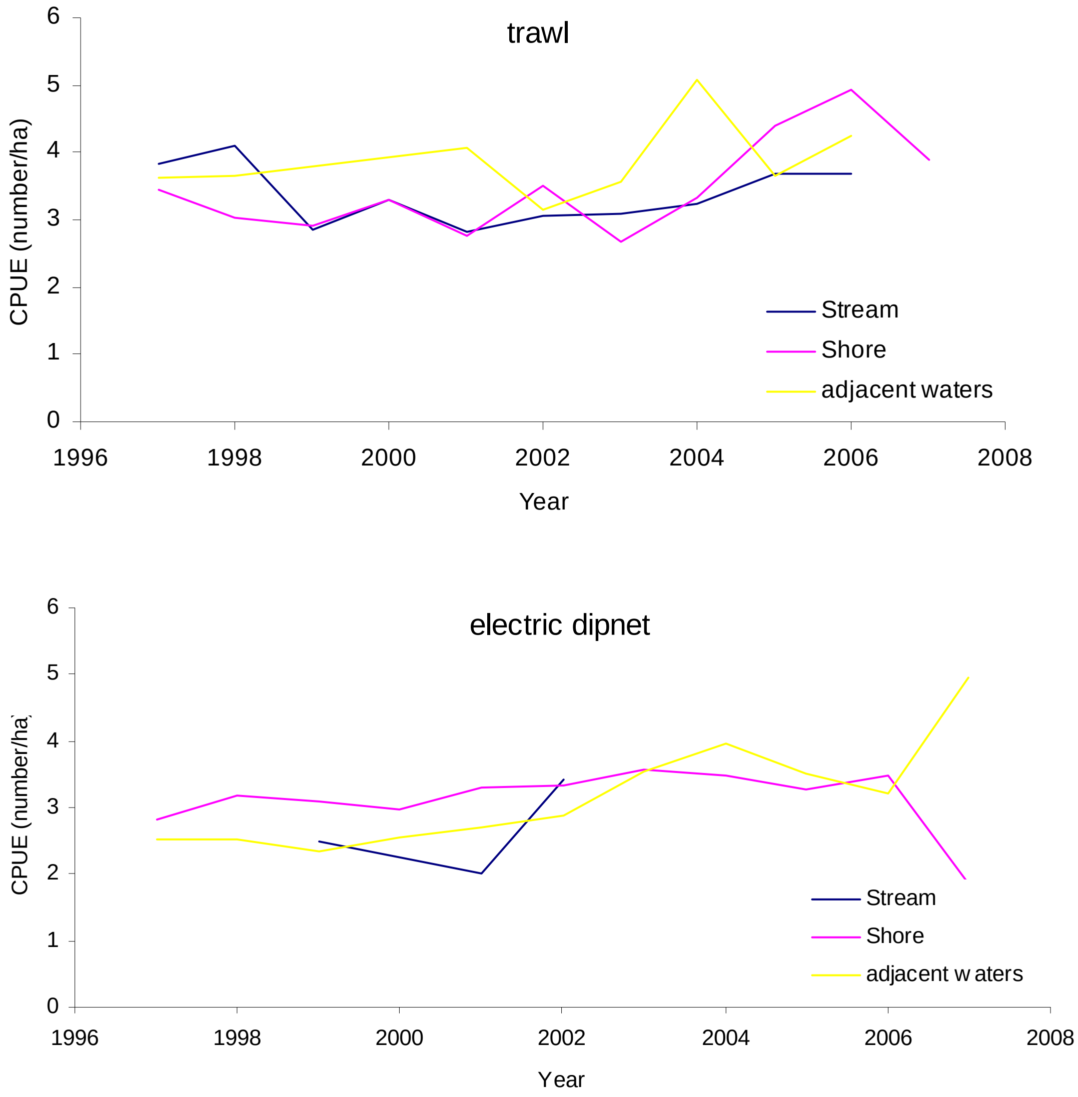


Figure NL.17 Trends in cpue in numbers per hectare, for the trawl (top) and electric dipnet (bottom), in the Main River surveys.

NL.G.2.3 Yellow eel stock surveys in coastal waters

The number of eels caught in coastal surveys (Dutch Young Fish Survey) is presented in Figure NL.18. Until the mid-1980s, considerable catches of eel were observed. Since that time, a gradual decrease is observed.

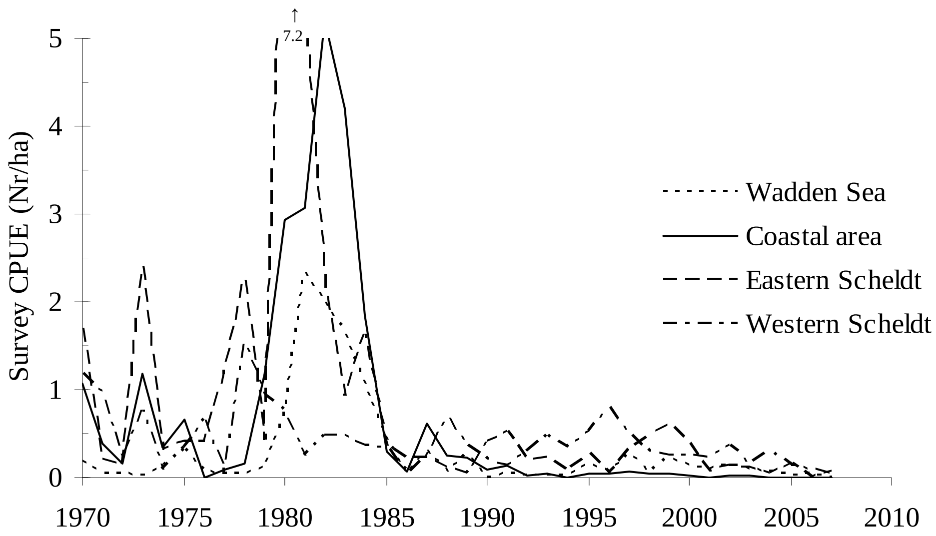


Figure NL.18 Trends in coastal survey cpue. Most of the Wadden Sea belongs to RBD Rhine; Eastern Scheldt is mixed Scheldt and Meuse; Western Scheldt belongs to RBD Scheldt (with an extra inflow from Meuse), Coastal area belongs to RBD Rhine.

Overall, the yellow eel surveys are not representative for the whole River Basin Districts or the Country, especially because the smaller water bodies (canals, polders, regional lakes) are not surveyed; these waters cover nearly 25% of the total water surface, but probably constitute the preferred eel habitat. Lake IJsselmeer is extremely overexploited; although fisheries in the remainder of the country are less severe, resulting in larger average sizes being exploited. The Main Rivers Surveys are probably reasonably representative for the rivers. However, Lake IJsselmeer and the Main Rivers differ substantially, and it is not quite clear how the two should be weighted, and how the uncovered waters relate.

NL.G.3 Silver eel surveys

There are no routine surveys for silver eel in the Netherlands.

In 2004–2007, the German states North Rhine-Westphalia and Rhineland-Palatinate, and the Netherlands have executed a silver eel tagging study in the Rhine, in order to:

- quantify the female part of the whole downstream migrating Rhine silver eel population independently from fisheries,
- determine the relevance of the different migration routes of these female migrants in the Lower Rhine, the mortalities during downstream migration and the escapement to the sea.

Results have been reported in

Klein Breteler, J., Vriese, T., Borcherding, J., Breukelaar, A., Jørgensen, L., Staas, S., de Laak, G., and Ingendahl, D. 2007. Assessment of population size and migration routes of silver eel in the River Rhine based on a 2-year combined mark-recapture and telemetry study. ICES Journal of Marine Science, 64: 1–7.

NL.H Catch composition by age and length

NL.H.1 Long term trends in length compositions

For Lake IJsselmeer, the landings are regularly sampled at the auctions. Results have indicated extreme overfishing. Because the catch composition did not change much over the years (see Figure NL.27), results have not been reported in detail for the past years.

In most recent years, length frequency distributions of commercial catches from Lake IJsselmeer have revealed a remarkable shift upwards (Figure NL.19). This shift is observed consistently in all gears, and in several years in a row. This upward shift might be the result of the effort reductions in 2005, of the further decline in recruitment since 2000 now progressing into the commercial sizes (corresponding to a sharp drop in commercial yield now observed), or of increased dependence on eels from other habitats (outside Lake IJsselmeer and/or hitherto unexploited habitats, such as dykes), which are less overexploited.

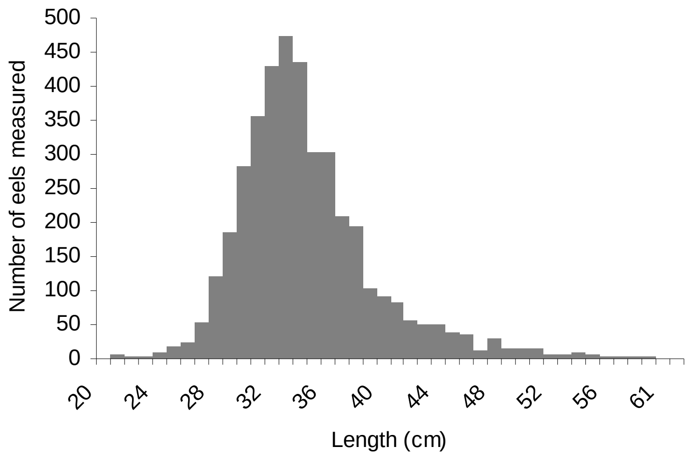


Figure NL.19 Length frequency of fykenet catches in Lake IJsselmeer, in 2006.

NL.I Other biological sampling

NL.I.1 Length and weight and growth (DCR)

For Lake IJsselmeer, the market sampling described under NL.H comprises measurements of length, weight, sex, maturity, liver weight, stomach content weight, parasitism (*Anguillicola crassus*), and otolith collection; see under NL.H. In addition to the market sampling, an annual sample of 100 specimens is collected during autumn stock survey on Lake IJsselmeer; see NL.G.2. This survey sampling conforms to the protocol for market samples (NL.H). For market and survey samples, otoliths are collected and stored dry, but no age reading is performed.

For all other areas, no biological sampling of catches is performed.

NL.I.2 Parasites

The market sampling for Lake IJsselmeer collects information on the percentage of eels demonstrating *Anguillicola* infection (Figure NL.11, based on inspection of the swimbladder by the naked eye). Following the initial break-out in the late 1980s, infection rates have stabilized between 40 and 60%, while the number of parasites per infected eel fluctuates between 4 and 6. In recent years, the infection rate and the parasite burden are slightly decreasing.

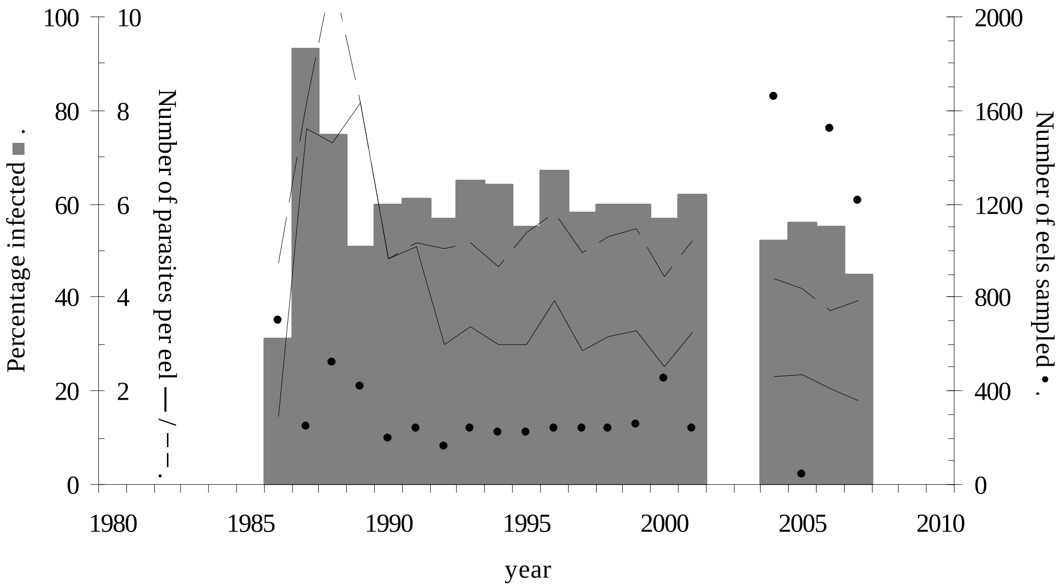


Figure NL.20 Trend in *Anguillicola* infections in Lake IJsselmeer eel.

NL.I.3 Contaminants

For a recent overview of contamination in eel in the Netherlands, see Hoek-Nieuwenhuizen and Kotterman, 2007 and Hoogenboom *et al*., 2007.

Nl.I.3.1 Spatial pattern

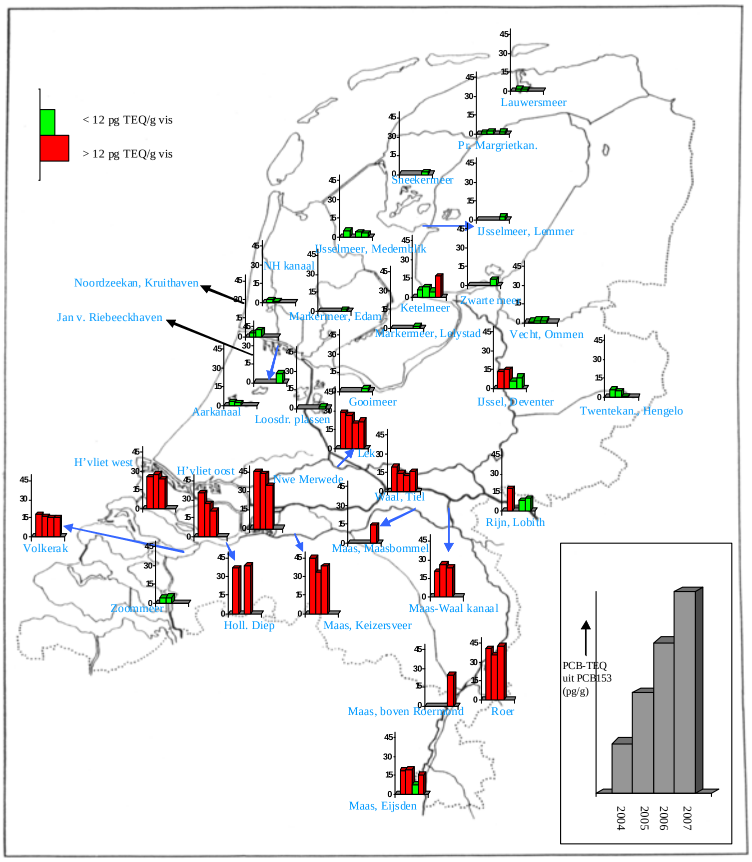


Figure NL.21 Temporal trend in PCB in eel (from Kotterman, 2007).

NL.I.3.2 Temporal trend

The temporal trend differs substantially between sampling locations, but overall a decline is observed. Figure NL.22 shows the trend in eels derived from Lake IJsselmeer.

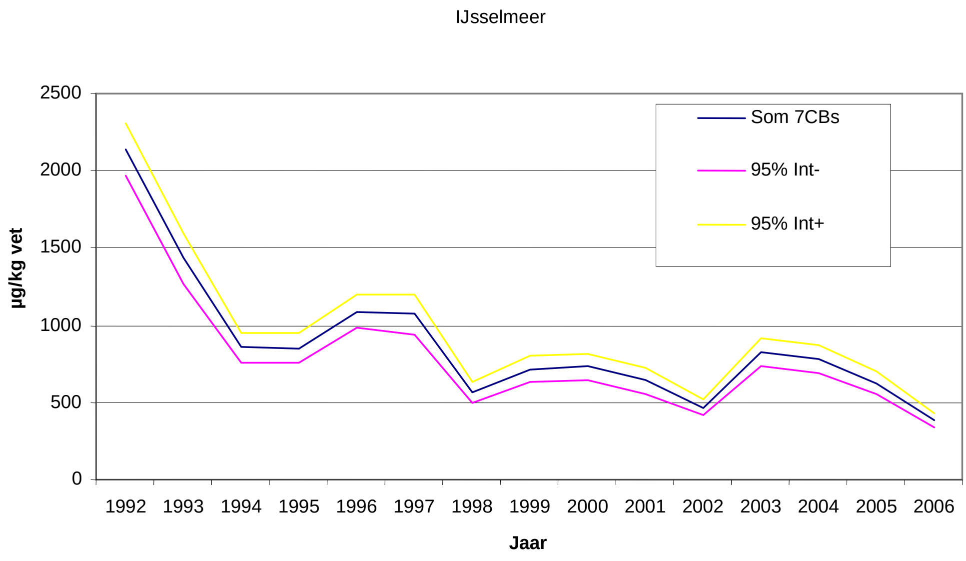


Figure NL.22 Temporal trend in PCB in eel (from Kotterman, 2007).

NL.I.4 Predators

Predation of eel by cormorants (*Phalacrocorax carbo*) is much disputed among eel fishers and bird protectionists. The number of cormorant breeding pairs increased rapidly until the early 1990s, then stabilized (Figure NL.23), remaining stable in recent years. For Lake IJsselmeer, food consumption has been well quantified (van Rijn and van Eerden, 2001; van Rijn, 2004); eel constitutes a minor fraction here. In other waters, neither the abundance, nor the food consumption is accurately known, but predation on eel appears to be a bigger issue here.

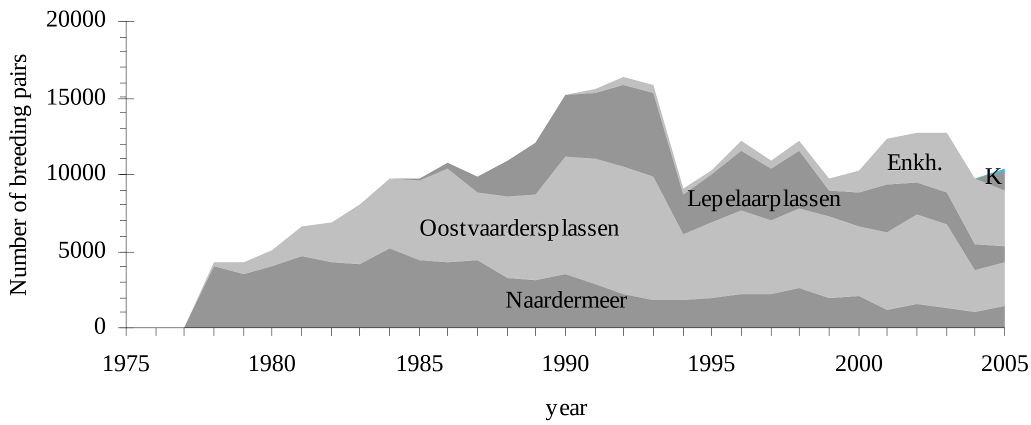


Figure NL.23 Trend in the number of breeding cormorants around Lake IJsselmeer, by breeding place. The breeding places are ordered from south (bottom) to north (top). Enkh=Enkhuizer Zand (de Ven), K=Kreupel.

NL.J Other sampling

NL.K Stock assessment

The basic results of the monitoring programmes in Lake IJsselmeer and the main rivers, the landings statistics and age-and-length sampling of the catch in Lake IJsselmeer are reported to the Ministry of Fisheries in annual status reports; salient details are published in the fishing press.

Dekker, 1996, 2000c developed a VPA-type assessment model for the eel fisheries on Lake IJsselmeer. This model has been applied to data from Lough Derg (Ireland) in the context of FP6-project 022488 SLIME (Dekker *et al.*, 2006).

Growth in eel demonstrates considerable inter-individual variation; individual year classes overlap almost completely in length. Additionally, fisheries, predation mortality (cormorants) and silvering are length-, rather than age-specific. The traditional age-structure of the VPA was therefore replaced by a length-structuring; a length-length transition matrix then replaces the conventional ageing process. Unfortunately, the retrospective application of this deterministic model yielded numerically unstable results (small glitches in the data causing huge shifts in outcome). Dekker, 2004a replaced the deterministic model by a statistical analysis, and included landings and catch-composition data as well as stock survey data. Although this cleared the numerical instability problem, results no longer match the status of the stock in individual years precisely, but reflect the overall trend over the years.

Initial assessment of the status of Lake IJsselmeer eel fishery indicated extremely severe overexploitation ($F \approx 1.0$; Dekker, 1996, 2004a). A 50% reduction in the nominal fishing effort in 1989 resulted in an effective drop in fishing mortality of only 25%. Although assessments were still available, further effort reductions in the 1990s have only loosely been related to monitoring and catch sampling results. In the mid-1990s, the quality of the landing statistics deteriorated, following the transfer of the registration from the Ministry of Fisheries to the Fish Board. Subsequently, the annual assessments have been discontinued. The latest formal management advice dates back to 2000 (an 80% reduction in fishing effort is required to obtain the maximal sustainable yield). Current fishing effort is in the order of 50% of that in 2000, and thus still well above the level of maximum sustainable yield. However, Dekker *et al.*, 2008 indicated that the fishing level F_{max} establishing the maximum sustainable yield MSY, is above the level at which the eel stock can be expected to recover (that is: F_{max} still establishes recruitment overfishing): only a further reduction in effort will be in accordance with the EU Eel Regulation. A preliminary estimate of the maximum acceptable effort is indicated in Figure NL.2, for the years 2009–2010.

NL.L Sampling intensity and precision

NL.L.1.1 Recruitment surveys

The glass eel survey at Den Oever collects between 200 and 500 hauls per year. The statistical properties of these data have been analysed by Dekker, 1998, 2004c, including the relation to environmental influences and sampling conditions. Above all, the relation between precision and (expected) mean catch determines the overall precision of the individual observations. Additionally, the number of observations per year is among others determined by the average catch: after several weeks without any glass eel, the motivation to continue sampling obviously declines, and the sampling programme is then closed. A lower precision of individual observations in combination with a smaller number of observations per year, results in a drastically expanded confidence limits of the annual mean.

(Since 2004, the sampling is no longer done by sluice personnel while on duty, but by people specifically hired for the job. They replaced the two-hourly sampling by hourly sampling, but did not extend the sampling season).

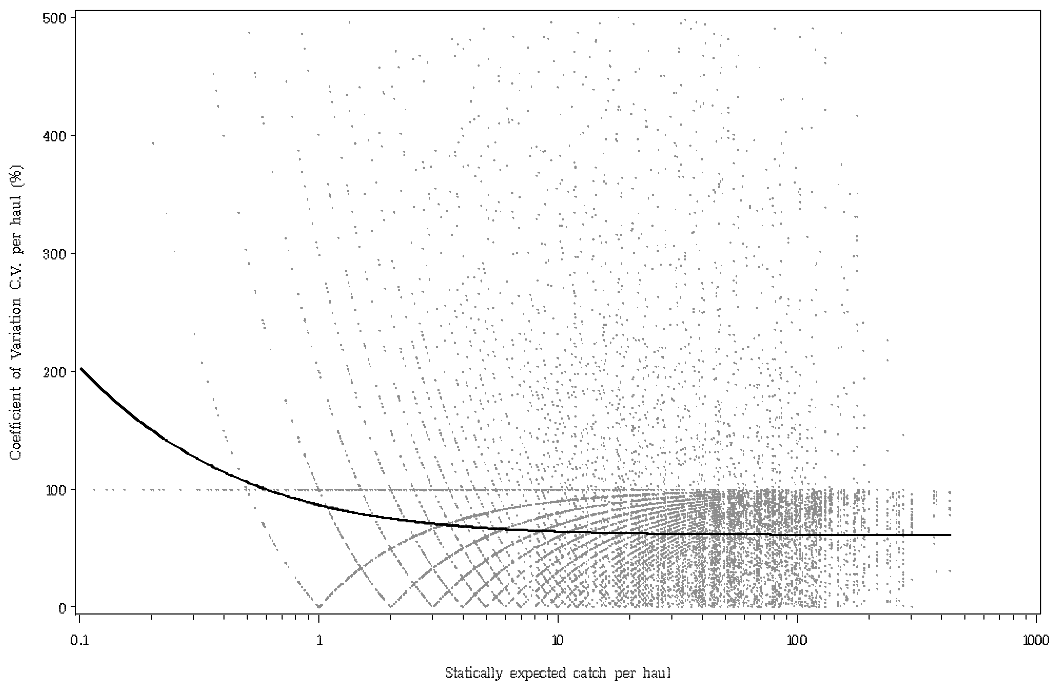


Figure NL.24 Relation between the statistically expected catch (horizontal) and the coefficient of variation (vertical) for the glass eel sampling at Den Oever. The dots represent the individual observations (one haul at a specific hour at a specific day), the line the functional relationship between residual and expectation (Var ∞ mean²+mean). Because the number of glass eels caught is an integer number (0, 1, 2, etc.), observations with 1½ or 2⅜ glass eels are lacking. Consequently, all observations of exactly 1 glass eel form a conspicuous V-shaped line (hitting the x-axis at 1), and all observations of exactly 2 glass eels too (hitting the x-axis at 2), etc. with no observations in between. The zero observations are on the horizontal line at CV=100%.

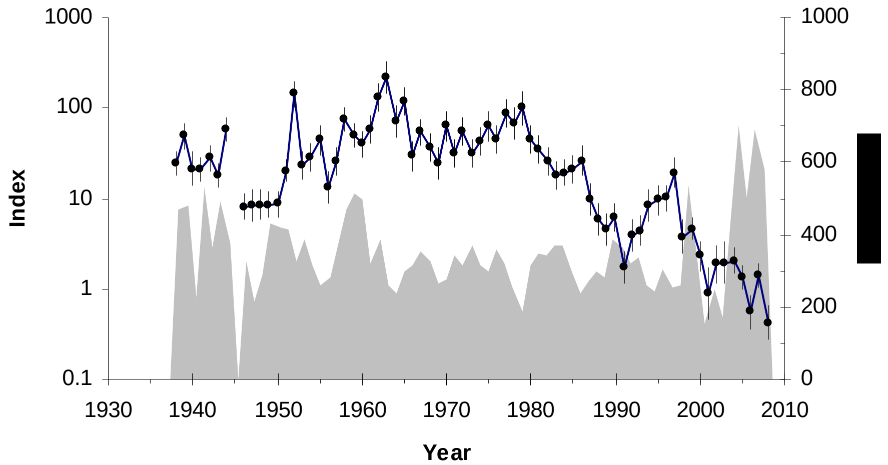


Figure NL.25 Time series of the recruitment series in Den Oever, presenting the index and confidence intervals (± 1 SD).

NL.L.1.2 Yellow eel surveys

The precision of the yellow eel surveys in Lake IJsselmeer has been analysed by Dekker, 1998. The same data contributed to the comprehensive analysis of historical data by Dekker, 2004a.

The precision of the yellow eel surveys in the main rivers has been analysed by Winter *et al.*, 2006.

NL.L.1.3 Length composition from market sampling

The spatial and temporal variation in market sampling of length compositions has been described by Dekker, 2005 before, leading to the following results:

NL.L.1.3.1 Spatial variation

The spatial variation in mean length of fykenet catches was analysed by Dekker, 2000a. For Lake IJsselmeer, the mean length varied irrespective of the distance between samples, while for other inland waters, the variation increased considerably from a distance of 10 km upwards (Figure NL.26).

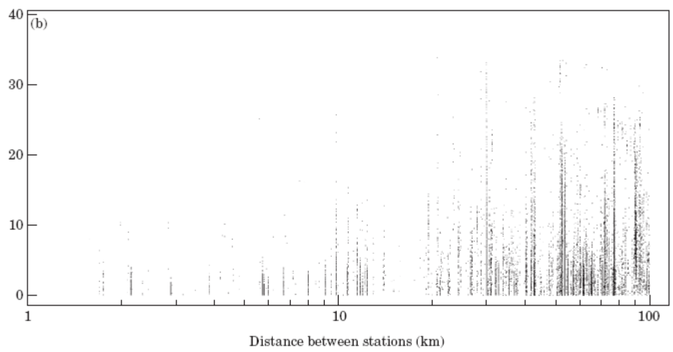


Figure NL.26 Variogram of mean length of yellow eel in fykenets, outside Lake IJsselmeer (Dekker, 2000a). The vertical axis demonstrates the difference in mean length between two samples, the horizontal axis the spatial distance between the two samples.

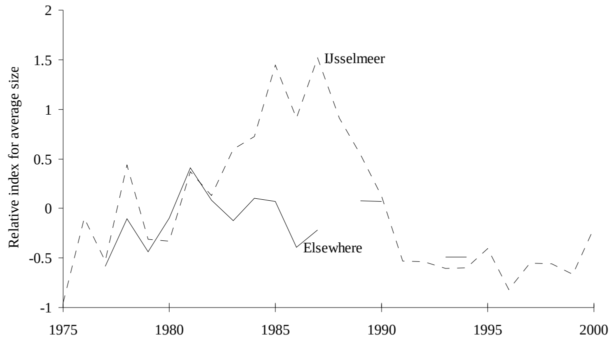


Figure NL.27 Relative change in size composition of eel landings. Positive values indicate a shift towards larger size classes. In Lake IJsselmeer, effort reductions and the recruitment failure in the 1980s initially shifted the length composition gradually to higher values. When the low recruitment had progressed into even the largest size classes, the mean size restored to normal values. Elsewhere, the data demonstrated less variability. Presumably, sampling ceased before the 1980s recruitment failure had progressed into the exploited length classes.

NL.L.1.3.2 Temporal variation

The temporal variation in length composition of Lake IJsselmeer eel catches was analysed by Dekker, 2000c in a VPA-type deterministic model, and in combination with survey data by Dekker, 2004a in a statistical model. However, the statistical properties of the sampling protocol were not highlighted.

Re-analyses of the length compositions of market samples from Lake IJsselmeer (Table NL.d), using the multinomial model of Dekker, 2004a indicates that 40% of the explained variance is accounted for by gear type and market selections, while the remaining 60% is related to temporal variation. The unexplained variance, however, is much larger, as usual. The temporal variation is largely as a consequence of year-to-year differences in length composition (Table NL.d, Figure NL.27**)**. From 1975 until 1987, a gradual shift towards larger sizes was observed; between 1987 and 1989, a rapid decrease occurred (Figure NL.27).

The quarterly and monthly variation in length composition is much smaller than the interannual variation, and very inconsistent over the years (interactions year*quarter and year*month exceed the main effects quarter and month).

Table NL.d Temporal resolution of market samples. Analysis of variance (type 1) in the length composition of market samples of legal sized eels from Lake IJsselmeer. Data since 1975; 1811 samples; 19 657 eels. See Dekker, 2004a for details on the data and statistical model.

SOURCE	DEVIANCE	D.F.	MS	F	P
gears	4200	5	840.08	632.31	<.0001
market selection	2020	2	1010.02	760.23	<.0001
√mesh	5	1	4.57	3.44	0.0637
year	6310	25	252.40	189.97	<.0001
quarter	32	3	10.81	8.14	<.0001
month	160	6	26.74	20.12	<.0001
year*quarter	1064	49	21.71	16.34	<.0001
year*month	1243	88	14.13	10.63	<.0001
explained	15 035	179	83.99	63.22	<.0001

residual	25 877	19 477	1.33
total	40 912	19 656	2.08

NL.L.1.3.3 Comparison of spatial and temporal variation

The variogram of Figure NL.26 (Dekker, 2000a) is based on sample mean lengths, grouped by decade. Re-analysing the same data, using the multinomial model of Dekker, 2004a allows a comparison of temporal and spatial variation. Figure NL.26 indicates that spatial processes apply at a spatial scale in the order of 10 km. Grouping the data in 10*10 km grid cells, and dropping the decadal grouping, results in a moderately sized model (Table NL.e). The spatial variation in length composition of the catches exceeds the temporal variation by more than a factor 20. However, this dataset was not designed for comparison of spatial and temporal variation; consequently, the colinearity is relatively large. The interaction between year and spatial grid, however, is relatively small, indicating that the time-trend was largely shared by all areas.

Table NL.e Comparison of temporal and spatial variation in market samples. Analysis of variance (type 3) in the length composition of market samples of legal sized eels, from areas outside Lake IJsselmeer. Data since 1975; 330 samples; 9871 eels. See Dekker, 2000a for details on the data, and Dekker, 2004a for details on the statistical model.

SOURCE	DEVIANCE	D.F.	MS	F	P
10*10 km grid	3876	27	143.55	106.37	<.0001
year	174	14	12.44	9.22	<.0001
colinearity	1738				
grid*year	645	28	23.03	17.88	<.0001
explained	5789	43	134.62	99.75	<.0001
residual	13 62	9827	1.35		
total	19 51	9870	1.93		

NL.L.1.3.4 f estimates

The analyses of variance presented in Table NL.d and Table NL.e are based on all historically available information. Therefore, these analyses are not fully representative for data collection under the Data Collection Regulation. However, the results do give an indication of the precision achieved (Figure NL.28). This indicates that the relative abundance of length classes can be estimated with a precision of slightly less than 10% for Lake IJsselmeer, respectively slightly less than 15% elsewhere. However, the consequence of this acquired precision on the assessment of the status of the stock and fisheries is not clear yet.

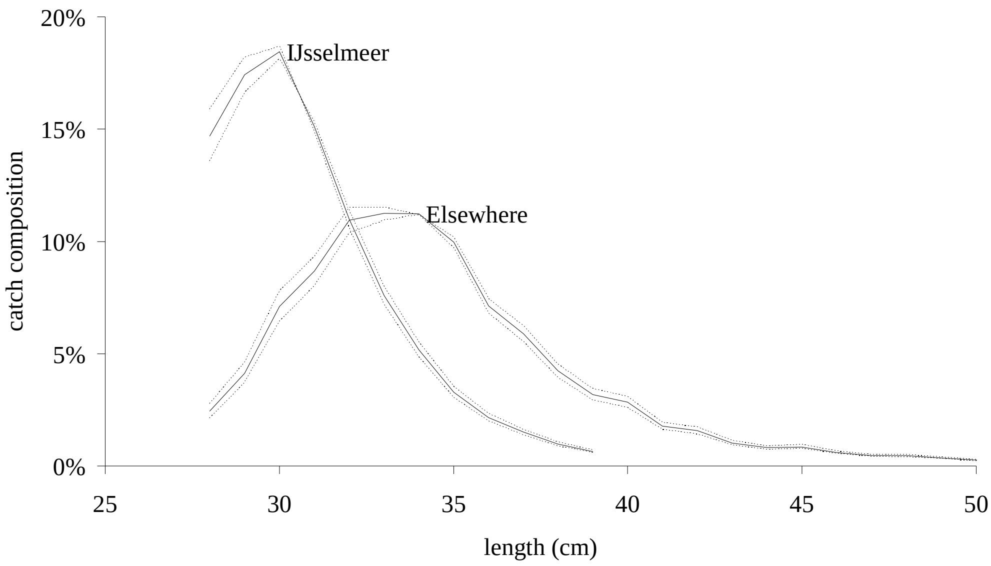


Figure NL.28 Average length composition of fykenet catches, with confidence intervals (±1 std), for Lake IJsselmeer and Elsewhere, based on the entire historical datasets. The presented length distributions conform to the situation in 1990.

Summarising the above findings:

1. the length composition of catches varies considerably between gears and market selections,
2. spatial variation at a 10-km scale plays a dominant role, but not in Lake IJsselmeer,
3. year-to-year variation is considerable, including gradual trends and sudden transitions,
4. within-year variation is small and inconsistent over the years,
5. spatial differentiation in time-trends appears to be weak, and
6. about 2/3 of the total variance remains unexplained.

NL.M Standisation and harmonization of methodology

Techniques and methods are standardized within the (marine and fresh water) institute, and are up to international quality standards (ISO 9000, DCR requirements). Eel specific topics are:

- Spatial distribution in scattered water bodies. Only the major water bodies (Lake IJsselmeer, main rivers) are sampled. For management of the stock and fishery, the existing policy is to decentralize responsibility to regional committees, but this policy will for the time being not be applied for the implementation of the eel management plan. Research is underway, to develop a regional approach to sustainable eel management.
- Ageing of eel: no ageing is performed yet.

NL.N Overview

The availability of data on eel stock and fisheries presented in this report is summarized in Table NL.f. Over all, the larger, State owned waters are reasonably documented, but the smaller regional waters are not. Within the framework of the development of a national eel management plan, research projects have been suggested, developing an adequate data collection framework for the regional waters too.

Table NL.f Overview of the data collection by area, described in this report. + = present, - = absent, +/- = incompletely present, (+) = present, but inadequate.

Area Item	Waddensea	IJsselmeer	Main Rivers	Zeeland, waters: open	closed	Smaller inland waters (lakes, polders, small rivers)
C capacity	+	-	-	+	-	-
D effort	+	+/-	-	+	-	-
E catch	+	+	-	+	-	-
F cpue	-	(+)	(+)	-	-	-
G surveys	+	+	+	+	-	-
H age/length	-	+	-	-	-	-
I sex, growth	-	+/-	-	-	-	-
J other sampling						
K assessment	-	(+)	-	-	-	-
L precision		+				
M methodology						

NL.O Literature references

Dekker W. 1991 Assessment of the historical downfall of the IJsselmeer fisheries using anonymous inquiries for effort data. *In*: Cowx I.G. (ed.) Catch Effort sampling strategies, their application in freshwater management. Fishing News Books, Oxford. pp. 233–240.

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Report on the eel stock and fishery in UK 2008

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Reporting Period: This report was completed in August 2008 for the ICES/EIFAC WGEEL 2008, held in Leuven, Belgium in early September. It must be noted that most of the data relating to 2008 are provisional and will not be finalized until complete catch and Her Majesty's Revenue and Customs (HMRC) trade data are obtained and records can be fully validated. In compiling the report, the previous year's data are routinely updated. Where revisions have been made from earlier reports, this is indicated in the text.

Contributors to the report: Peter Wood, UK Glass Eels, Gloucester, England.

UK.B Introduction

UK.B.1 Distribution of eel within England and Wales 2001–2007

Routine electric fishing surveys for coarse fish and salmonids conducted by the Environment Agency (EA) from 2001 to 2007 demonstrate eels are present in nearly all river systems in England and Wales (Figure 1). There are some areas where eels are scarce or absent, particularly the upper reaches of rivers, though some lower reaches of rivers appear devoid of eel while the species is present further upstream. This may result from different survey techniques being utilized across a catchment. Eel were present in 43–51% of the survey samples during this period.

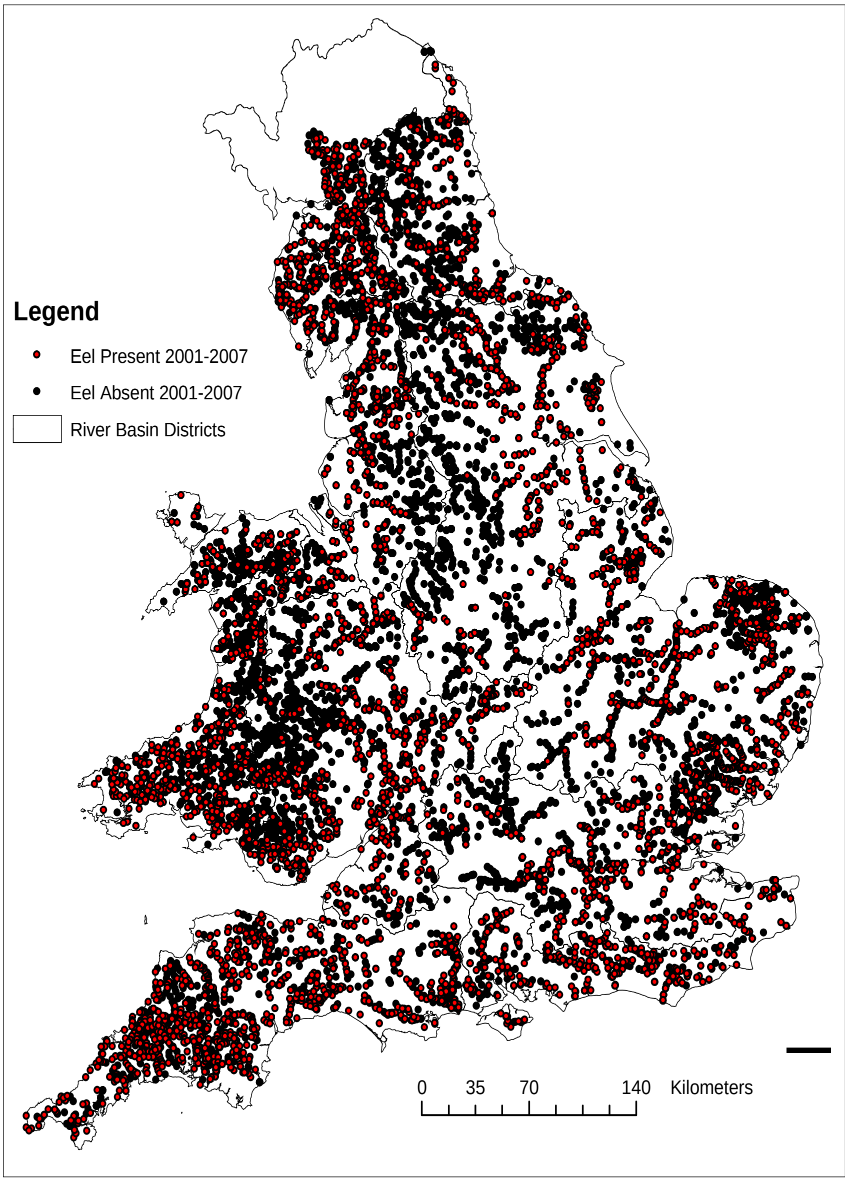


Figure 1. Environment Agency data on eel presence and absence in England and Wales, 2001–2007.

The Environment Agency is responsible for the management of eel fisheries in England and Wales. Annual licences are issued for a single region and are not transferable other than where estuaries are shared by more than one Environment Agency region (the Thames Estuary, for example). Fisheries are managed by national and local byelaws. National Eel Fishing Byelaws introduced in 2004 authorize the use of six instruments for eel fishing: permanently fixed traps (e.g. weir or rack traps and 'putts'); moveable or temporary nets or traps without leaders or wings and with an opening with a maximum diameter of less than 75 cm; moveable or temporary nets or traps with leaders or wings with an opening with a maximum diameter of less than 100 cm (usually fykenets); large fykenets used on the River Severn (Gloucester wing nets), not exceeding 25 m in length and with leaders of up to 7 m; eel trawlnets and elver (glass eel) dipnets. Recreational angling is permitted using rod-and-line. Appendix 1 in the 2007 UK report provides a summary description of netting and trapping methods used to catch eels in the UK.

The National Eel Byelaws also stipulate that all eel (apart from glass eel) less than 300 mm in length must be returned to the water, that no part of any net, wing or leader shall be made of a mesh greater than 36 mm stretched mesh, and that monofilament material is prohibited (except for an elver dipnet or fishing with rod-and-line). It is also a requirement that nets set in tidal waters should not dry out, unless they are checked just before they do so, and that nets should not cover more than half the width of the watercourse, or should not be set closer than 30 m apart (apart from in stillwaters and tidal waters). All fykenets must be fitted with an otter guard (a 100 mm square mesh hard plastic frame, fitted in the mouth of the first trap, to prevent otters becoming trapped in the nets). No fishing is allowed within 10 m upstream and downstream of any obstruction. Elver dipnets must be used singly, by hand and without the use of ropes, nets, chains, floats or boats.

Every licensed instrument must carry an identity tag issued by the Environment Agency and it is a legal requirement that all eel fishers submit a catch return. Licences are required to give details of the number of days fished, the location and type of water fished, and the total weight of eel caught and retained, or a statement that no eel have been caught. Fixed traps can be used across the whole of England and Wales, except the North East Region, non-tidal rivers in Devon and Cornwall, or in the Border Esk, while small wingless traps and winged traps can be used across the whole of England and Wales except in non-tidal rivers in Devon and Cornwall and parts of North East Region. Gloucester Wing nets can only be used in the River Severn, and eel trawls are restricted to a box in the outer Thames Estuary (but they no longer operate). The glass eel fishery is restricted to two zones in parts of Wales and the North West and South West of England.

UK.B.2 Distribution of eel within Northern Ireland

Lough Neagh in N. Ireland is the largest fresh-water lake in the UK. Prior to 1983, estimates of annual recruitment of glass eel to the Lough consistently exceeded 6 million and averaged in excess of 11 million (based on a mean weight of 3000 kg^{-1}). Productivity is such that the Lough sustains a large population of yellow eel and produces many silver eels that migrate via the out-flowing Lower River Bann.

The system sustains the largest remaining commercial wild eel fishery in Europe, producing 25% of the total recorded EU wild catch and supplying 3% of the entire EU market. Fishing rights to all eel life stages are owned by the Lough Neagh Fishermen's Co-operative Society (LNFCS). The fishery is managed to allow the capture of approximately 250–350 t of yellow eel and 75–100 t of silver eels annually, with an escapement of silver eels at least equivalent to the catch of silvers. Whilst it is illegal to fish for glass eels in N. Ireland, provision is made whereby staff from the LNFCS is allowed to catch glass eels using drag nets below a river-spanning sluice gate, which creates a barrier to upstream juvenile eel migration, for onward stocking into L. Neagh. Elvers are also trapped at the same location and stocked into the Lough.

The yellow eel fishery (May–September, 5 days a week) supports 80–90 boats each with a crew of two men using draft nets and baited longlines. Eels are collected and marketed centrally by the Co-operative. Around 300 families derive and depend on income from the fishery. Through the Co-operative, yellow eel fishers are paid the market price for their catch. Silver eels are caught in weirs in the Lower River Bann. Profit from the less labour-intensive silver eel fishery sustains the management of the whole co-operative venture, providing working capital for policing, marketing and stocking activity and an out of season bonus payment for yellow eel fishers at Christmas.

Natural recruitment has been supplemented since 1984 by the purchase of glass eel. Approximately 77 million additional glass eel have been stocked by the LNFCS. Reviews on the fishery, its history and operation can be found in Kennedy, 1999 and Rosell *et al.*, 2005.

The cross-border Erne system is comparable in size to L. Neagh and produces a fishery yield in the region of 35–50 t of eels per year. Within N. Ireland, Upper and Lower Lough Erne sustain small-scale and declining yellow and silver eel fisheries. Elvers are trapped at the mouth of the River Erne using ladders placed at the base of the hydroelectric facility that spans the Erne, and trucked into the Erne lake system for stocking. A comprehensive study into the structure, composition and biology of the eel fisheries on the Erne was conducted by Matthews *et al.*, 2001.

Overall policy responsibility for the supervision and protection of eel fisheries in Northern Ireland, and for the establishment and development of those fisheries rests with the Department of Culture, Arts and Leisure (DCAL).

Summary of management measures for eel fisheries in Northern Ireland:

- Ban on glass eel fishing (other than for stocking);
- Trapping and transport of juveniles on the Erne system;
- Restricted access to the fisheries through a system of licence, permits and seasonal closures;
- Minimum landing sizes (30 cm, though fisheries impose voluntary 40 cm);
- Technical measures associated with fishing gears;
- Closure of the Department-owned silver eel fishery on the Erne as a conservation measure;
- Free gaps (10%) in silver eel fishing weirs.

In addition to the above, the LNFCS has in place:

- Trapping and transport of juveniles on the Bann;
- A quota system on yellow eel catch;
- Restocking with purchase of supplemental glass eel;
- Ban on the use of fykenets;
- Suspension of two silver eel fisheries on the Lower River Bann.

UK.B.3 Distribution of eel within Scotland (1996–2006)

Electrofishing surveys by the Fisheries Trusts in Scotland (from 1996–2006) indicate that the eel is widespread in Scotland (Figure 2). These surveys were primarily targeted at salmonids. Eels appear absent from many of the upper reaches of rivers, likely as a consequence of difficulties of access. Data are currently available only for the Scotland River Basin District (excluding areas of Galloway and the Tweed in the South). In all 6651 electrofishing visits were made to 3645 sites. Eels were present at 39.7% of visits, and recorded as present on more than one visits at 44.3% of sites.

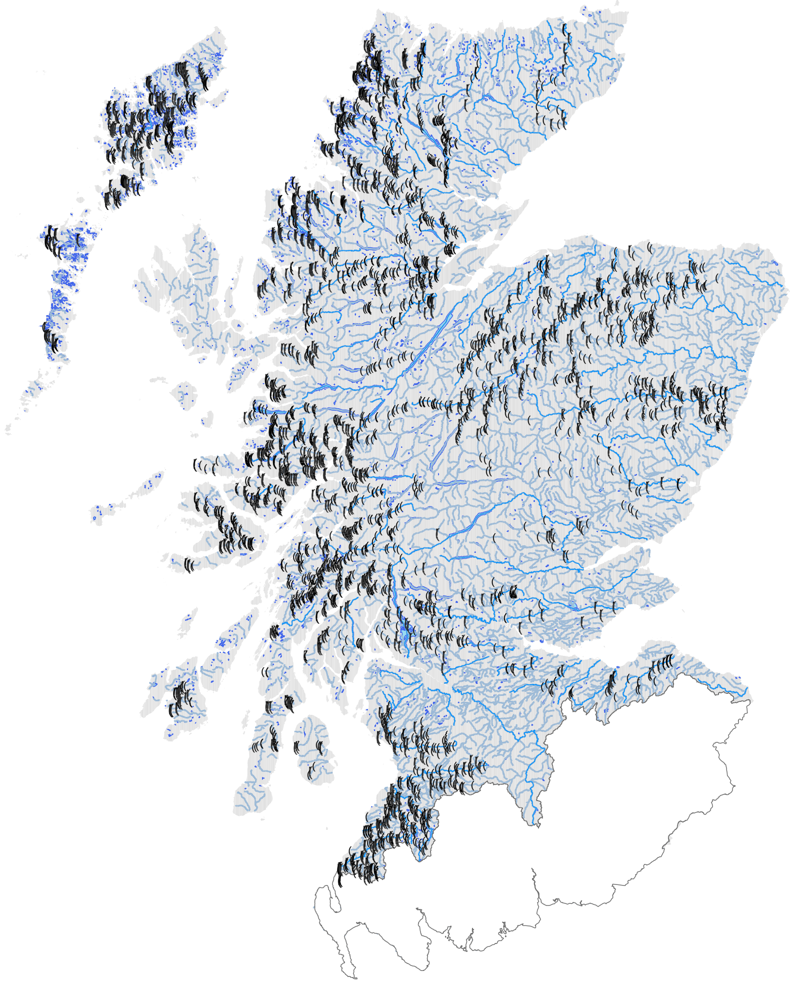


Figure 2. Eel presence (•) or absence (◦) for sites electrofished by the Fisheries Trusts in Scotland RBD (1996 to 2006). Where sites were visited more than once, eels appear as present if they were reported at the site on any occasion.

UK.C Fishing capacity

UK.C.1 England and Wales

All life stages of eel are exploited in England and Wales by approximately 1000 eel fishers using altogether around 2500 licensed instruments. At present, there is no legislative mechanism to limit the number of licences. The main fisheries are for glass eel by dipnets (654 licences in 2008), in estuaries draining into the Bristol Channel, in particular from the Rivers Severn, Wye and Parrett, with smaller fisheries, such as that in

Morecambe Bay, Cumbria (Figure 3). The main fisheries for eel >300 mm are based in southern and eastern lowland England, with fykenets being the preferred instrument used for capturing yellow and silver eel (Figure 3).

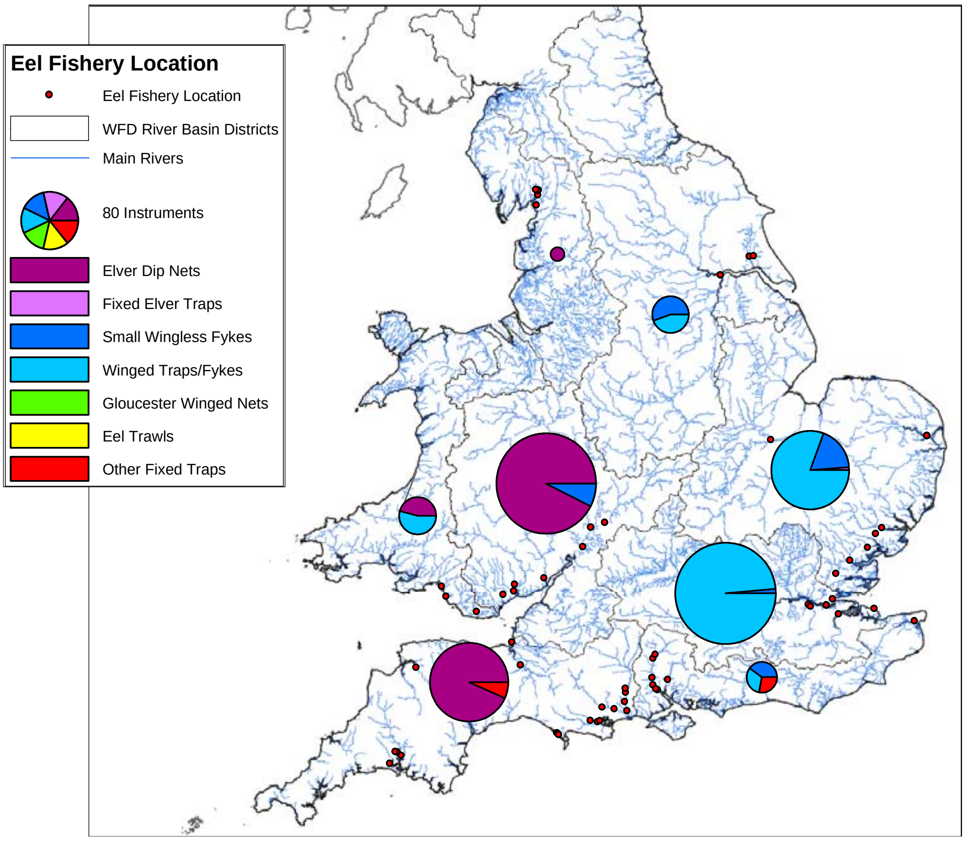


Figure 3. Eel and Elver Fisheries in England and Wales. Proportional size pie charts representing number of each instrument type in each WFD River Basin District.

UK.C.2 Northern Ireland

L. Erne

Fishing capacity is measured in the number of licensed instruments (by type of gear) and is an individual activity with no regulating company. Currently there are 14 commercial fishers operating on this catchment, with 14 eel permits (11 longline and three fykenets) issued. Boat size on the Erne is restricted to 6.1 m long by 2.2 m at the widest point. Licence applications are approved by the fishery owner (DCAL) and are issued on the condition that a catch declaration is returned at the end of each year. All of these catch data are held within DCAL Inland Fisheries Division. The elver run to the River Erne is monitored by capture at a box at the tidal head and transported to upper and lower Lough Erne. Silver eel fisheries let by the State on Lower Lough Erne have been suspended since 2005.

L. Neagh

Lough Neagh/River Bann comprises a 400 km^2 lake-based system, which produces around 95% of the total Northern Ireland eel catch. Eel fishing on L. Neagh is controlled by a Registered Company, the LNFCS who licence the fishery to 180 fishers. Around 1990, there were 200 boats fishing the Lough, but this number has steadily declined to the present day number of 80 to 90 boats as a result of an aging fisher population, availability of alternative employment and falling market prices for eel. Boat size on L. Neagh is restricted to 8.6 m long and 2.7 m wide. Information on licence applications, number of boats, fishing activity, recruitment to the fishery and the catch of yellow and silver eels from L. Neagh is collected and maintained by the LNFCS with several aspects of these data spanning 40 years. This information is made available to DCAL and the Agri-food and Biosciences Institute (AFBI) for scientific analysis.

UK.C.3 Scotland

Historically there has been no regulation of commercial eel fisheries in Scotland, no licenses were issued and there was therefore no means of collecting catch return data. There is no export of any eel product and therefore no proxy values for recruitment or home or international market trends.

However, early in 2007, provision was made by the Scottish Parliament to allow for the regulation of eel fisheries if Scottish Ministers considered it necessary or expedient for eel conservation (see: http://www.scottish.parliament.uk/business/bills/67aquaFish/b67s2-introd.pdf).

UK.D Fishing effort

UK.D.1 England and Wales

Fishing effort is not directly quantified, but annual licence sale data from the EA and predecessor agencies provide an index from which we can examine changes in apparent effort over time.

Glass eels and elvers

Around 1100 glass eel/elver licences (dipnets) were sold each year from 1980 to 1994, which increased rapidly to peak at nearly 2500 in 1998, declined to about 800 in 2001, and have since remained around this level (Figure 4). The rapid increase in sales of licenses in 1995–2000 was likely as a consequence of substantial increases in the market value of glass eel from about £100/kg to over £250/kg, as a consequence of extra demands from eel farms in the Far East. Fishing activities were depressed during the 2001 Foot and Mouth Disease outbreak because of restrictions imposed on access to fishing sites and licence sales have not recovered.

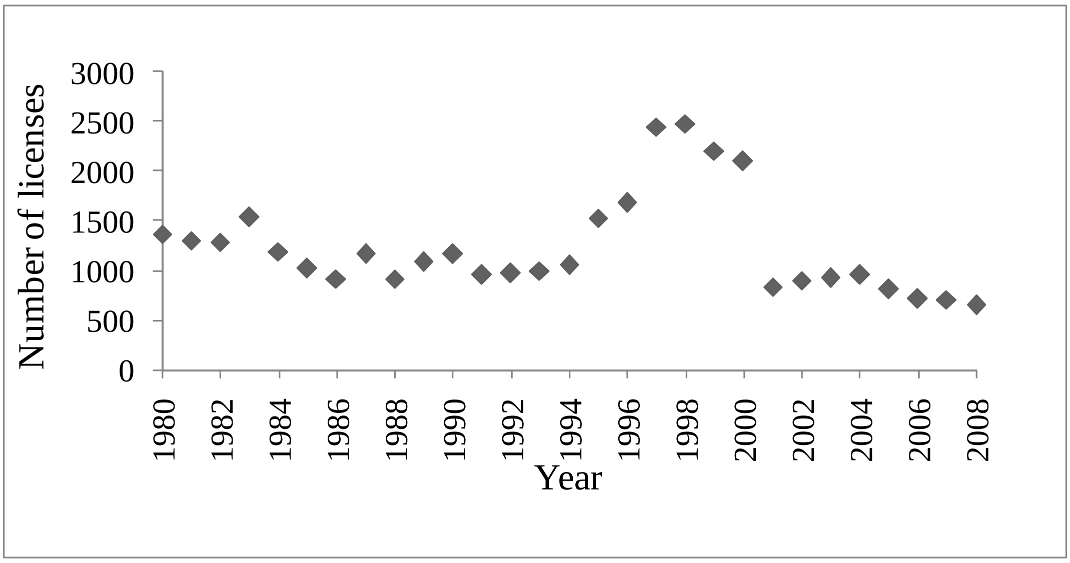


Figure 4. Number of licenses sold per year across England and Wales for dipnet fishing for glass eel, 1980 to 2008 (Agency data).

Yellow and silver eels

Environment Agency sales of yellow and silver eel licences (combined) have varied from around 1100 to 2900 over the period 1983–2007, with highest sales in the mid-1980s, mid-1990s and again in 2005 to 2007 (mean 2622) (Figure 5).

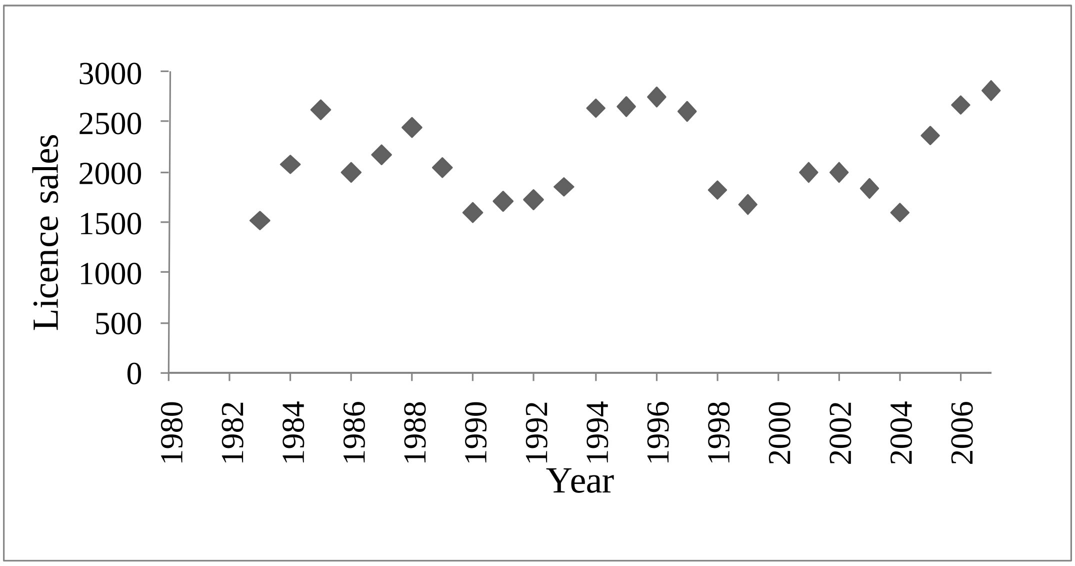


Figure 5. Number of licenses sold per year across England and Wales for yellow and silver eel fishing, 1983 to 2007 (Agency data).

UK.D.2 Northern Ireland

The capture of glass eel and elvers is prohibited in N. Ireland, except under licence from DCAL to help with upstream migration past in-river obstacles on the River Bann.

In N. Ireland, fykenets, longlines and draft nets are authorized fishing instruments for yellow eels. Silver eels are trapped at fixed weirs using large coghill nets (the 2007

UK Report: Appendix 1 provides a description of net and trap methods).

L. Erne

Fifteen longline licences were issued in 2007 and each fisher is allowed to fish a longline not exceeding 1200 hooks of a standard hook size 23 mm long, 7.75 m gape. Four fykenet licences were issued in 2007 and a fisher is not eligible to fish fykenets and longlines simultaneously. Each fykenet licence permits the holder to use 60 fykenets (not exceeding 7.3 m in length, a trap at each end on which no hoop shall exceed 50 cm in diameter and no mesh size of less than 12 mm knot to knot). There is no obligation for a fisher to use a logbook to record his catch, but it is a condition of the licence to report the total catch at the end of each year. Catches are sold to travelling eel dealers who are also required to make annual returns. The small silver eel fishery in the Erne River has been suspended since 2005.

L. Neagh

Glass eel fishing on the River Bann for stocking into L. Neagh is carried out using a drag net with an area of 0.94 m^2. A record of total catch per night is recorded, but not of catch per individual net. Thirty per cent of the L. Neagh yellow eel catch is derived from draft nets, the other 70% from longline fishing using a maximum of 1200 standard sized hooks baited with either earthworms, fish fry or the larvae of the flour beetle (meal worm). The fishery is run on a quota based system (normally 60 kg per boat per day) and a log is kept of each individual boat's daily (Monday–Friday) catch. However, as most fishers catch their quota every day, the catch is not limited by the size of the eel population, and it is not appropriate to calculate cpue. New technologies such as hydraulic draft net haulers have been introduced over the last 10 years, thereby reducing the labour needed in the fishery. Daily catch statistics and division by method are recorded by the LNFCS.

Silver eel catch is taken by three weirs at two locations using coghill nets. The number of coghill nets fished depends on weather and flow conditions in the river at the time of fishing and normally ranges from 2–4 nets per fishing night. The record of nightly catch is only obtained if the catch is processed and sold the following day, otherwise catches are retained in tanks, processed and sold as and when market conditions are more favourable, and therefore a 'single' catch record may be a total for several nights fishing.

UK.D.3 Scotland

Glass eel fisheries and recruitment

In survey in the early 1970s no elver fisheries were recorded in the Scottish Highlands and Islands (Williamson, 1976). During the mid-late 1990s there was a short period of exploitation, in response to the rise in demand and thus prices. Catches were estimated at 1–2 t per annum, mainly from the North West and Outer Hebrides. Present levels of exploitation are unknown.

There have been no studies of glass eel recruitment in Scotland, although there is some interest in establishing traps on some systems as a means of monitoring recruitment.

Yellow eel and silver eel fisheries

Commercial fisheries for yellow eels are largely based in low-lying productive lochs, the eels being sold mainly to local smoke houses. There is no tradition of eel consumption in Scotland. During the 1960s–1970s, eel catches in Scotland were estimated at around 10–40 t per annum. In 1989, 17 eel fisheries were operating, with catches ranging from 0.25 to 10.76 t (total: 23 t) (I. McLaren, FRS, unpublished data). Correspondence with proprietors of eel fisheries in 2003 indicated a catch of less than 2–3 t per annum, chiefly yellow eels, with silver eels contributing less than 100 kg, mostly from traps in mill-races. Although there are few comprehensive records, data for one silver eel fishery demonstrate a 90% decline in catches between the early 1990s and 2002, although a yellow eel fishery was established in the upstream loch during the same period. The last known commercial yellow and silver eel fishery in Scotland ceased operation in late 2006, and today, catches of silver eels are largely destined for research purposes.

It is concluded that eel exploitation in Scotland is at its lowest level in the recent past, with fishing for silver eels and glass eels/elvers in particular being less than a few hundred kg per annum. Fisheries for yellow eels probably amount to little more than 2 t per annum.

UK.E Catches and landings

UK.E.1 England and Wales

Glass eels and elvers

The glass eel/elver catch reported to the Environment Agency for 2008 (0.23 t) is the lowest on record since 1972, and continues the very low trend since 2001 (Figure 6, Table 1). In comparison, reported catches in the 1970s and 1980s ranged between 10 and 70 t (Figure 6, Table 1). However, comparison of these reported catch data with net exports from HM Revenue and Customs (HMRC) data for England and Wales suggests a significant level of underreporting to the Agency, by between 5 and 15 times, which varied between years.

HMRC data are collected for trade in live, chilled, smoked and frozen eel separately, but the records do not distinguish between life stages. For the purposes of the analyses reported here, therefore, trade records are assigned as glass or yellow/silver eel based on their unit value: values greater than £200 per kg are classed as glass eel, those less than £10 per kg are classed as yellow and/or silver eel, and intermediate values are classed as mixed batches. Glass eel are imported into England from France and Spain throughout the winter season (typically November to March) and subsequently re-exported (HMRC data). By subtracting imports from exports and adding the quantities of glass eels sold for stocking Lough Neagh in Northern Ireland, the UK catch of glass eel is estimated from the net export. Neither of these datasets is particularly robust, but they do yield useful information and provide proxy estimates of recruitment and of home and international market trends (Knights *et al.*, 2001; Knights, 2002).

Based on these HMRC data, it is estimated that the glass eel catch in England and Wales averaged 10.4 t in 2003–2006 (Figure 6). The trade data for 2007 include a large proportion of trades with intermediate values and, therefore, it is not possible to include a robust trade figure for 2007 in the dataset. Peter Wood (UK Glass Eel) estimated that about 8–10 t of glass eel were landed across England and Wales (B. Knights, pers. comm.).

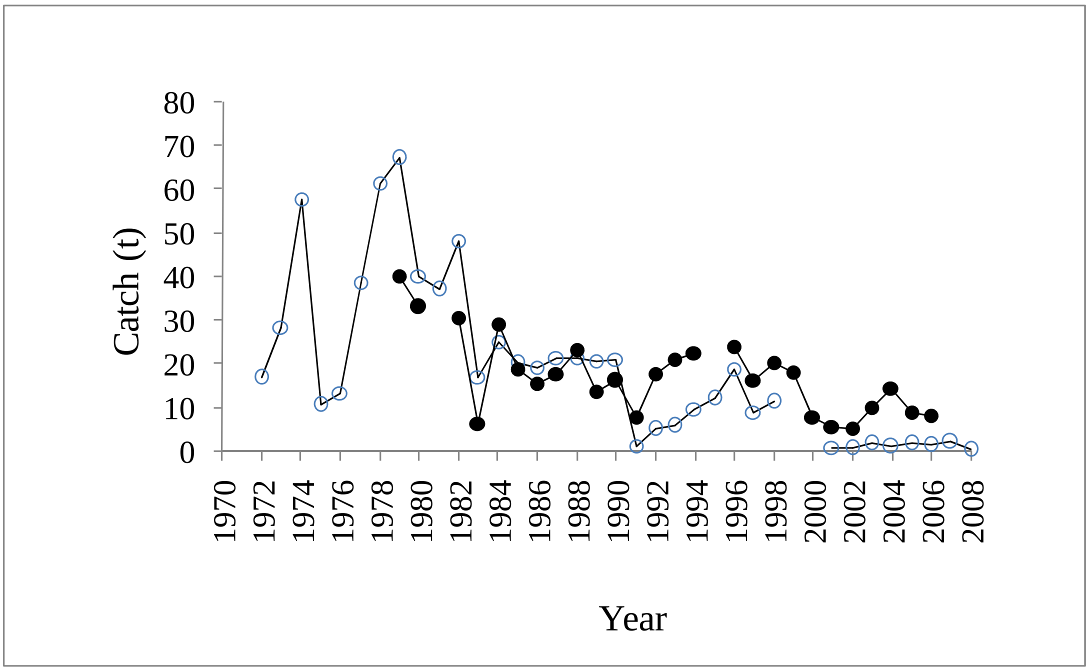


Figure 6. Trends in UK glass eel/elver catches reported to the Environment Agency in t (open circles), and derived from HMRC net export data (closed circles) from 1972–2008.

Both datasets demonstrate a general decreasing trend in both glass eel catches. Considerable between-year variations in these data preclude meaningful analyses based on period means. A more simplistic comparison is between maximum catch levels in the late 1970s and early 1980s and minimum levels in the 2000s. This suggests that the catch reported to the Agency has declined by at least 98% and the HMRC net exports by 75% (but see Section UK.F).

Table 1. Glass eel/elver catch and cpue estimates for England and Wales, based on catch reports to the Environment Agency, and HMRC net export data, 1972–2008. na = data not available. Note, HMRC data not available for 2007 or 2008 as a consequence of data: the 2007 HMRC data presented in the 2007 UK report were provisional, but could not be verified.

	Catch estimates based on		Licence sales	CPUE	
	Defra/EA	HMRC Nett Exports		HMRC/EA	
Year	t	t	No. dip-nets	kg/net	£/net
1972	16.70				
1973	28.20				
1974	57.50				
1975	10.50				
1976	13.10				
1977	38.60				
1978	61.20				
1979	67.00	40.10			
1980	40.10	32.80	1367	23.99	121
1981	36.90	na	1303	na	na
1982	48.00	30.40	1288	23.60	187
1983	16.90	6.20	1537	4.03	49
1984	25.00	29.00	1192	24.33	162
1985	20.00	18.60	1026	18.13	245
1986	19.00	15.50	917	16.90	330
1987	21.30	17.70	1162	15.23	384
1988	21.40	23.10	918	25.16	861
1989	20.60	13.50	1087	12.42	804
1990	20.90	16.00	1169	13.69	986
1991	1.10	7.80	960	8.13	625
1992	5.00	17.70	969	18.27	1335
1993	5.73	20.90	1000	20.90	1959
1994	9.50	22.30	1058	21.08	1304
1995	11.90	na	1530	na	na
1996	18.80	23.90	1682	14.21	1480
1997	8.70	16.20	2450	6.61	821
1998	11.20	20.10	2480	8.10	1113
1999	na	18.00	2207	8.16	1012
2000	na	7.60	2100	3.62	na
2001	0.81	5.40	838	6.44	1021
2002	0.52	5.10	899	5.67	na
2003	1.72	10.00	922	10.85	1213
2004	0.97	14.40	957	15.05	709
2005	1.70	8.80	812	10.84	1836
2006	1.27	8.20	719	11.40	1789
2007	2.05	na	705	na	na
2008	0.229	na	654	na	na

Yellow and silver eels

EA returns for yellow and silver eel fisheries (combined) for 2007 (18.9 t) continue at the low level since 2001 (Table 2, Figure 7). As with the glass eel/elver reported catches, however, these reported data are likely underestimates (by ~ 6 times) of the true catch when compared with net exports from HMRC data for England and Wales. The annual HMRC net export of yellow and silver eels has averaged 125.6 t over the period 2003–2007.

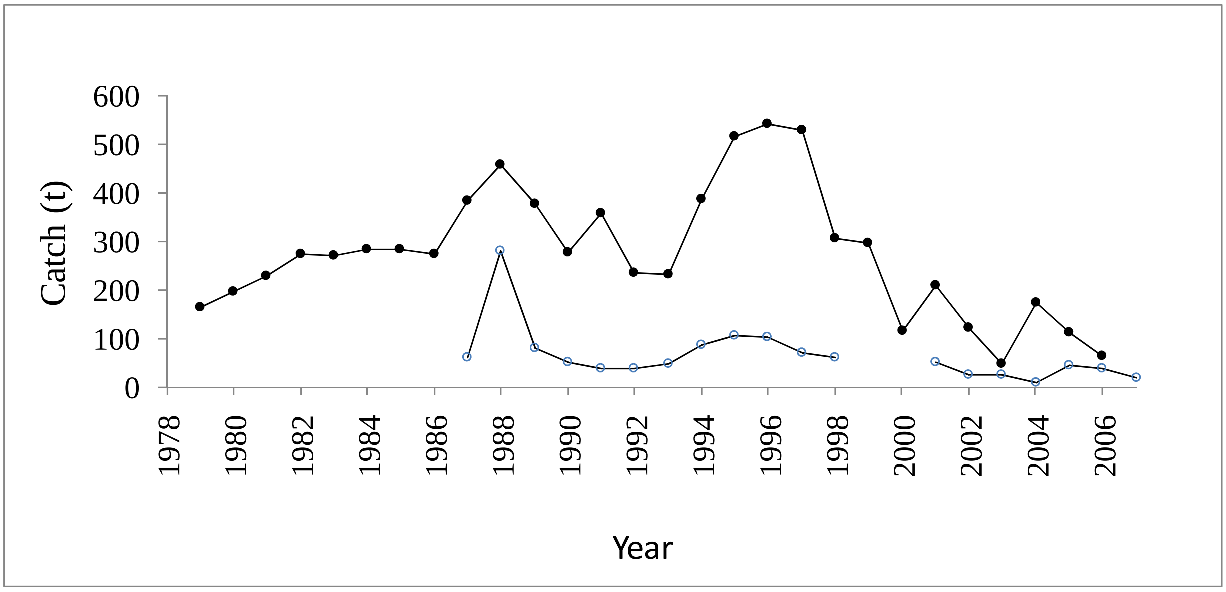


Figure 7. Trends in yellow and silver eel catches (t) reported to the Environment Agency (open circles), and derived from HMRC net export data (closed circles) from 1979 to 2007.

Table 2. Yellow and silver eel catch and effort data for England and Wales, 1979–2007. The 2007 Environment Agency data have been revised, but the provisional HMRC data for 2007 could not be verified and therefore have been removed. No catch data available for 2008 at the time of publication. Note column headings have been revised to clarify data sources.

	Catch estimates based on		Export trade value		Licence sales	CPUE	
	HMRC Nett Exports	EA catch returns	Total value	Unit	No. of licensed gears	HMRC/EA	
Year	(t)	(t)	£000	£/kg		kg/gear	£/gear
1979	162						
1980	196		670	3.42			
1981	229		759	3.31			
1982	273		850	3.11			
1983	270		888	3.29	1523	177	583
1984	283		922	3.26	2085	136	442
1985	283		1012	3.58	2624	108	386
1986	274		1190	4.34	1994	137	597
1987	381	60.41	1869	4.91	2168	176	862
1988	456	280.58	2992	6.56	2443	187	1225
1989	376	80.63	1699	4.52	2041	184	832
1990	277	48.74	1016	3.67	1589	174	639
1991	358	38.26	1724	4.82	1704	210	1012
1992	234	35.63	1383	5.91	1724	136	802
1993	232	46.62	1442	6.22	1859	125	776
1994	384	86.79	1920	5.00	2647	145	725
1995	514	103.76	2484	4.83	2648	194	938
1996	540	100.51	2532	4.69	2752	196	920
1997	526	68.04	1956	3.72	2602	202	752
1998	306	58.31	1126	3.68	1825	168	617
1999	294	na	1012	3.44	1670	176	606
2000	113	na	345	3.05	na	na	na
2001	207	48.62	771	3.72	1991	104	387
2002	122	24.06	445	3.65	1992	61	223
2003	46	25.44	195	4.24	1831	25	106
2004	171	9.58	232	1.36	1600	107	145
2005	110	42.26	160	1.45	2369	46	68
2006	62	35.91	314	5.06	2679	23	117
2007	na	18.90	na	na	2818	na	na

UK.E.2 Northern Ireland

Glass eels and elvers

Glass eel recruitment to Lough Neagh from 1936 to 1946 was provided by the Toome eel fishery (Figure 8).

The LNFCS has provided data since the 1960s. Glass eel and elver supply to Lough Neagh, as recorded by the capture in traps and nets in the Bann Estuary, for transport to Lough Neagh, is given in Table 3 and Figure 8. In 2006 and 2007, these were 444 kg and 456 kg, respectively, a 50% reduction on 2005 (930 kg) and around 65% of the previous 5 year average (691 kg). As in most years since 1984, glass eels were bought from the Severn Estuary to stock L. Neagh (Figure 8). Recruitment in 2008 has reached a new historical minimum with only 24 kg (approx 75 000 eels) caught. To supplement this 428 kg of elvers (1.3 million individuals) were purchased from the River Severn.

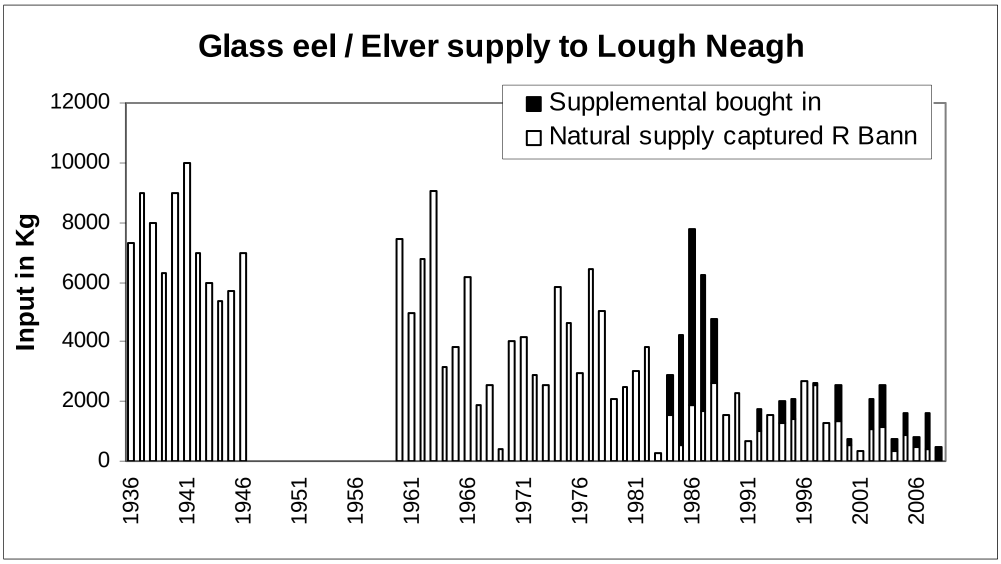


Figure 8. Elver supply to Lough Neagh, 1936 to 2008.

Table 3. Lough Neagh eel fishery data, 1965–2008. The natural elver run from 1960 to 1964 was 4708.55, 4938.69, 6740.46, 9076.7 and 3136.92 kg, respectively.

Year	Natural elver run (kg)	Additional elvers bought from UK (kg)	Emigrating silver eel catch (kg)	Yellow eel catch (kg)	Total yield (kg)
1965	3801	0	329563.6	236759.1	566322.7
1966	6183	0	332800	284772.7	617572.7
1967	1898.77	0	242727.3	327281.8	570009.1
1968	2524.9	0	204618.2	382327.3	586945.5
1969	422.03	0	238327.3	368677.3	607004.5
1970	3991.63	0	237345.5	516504.5	753850
1971	4157.07	0	233309.1	610909.1	844218.2
1972	2905.27	0	124945.5	509090.9	634036.4
1973	2524.2	0	162400	562481.8	724881.8
1974	5859.47	0	178872.7	587904.5	766777.3
1975	4637.27	0	187527.3	576354.5	763881.8
1976	2919.93	0	144872.7	481886.4	626759.1
1977	6442.8	0	236690.9	455350	692040.9
1978	5034.4	0	280727.3	544695.5	825422.7
1979	2088.8	0	341163.6	702609.1	1043773
1980	2485.93	0	245272.7	668945.5	914218.2
1981	3022.6	0	228690.9	681545.5	910236.4
1982	3853.73	0	209890.9	705759.1	915650
1983	242	0	203636.4	662709.1	866345.5
1984	1533.93	1334.67	165890.9	807672.7	973563.6
1985	556.73	3638.51	135054.5	616668.2	751722.7
1986	1848.47	5935.16	129854.5	522359.1	652213.6
1987	1682.8	4584.07	121345.5	503777.3	625122.7
1988	2647.4	2107	150981.8	503236.4	654218.2
1989	1567.53	0	152436.4	643395.5	795831.8
1990	2293.2	0	123600	613231.8	736831.8
1991	676.67	0	121381.8	578868.2	700250
1992	977.67	785.87	148036.4	533240.9	681277.3
1993	1524.6	0	90327.27	535150	625477.3
1994	1249.27	771.87	95200	597418.2	692618.2
1995	1402.8	686	138581.8	659050	797631.8
1996	2667.93	33.19	112290.9	594045.5	706336.4
1997	2532.6	70.47	109418.2	554750	664168.2
1998	1283.33	17.27	104545.5	531968.2	636513.6
1999	1344.93	1200	113054.5	556213.6	669268.2
2000	562.8	150.33	101963.6	486595.5	588559.1
2001	315	0	84000	451309.1	535309.1
2002	1091.53	1007	95963.64	432313.6	528277.3
2003	1155.93	1368.03	114327.3	413763.6	528090.9
2004	334.6	427.09	99636.36	363522.7	463159.1
2005	930	718.67	116727.3	317800	434527.3
2006	456	330	104000	242000	346000
2007	444	1000	76000	351000	427000
2008	24	428	na	na	na

The elver run to the Erne in 2007 was 189 kg and 32.8 kg in 2008, monitored by capture at a box at the tidal head and transported to upper and lower Lough Erne.

Yellow and silver eels

Annual commercial production figures (LNFCS) are divided into outputs of yellow eels (line or draft net catch) and silver eels (caught in traps in the River Bann when migrating downstream from L. Neagh) (Table 3, Figure 9).

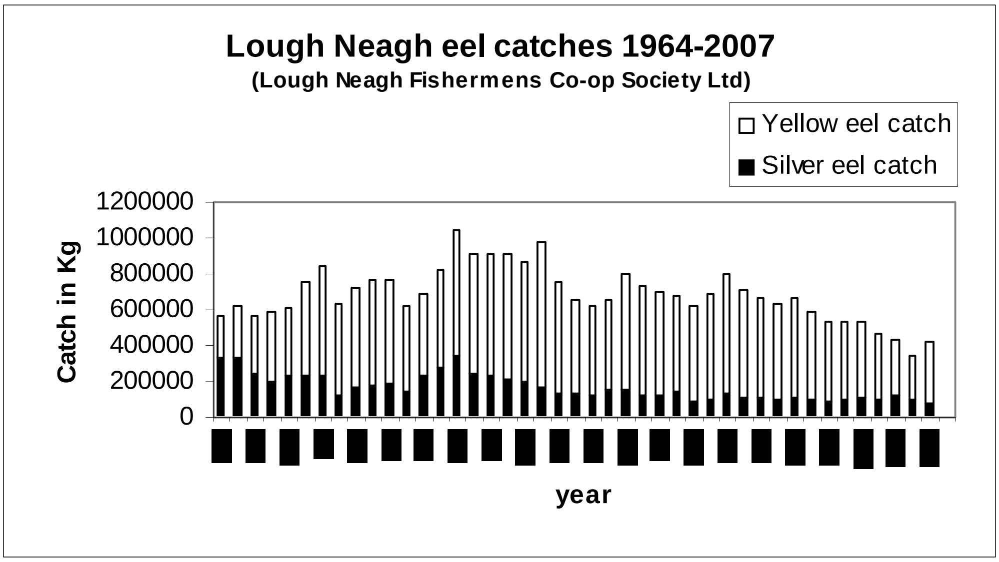


Figure 9. Yellow and silver eel catches-Lough Neagh, 1965 to 2007.

Yellow and silver eel catches in L. Neagh in 2007 amounted to 351 and 76 t, respectively, continuing the general downward trend since the late 1990s (Figure 9) associated with reducing effort in the yellow eel fishery as a function of falling boat numbers. Licences have fallen from 200 active boats in 1990 to around 80–90 boats in 2007, a significant cause of the long-term decline in catches and a response to alternative work/low prices available for yellow eels rather than declining stocks. Catches per boat per day in the longline and draft net fisheries continue to meet or exceed daily quotas imposed by the Co-operative, implying that sufficient stocks for the number fishing in the Lough are being maintained. In 2007, a mild autumn meant that yellow eel fishing continued through until the end of October. This was responsible for the increase in yellow eel catch in 2007 compared to 2006.

Sex ratio in the silver eels in 2004 to 2005 was numerically close to 1:1 male:female, but changed in 2006 to 0.37:0.63 and 2007 to 0.38:0.62 (Table 4). Taking account of differing sizes and weights of males and females, 80% of the recorded silver eel biomass is now female.

Table 4. Biological characteristics of silver eels emigrating from Lough Neagh. Note–mean ages of males and females for 2005 and 2006 have been revised in light of additional data.

	Males				Females			
year	%	mean L (cm)	mean Wt (g)	mean Age	%	mean L (cm)	mean Wt (g)	mean Age
1927	0				100		567	
1943	27				73			
1946	40				60			
1956	61				39			
1957	62				38			
1965	10		180		90		330	
2004	51	40.6	122	11	49	58.6	386	18
2005	52	41.4	126	11.4	48	58.1	393	18.2
2006	37	40.1	117	11.3	63	59.5	368	18.7
2007	38	40.2	121	na	62	62.3	370	na
2008	na				na			

An annual mark-recapture programme was initiated in October 2003, with the objective of estimating escapement of silver eels past the fishery (weir traps), which is subject to a trap-free gap in the river channel, a three-month fishing season (some silver eel movement occurs outside this season), and inefficient fishing when river flows are very high. Recaptures occur both during the year of upstream release and at least one or even two years thereafter. Maximum estimates of escapement, based on the proportion of recaptured Floy™ tagged silver eels, range from 62% to 84% during 2003 to 2006 (Table 5): no tagging was undertaken in 2007 as a consequence of the sporadic nature of the silver eel run as a consequence of a dry autumn.

Table 5. Results of mark-recapture estimation of silver eel escapement from the Lough Neagh fishery. No silver eels were tagged in 2007 as a consequence of the sporadic nature of autumn run.

	Males				Females			
year	%	mean L (cm)	mean Wt (g)	mean Age	%	mean L (cm)	mean Wt (g)	mean Age
1927	0				100		567	
1943	27				73			
1946	40				60			
1956	61				39			
1957	62				38			
1965	10		180		90		330	
2004	51	40.6	122	11	49	58.6	386	18
2005	52	41.4	126	11.4	48	58.1	393	18.2
2006	37	40.1	117	11.3	63	59.5	368	18.7
2007	38	40.2	121	na	62	62.3	370	na
2008	na				na			

UK.E.3 Scotland

No commercial fisheries.

UK.F Catch per unit of effort

UK.F.1 England and Wales

Glass eels and elvers

Trends in glass eel recruitment are likely to be better indicated by catch per unit of fishing effort (cpue) than by reported catch alone. Glass eel/elver fishing effort is not directly quantified in the UK, but annual licence sales data from the Environment Agency and predecessor agencies provide an index from which changes in effort over time can be inferred, because each licensee is likely to fish the same number of suitable tides over the short season each year.

However, the variable, apparent underreporting of glass eel/elver catches to the Agency precludes a meaningful analysis of cpue from Agency data alone. Therefore, trends in cpue are examined based on net export over Agency licence sales (kg/licensed net).

The HMRC data are also limited in value, because the trade statistics do not differentiate between life stages, and trade in glass eel is inferred from unit value calculations. Trends in cpue (kg/net licence sales) derived from reported catch or net exports are similar (Figure 10), at least to 1998 (correlation coefficient: 0.62). Both indices demonstrate declining trends throughout the 1980s and 1990s, similar in magnitude to those of reported catch and HMRC net exports: 98% for reported catch and 85% for net exports. In contrast, both indices demonstrate increases from 2002, by about 3 times to 2006.

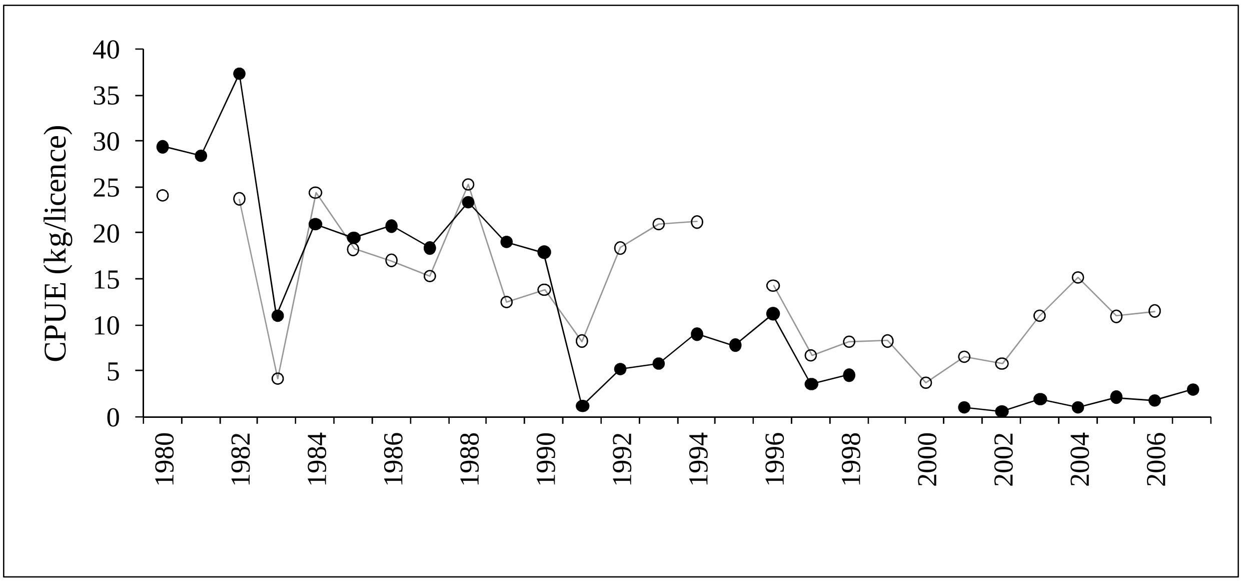


Figure 10. Trends in UK glass eel/elver fishery catch per unit of effort, derived from HMRC net export weight (kg) against Environment Agency net licence sales (open circles), and from catch reported to the EA against net licence sales (closed circles) from 1980 to 2007.

Yellow and silver eels

As with glass eel/elver data, estimating cpue for English and Welsh yellow and silver eel fisheries is problematic, given concerns regarding underreporting, but indices derived from HMRC net exports or reported catches per licence sold both suggest relatively consistent cpues in the late 1980s and mid 1990s, with a decline of about 80% from then onwards (Figure 11).

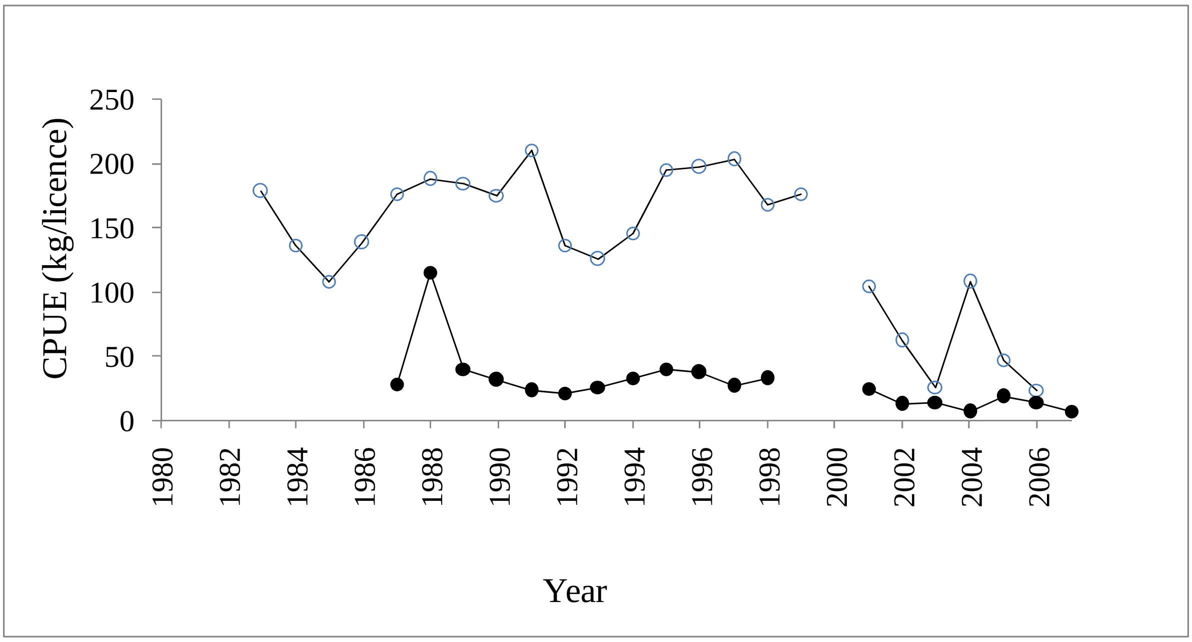


Figure 11. Trends in England and Wales yellow/silver eel fishery catch per unit of effort, derived from HMRC net export weight (kg) against Environment Agency net licence sales (open circles), and from catch reported to the EA against net licence sales (closed circles) from 1983 to 2007. Note that licenses are required for each fixed trap and for each net-end, and therefore the number sold is considerably greater than the number of 'licensed' fishers.

UK.F.2 Northern Ireland

Glass eels and elvers

No standardized cpue data are available for glass eel fishing (for stocking) on the River Bann.

Yellow and silver eels

A quota-based catch management system on L. Neagh means it is not possible to calculate cpue. Daily catch statistics and division by method are recorded by the LNFCS.

UK.F.3 Scotland

No commercial fisheries.

UK.G Scientific surveys of the stock

UK.G.1 England and Wales

Environment Agency eel-specific and multispecies surveys

The EA conducts annual multispecies surveys of fish populations in rivers, lakes and estuaries throughout England and Wales. Prior to 2001, eels were not a target species for these surveys, but some records of presence/absence or more quantitative data are available. From 2001 to 2006, at least the presence/absence of eels was recorded on all surveys (see Figure 1). From 2007 onwards, all Environment Agency surveys will collect length, and possibly weight, measurements for all eel caught.

More intensive, eel-specific electrofishing surveys, and silver eel or elver trapping exercises have been conducted in a number of basins (Figure 12), yielding more accurate estimates of survey site population biomass, density and length frequency distributions over a number of years. In addition, fykenet surveys have been conducted in still waters and estuaries, yielding length and weight data for eels along with catch per unit of effort indices.

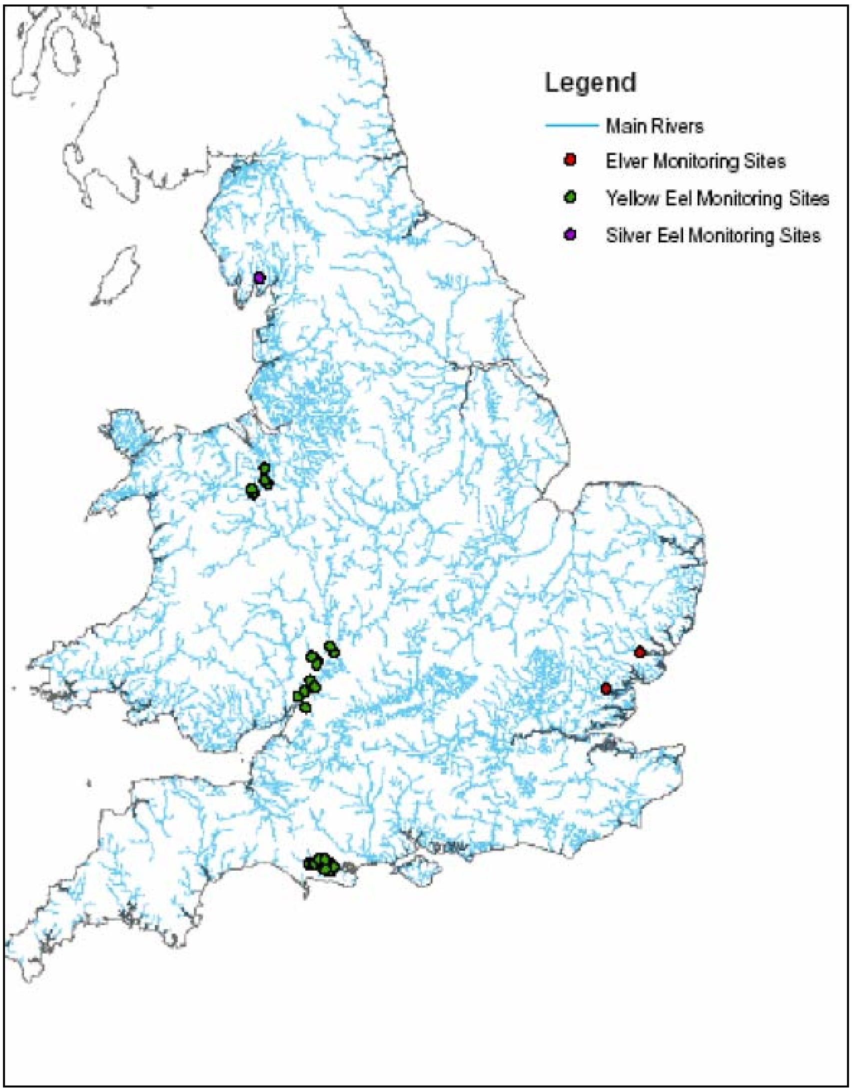


Figure 12. Regional distribution of eel-specific monitoring by the Environment Agency in England and Wales.

UK.G.2 Northern Ireland

The North South Shared Aquatic Resource (NSSHARE) Project covers three river basin districts; North Western International River Basin District, Neagh Bann International River Basin District and North Eastern River Basin District. One of the main outcomes of the project is to develop ecological classification tools for assessing water quality under the Water Framework Directive using three biological quality elements; aquatic flora, benthic invertebrate fauna and fish fauna. The fish fauna biological quality element must include species composition, abundance and age structure. Eels are recorded as part of the species composition element (see Table 6).

The NSSHARE Fish in Lakes team was set up to develop an ecological classification tool using fish fauna, suitable for monitoring and classification of lakes under the requirements of the Water Framework Directive. This involved developing a standard methodology for sampling fish populations in lakes, with which in all 83 lakes have been surveyed to date. The ecological classification tool is currently under development.

Table 6. Eel population data for Northern Ireland lakes from surveys conducted during the development of ecological classification tools for the WFD, 2005–2006. No eels were caught in loughs Big Dog, Carrick, Carrickavoy, Corry, Drumacrittin, Formal, Lea (Knox Lake), Legane, Nadarra, Natroey, Portmore, Rossole, Roughan and Skale.

			Length (cm)		Weight (g)		Age (y)	
Lake	Catch	CPUE	Mean	Range	Mean	Range	Mean	Range (no.)
Ballydoolagh	1	0.125	62.5	62.5	654.9	654.9	18	18 (1)
Beg	11	1.375	48.9	20.0-70.0	297	35.0-740.0	14	14 (1)
Brantry	1	0.125	80	80.0	1362	1362		
Castlehume	2	0.25	31.5	30.0-33.0	71	64.5-77.5		
Castlewellan	13	1.625	73	62.5-80.0	857.3	616.5-1362.0	23.1	18-25 (11)
Clea Lakes A	16	2	49.4	41.2-56.2	219.7	106.8-347.8	16.6	14-23 (14)
Corranny	1	0.25	56	56.0	867.9	867.9	18	18 (1)
Creeve	4	0.5	54	49.0-57.0	253.7	169.8-303.5	15.3	13-18 (4)
Erne Upper	5	1.25	45.3	42.5-48.2	170.6	125.0-230.2	14	13-15 (5)
Glencreawan Lough	1	0.25	60	60.0	402.1	402.1		
Knockballymore Lough A	1	0.25	68.5	68.5	748	748	14	14 (1)
Lisleitrim	4	1	43.4	37.0-52.5	176.2	93.0-341.6		
Macnean Lower	8	0.889	50.5	36.0-60.2	261.6	82.1-423.1	12.4	8-17 (8)
Macnean Upper	5	0.556	49.4	42.0-55.2	229	126.4-338.5	13.5	12-16 (4)
Meenameen	2	0.5	37	34.0-39.0	90	65.0-115.0		
Nalughoge	2	0.5	58.5	56.0-61.0	423.4	397.2-449.6		
Sand	2	0.5					16	16 (2)
Tullybrick	1	0.25	60	60.0	407.8	407.8		

L. Erne

There are no surveys of the L. Erne eel population at present.

L. Neagh

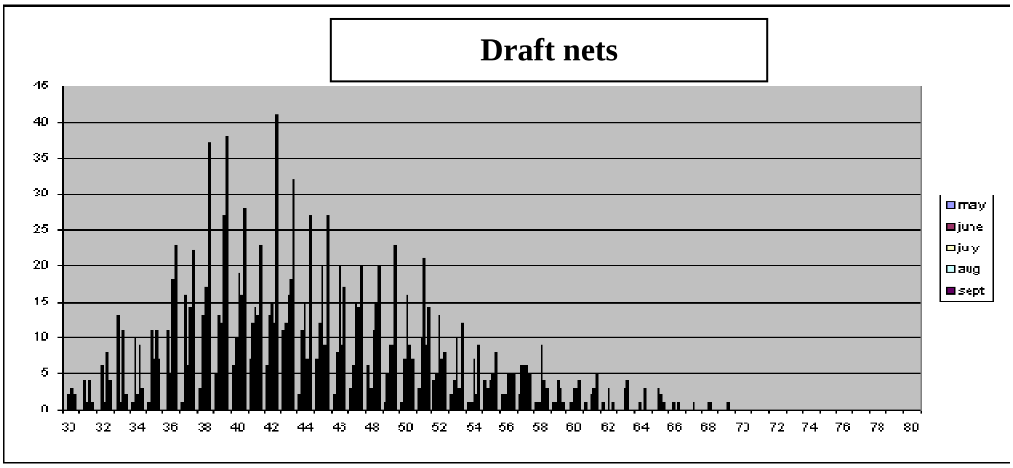
Eels are sampled regularly as part of an ongoing long-term research programme, which investigates all life stages throughout the year.

Glass eel/elvers are sampled twice a month from their arrival in February/March through to August. A sample of 50 juveniles is removed for morphometric analysis, calculation of number per kg and length frequency analysis.

Yellow eel catches are sampled weekly over 20 weeks (from May to September). A sample of 20 eels is chosen to reflect all size ranges caught, and analysed for age and length. In addition, the entire, ungraded landing of two fishing crew on one day each month is sampled, usually comprising 400–600 eels captured by longline and a similar number by draft net, to allow comparison between methods. Every eel is measured for length and the total number of fish captured recorded.

Preliminary analysis indicates that a larger proportion of small eels (<40 cm) are captured by draft nets (34%, compared to 21.4% on longlines), and that more of the larger eels (>60 cm) are taken on longlines (Figure 13). The results also indicated there was significant variation in the numbers of small eels captured by long lining dependent upon bait type (earthworm caught more) and hook size (larger hook caught fewer small eels). Undersized eels are returned to the Lough.

Silver eel catches are sampled over a 12 week period (from October to December). At weekly intervals, the previous night's haul averaging at least 400 fish is measured for length, and 10 eels are chosen to reflect all size ranges caught, and analysed for age.



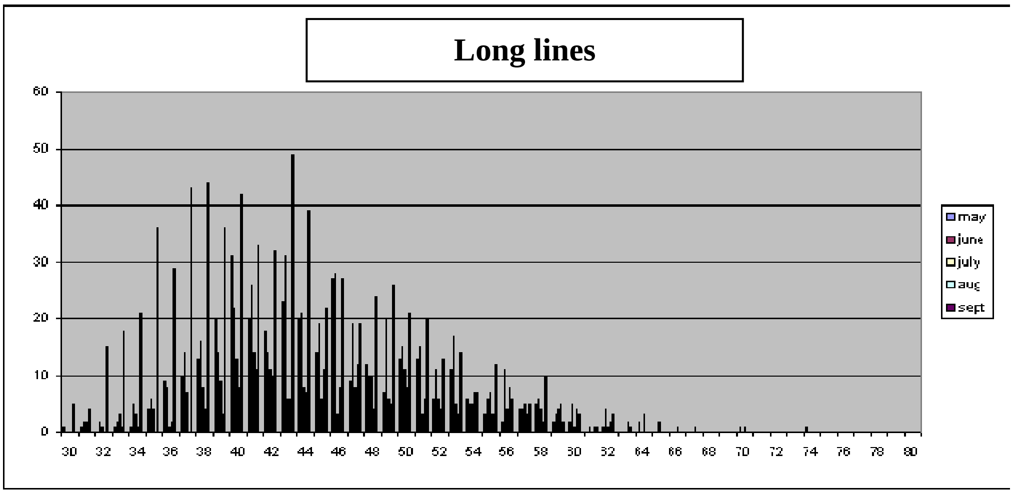


Figure 13. Length frequency distributions for L. Neagh yellow eels caught via longlines and draft nets.

UK.G.3 Scotland

The FRS Freshwater Laboratory has two long-term, but intermittent, datasets on yellow eels, both from small, upland tributaries. FRS has operated a fish trap on the Girnock Burn, a tributary of the River Dee in Northeast Scotland, since the mid-1960s. The Girnock Burn rises at an altitude of 500 m and flows northwards, joining the River Dee some 70 km above the tidal limit. The stream channel has a largely open aspect, and is typically <5 m wide, depths ranging from a few cm to 0.5 m. Annual trap catch and electrofishing data were collected between 1967 and 1982 and again in

2004 and 2005. Since 2004, eels >200 mm have been PIT-tagged in order to determine movements and growth.

Analysis of these data (Chadwick *et al.*, 2007) demonstrates that, in the late 1960s, the Girnock Burn eel population was composed of relatively high densities of small (140–180 mm) males and with few females (320–360 mm). Growth rates are currently estimated to be between 8.7 and 17.4 mm y^{-1}, with growth occurring chiefly in summer. Small eels leave the system in late spring/early summer, larger eels in late summer/early autumn. Due to construction of a major barrier to immigration (plus the effects of recruitment declines since the 1980s), the estimated standing stock and escapement declined from 1968 to 2005 by about 80%. The mean population density declined between 1968 and 2005 from 16 to 3 eels 100 m^{-2}, and biomass from 256 g to 71 g m^{-2}. Thus, current densities are about 19% of the 1968 level, biomass about 28%. Biomass has probably fallen more slowly than density because the average body length has increased 11% over the 37 year time-series, possibly as a consequence of lower in-river densities reducing competition and density-dependent mortality.

The other site monitored by FRS is the Allt Coire nan Con Burn, which is situated in the Strontian region of western Scotland and drains into the River Polloch, an inflow to Loch Shiel. The catchment covers 790 ha and its altitude falls from 756 m to 10 m at the sampling point, where the river is 5–6 m wide and features riffle interspersed with glides which can be deep. Riparian vegetation at the sampling sites is predominantly mature deciduous woodland. In Table 7, data from the annual electrofishing survey demonstrate no clear evidence of declines in yellow eel densities since 1992 (source: P. Collen, unpublished data).

Table 7. Relative population density of eels in electrofishing surveys in a small stream in north Argyll, 1990–2007.

Year	Population density (no.s/100m^2)
1990	41
1991	30
1992	16
1993	14
1994	11
1995	15
1996	18
1997	12
1998	14
1999	8
2000	10
2001	14
2002	15
2003	3
2004	14
2005	24
2006	8
2007	12

Fisheries Trust Data

The establishment of Fisheries Trusts and the Scottish Fisheries Coordination Centre has allowed the coordination of a number of electrofishing surveys, which now represent the principal source of information. The earliest of these data are from 1996, but spatial coverage is adequate only from 1997 onwards. It should be noted that there is considerable variation among the reports from individual Trusts in the level of detail that are recorded. Some of the data were collected with funding from Scottish Natural Heritage (SNH) and are their property. Otherwise all data are the property of the relevant Fisheries Trusts which have kindly allowed their use here. There are substantial areas of Scotland RBD for which data are not available, including the catchments of the Rivers Clyde, Don, Ythan, Nairn, Ugie, as well as the entire islands of Skye, Orkney and Shetland, (these latter two island groups are omitted from subsequent maps for reasons of space and clarity).

There are a number of problems with the interpretation of these data:

1. The surveys were not specifically targeted at eels; instead the eel data were a bycatch of a sampling programme aimed at assessing salmonid densities.
2. Even directly targeted at the species, electrofishing for eels is an inexact science, and density estimates should be regarded with caution. Observed densities are likely to be size and habitat (in particular substrate) dependent, and no attempt has been made to account for this.
3. The dataset is composed of different types of electrofishing: multi-pass (22.9%), single-pass (69.5%), and timed fishing without delineated areas (7.6%).
4. In most cases the numbers of eels caught were not recorded directly, but allotted to abundance classes (Absent, 1–10, 11–100, 101–1000). For some Trust areas the exact number of eels was routinely reported. In others the exact number was only occasionally reported, with potential for bias (of unknown size or direction).
5. In most cases the size of eels was not reported. For some Trust areas length of eels was routinely reported, in others the lengths of eels were only occasionally reported, with potential for bias (of unknown size or direction).
6. Where eel lengths were recorded individual eels were sometimes described as 'silver', but it is not known how often (if ever) the lengths of eels was recorded and their maturity status overlooked.

In an attempt to standardize these disparate fishing methods, the following assumptions were made:

- Based on the average decline in capture rates of eels in three run fishing (where they were recorded), the likely result of a single-pass fishing was calculated for the remaining three-pass and two-pass fishings;
- Based on a negative binomial distribution of the observed data, the mean value expected for each class of eel number (1–10, 11–100, 101–1000) was calculated. This number, or the exact number if recorded, was used to calculate density by dividing it by the reported area of the site fished.
- For timed fishings (<4% of the total fishings), the area was estimated from the time fished (based on the relationship between time and area fished from a subsample of sites in which both parameters were recorded). A few timed fishings (n = 445 or 0.67% of fishings) had neither time nor area associated with them, and these were assumed to have the same area as the mean of the other timed fishings. In this way all the fishings were con-

verted to the same units (number of eels per $100m^{-2}$ in a single-pass fishing).

There are a number of assumptions inherent in the treatment of the data described above:

- That the sample for which capture rates of eels on all three runs were reported were representative of all fishings (i.e. that the decline in capture rates is constant across fishers and habitats);
- That the sites for which exact numbers were recorded were representative of sites for which the number of eels was estimated only to a class size category;
- That 'timed' fishings for which no time was recorded were of a similar duration to average duration of timed fishings where the time was recorded;
- That effort was constant over the survey period.

All these assumptions are likely to be violated to some extent, compromising the confidence that can be placed in the density estimates and strong confidence can only be placed in the presence/absence data.

The data demonstrate no consistent trend in reported eel abundance class over the period 1996–2005 (Figure 14). In contrast, an analysis of the percentage of sites where eels were absent on the adjacent Solway Tweed RBD suggests this increased from 12% in 1972–1988, to 24% in 1992–1996, to 44% 1997–2001 and to 46% 2002–2005 (B. Knights, unpublished data), but it is possible that this represents a change in methodology in the early 1990s rather than a genuine decline in distribution.

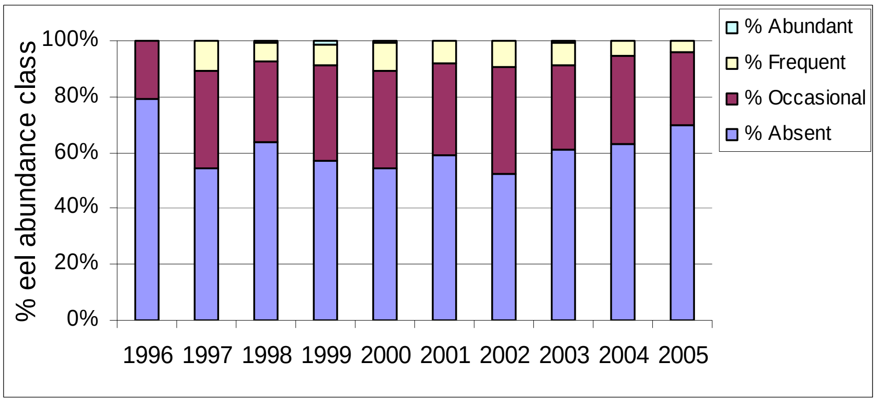


Figure 14. Eel presence/absence and abundance classes in Scotland RBD, 1996–2005. All site visits (n=6651) are included, number of site visits and contribution of different areas to the Scotland RBD total varies; in 1996 only 19 sites were fished, all on one river (the Spey). Abundance classes as follows: Absent 0 eels, Occasional =1–10 eels, Frequent =11–100 eels, Abundant = >100 eels.

There was considerable spatial variation in the distribution of eels, with eels being much less likely to be absent from sites in the northwestern parts of Scotland RBD. In the Western Isles, West Sutherland and Wester Ross, eels were absent at approximately 20% of sites, compared with 55% in Scotland RBD as a whole (Figure 15). This probably reflects the proximity of the northwest of Scotland RBD to the continental shelf (Knights *et al.*, 2001).

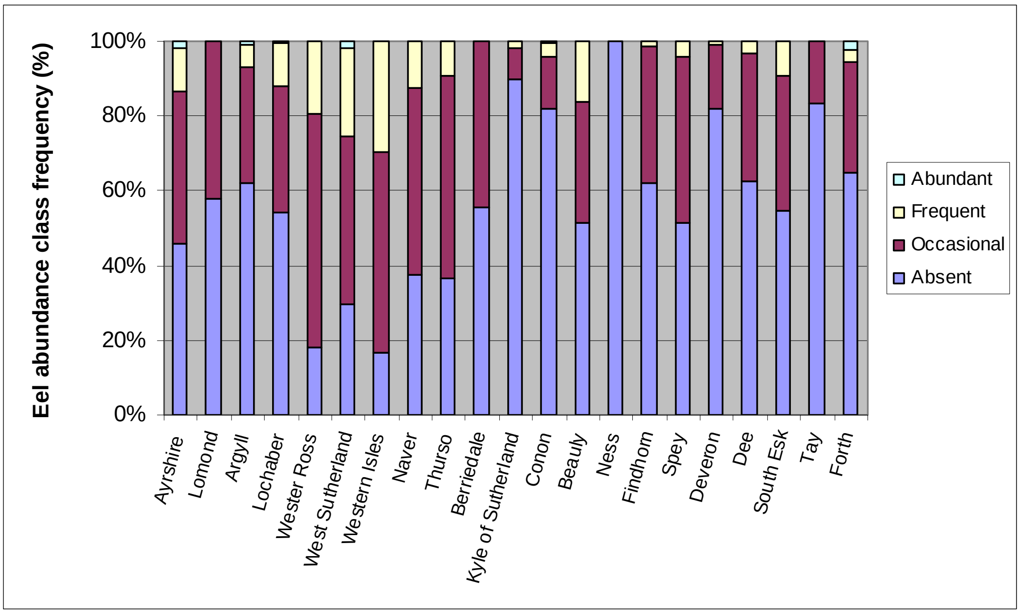


Figure 15. Percentage frequency of eel abundance class at electrofishing sites in various rivers or districts of Scotland RBD. Areas are arranged clockwise around the coast, from Ayrshire in the southwest, to Naver and Thurso on the north coast then down the east coast to the Forth region. Where more than one visit to a site was made, the highest recorded abundance was used. In general, eels were more widely distributed and more common in the northwest and north.

There is weak evidence that eel densities in Scotland may have declined since 2002 (Figure 16). It is possible that this is a spatial rather than a temporal effect, however, because the distribution of sites differed between years, both locally and regionally. A similar pattern of decline in recent years was evident for several individual regions of Scotland RDB for which data were available, but was not universal; in particular West Sutherland in the North West revealed a trend for an increase in population density (Figure 17).

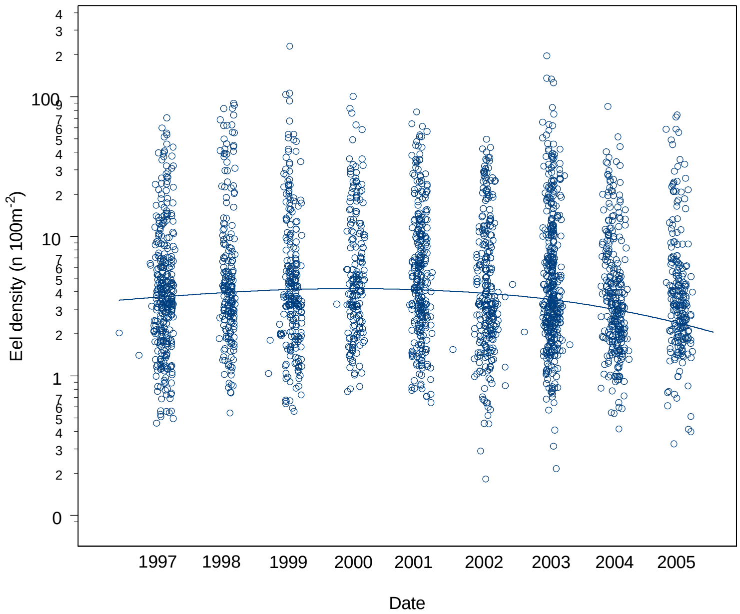


Figure 16. Eel density (log scale) from all electrofishing sites between 1997 and 2005. Smoothing spline fitted with 3 degrees of freedom suggests a slight decline in density post-2002, however, different regions of Scotland RBD are not equally represented in each year.

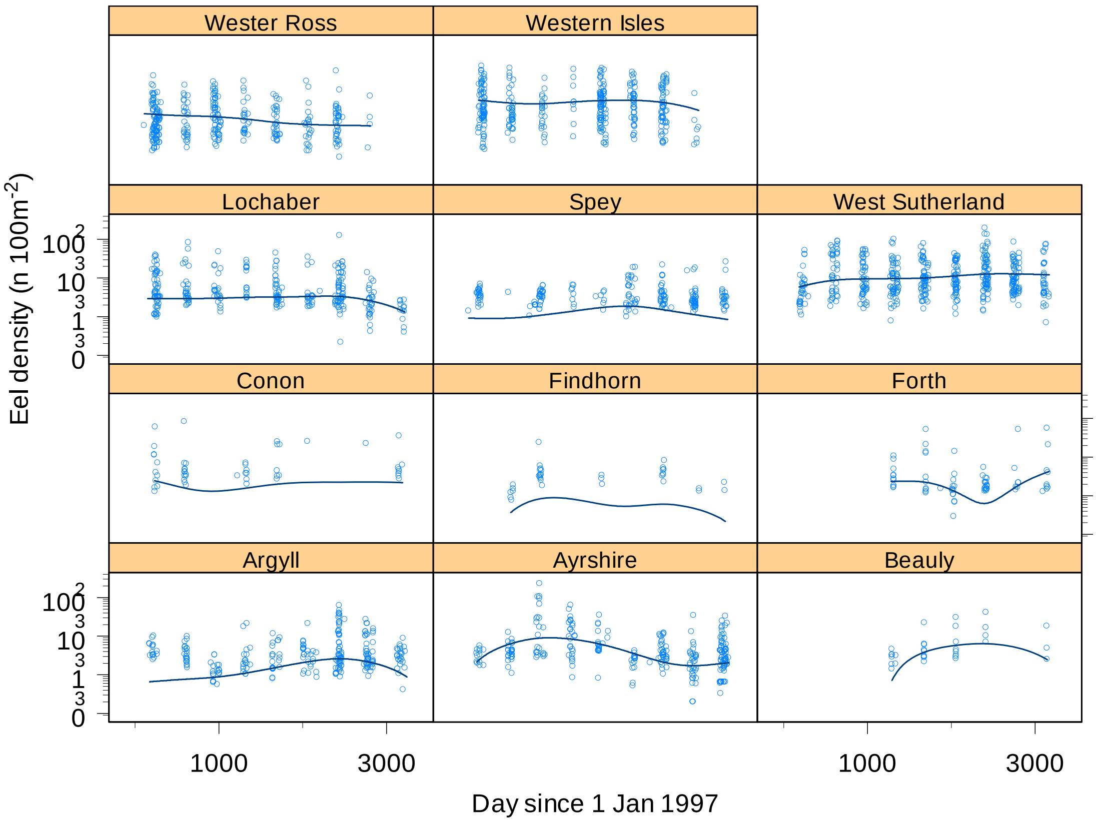


Figure 17. Temporal variation in eel population density at regional level within Scotland RBD, 1997–2005. Sites where eels are absent do not appear in the graphs, but the lines (smoothing splines with 3 degrees of freedom) are fitted with them.

UK.H Catch composition by age and length

UK.H.1 England and Wales

Catch are only reported by stage (glass/elver, yellow, eel), so there are no data on catch composition by age and length.

UK.H.2 Northern Ireland

See above.

UK.H.3 Scotland

No commercial fisheries.

UK.I. Other biological sampling

UK.I.1 Reported by catchment or River Basin?

UK.I.2 Length and weight and growth (DCR)

England and Wales

As of 2007, measurements of length are now collected from all eel captured by the Environment Agency during eel-specific and multispecies surveys. In all 637 lengths were collected in 2007. The 2008 sampling programme is ongoing at the time this report was produced.

The Defra-funded study, "The Development and Implementation of Biological Reference Points for the Management of the European Eel (SFO236)", included the sampling of 13 500 eels from surveys of none basins across England and Wales during 2002 to 2006 (Bark *et al*., 2007; in press). Length and weight were recorded, with a subsample of 1400 eels sexed and aged.

Northern Ireland

In addition to the glass eel sampling at the River Bann, other sampling is undertaken at several other coastal sites in N. Ireland: the Foyle Estuary, the River Lagan (Belfast), River Quoile (Strangford Lough) and Carlingford Lough Estuary.

L. Erne

There are no surveys on going on L. Erne.

L. Neagh

The monitoring programmes listed above also measure many other biological parameters within the fishery stock and samples removed from it.

The glass eel/elvers are monitored for the presence of *Anguillicola crassus*.

The weekly samples of yellow eels are also examined for weight, sex, age, stomach contents, the prevalence and intensity of *A. crassus*, and gastrointestinal endohelminths.

The undersized yellow eels (<40 cm long) captured via longline are returned to the Lough at the point of capture with hooks in place. Every month 100 undersized eels are sampled at the fishery, their hook location recorded and in conjunction with catch composition analysis; attempts are made to quantify possible losses to the fishery through hook mortality.

The weekly silver eel samples are also analysed for weight, sex, age, stomach contents, the prevalence and intensity of *A. crassus*, and gastrointestinal endohelminths. Sex ratio of the silver eel population is also estimated by counting the numbers of individuals contained in the graded 15 kg boxes which the fishery then sell. Eels are graded as small (males) and large (females), based on a length-sex key derived from previous sampling.

Scotland

An un-coordinated effort to determine the presence/absence of *Anguillicola crassus* is currently being undertaken in Scotland.

Some Fisheries Trusts collect data on the length of eels captured during routine electrofishing surveys targeted at salmonids (1136 eels have been measured since 1996).

UK.I.3 Parasites

England and Wales

Anguillicola crassus is now considered ubiquitous throughout the UK (Nigel Hewlett, Environment Agency National Fisheries Laboratory, pers. comm.). Foster and Block, 2006 reported infestation levels in eels (~300 mm total length) sampled across the Sussex area in 2005–2006 ranging from 60% to 88% (regional mean 72%). Similar levels of infestation were reported for eels in Kent rivers in 1996–1998 (Cave, 2000).

Northern Ireland

L. Erne

Anguillicola crassus was first recorded in the swimbladders of eels in Ireland during an extensive fykenet survey of the Erne system in July 1998. Of 328 yellow eels examined in 1998, 24 (7.3%) were infected, with a mean intensity of 4.3 worms per eel. Infected eels were only recorded in southern Lower Lough Erne and northern Upper Lough Erne. Examination of 432 yellow eels in 1999, revealed an increase in both mean intensity (6.7 worms per eel) and prevalence (9.9%) of *A. crassus*. The range of the parasite had also increased, with infected eels recorded from the lower reaches of the Erne, 30 km downstream of the original area of infection. Monthly samples of silver eels taken by commercial nets near the outlet of the Erne during October–December 1998 and 1999 confirmed active migrants contained the parasite. Prevalence and mean intensity among silver eels rose from 4.5% and 2.5 worms per silver eel in 1998 to 15% and 8.6 worms per eel in 1999 (Evans *et al*., 2001).

L. Neagh

A. crassus was found in Lough Neagh yellow and silver eels for the first time in 2003, and its spread has been monitored via the analysis of a total of 1100 yellow and 400 silver eels from 2003 to 2006. Samples were stored in 70% alcohol and in the lab; swimbladders were examined macroscopically for the presence of pre-adult and adult *A. crassus*, but not for larval *A. crassus*. Recorded prevalence and mean intensity in yellow eels rose from 24.4% and 2.2 in 2003 to 69% and 3.6, and to 100% and 7.7 in 2004 and 2005, respectively. However, the same infection parameters recorded for silver eel were significantly different, with almost 60% infected in 2003 rising to almost 90% in 2004. By 2005, 100% of yellow and silver eels were infected with *A. crassus* (Evans and Rosell, 2006). In 2007 the prevalence of *A. crassus* in both yellow and silver eels had fallen to 70% and 76%, respectively.

Scotland

There is to date only a single reported instance of *Anguillicola crassus* in Scottish RBD (Lyndon and Pieters, 2005), for a fish farm near Bridge of Earn, on the Tay system. However, the absence of targeted effort on the identification of *A. crassus* in the Scottish RBD may have led to under-recording. The parasite is currently being sought in eel samples collected in the catchments of central Scotland, and there is an unconfirmed report of an infected eel from the Forth (Willie Yeomans, pers. comm.). However, the likelihood is that *A. crassus* is not sufficiently widespread as yet in Scotland, as a consequence of low levels of stock transfer, to have had possible impacts on eel populations.

UK.I.4 Contaminants

England and Wales

Concentrations of most metals including mercury, arsenic, cadmium, chromium, copper, lead, nickel and zinc, Poly chlorinated biphenyls (PCBs), Dichloro-diphenyl-trichloroethanes (DDTs), Hexa-chlorocyclo-hexanes (HCHs) and Aldrin and Endrin ('Drins) decreased substantially in eels from Sussex rivers between 1994–1995 and 2005–2006 (Foster and Block, 2006). In 2005–2006 more eels were in the low to moderate risk bands (to people) and fewer eels were in the high risk band for PCBs proposed by the Oslo and Paris Commissions. The EU regulation limit of 8 pg/g of dioxin-like PCBs in eels was significantly exceeded for the dioxin-like PCB-118 at 100% of sampled sites in 1994–1995 and 2005–2006. Current levels of dioxin-like contaminants in eels in Sussex rivers are higher than those necessary to impair survival of fertilized eel eggs (Palstra *et al.*, 2006).

Northern Ireland

No routine sampling undertaken but available by request.

Scotland

No assessments of contaminants in eels have been undertaken in Scotland.

UK.I.5 Predators

England and Wales

Limited studies of the diet of piscivorous birds shot during winter suggest that eels are rare in the diet at this time of the year, but other published information for England and Wales indicates a fairly large proportion of eel at other times.

Northern Ireland

None undertaken and studies into the impacts of predators on the eel stocks of N. Ireland are not likely to form part of Management Plan contents.

Scotland

No information.

UK.J Other sampling

England and Wales

The Environment Agency's eel population model development programme, running from 2006 to 2010, includes the collation and analysis of existing and new data describing eel production processes from river basins in England and Wales.

A Defra-funded research programme (SF0249), running from 2007 to 2012, will (1) determine and compare the population structure and relative production of eels from different habitats within river basins, and (2) investigate relationships between habitat and eel production in order to inform the transport of models from data-rich to data-poor locations within and between river basins. This programme includes substantial field sampling of eel populations from the variety of habitats utilized within river basins in England and Wales.

Northern Ireland

None at present.

Scotland

No information.

UK.K Stock assessment

England and Wales

No formal assessments of eel populations have been conducted to date for England and Wales, although assessment methodologies are being developed to provide the tools required for Eel Management Plans (EMPs). EMPs require the assessment of silver eel escapement biomass against a historical target level, but as silver eel escapement biomass is not, nor has been, measured from any river in England and Wales, a modelling approach is required to estimate potential and actual escapement, and to assess the likely effects of management measures. Two modelling approaches have been developed in the UK: the Reference Condition Model (RCM: EIFAC/ICES, 2004; Aprahamian *et al*., 2007) and the Scenario-based Model for Eel Populations (SMEP: developed for the Department for Environment, Food and Rural Affairs (Defra) by El-Hosaini, Bark, Knights, Williams (Kings College, London) and Kirkwood (Imperial College, London): El-Hosaini *et al*., in prep; Aprahamian *et al*., 2007). The EA is supporting the further development of SMEP and the RCM.

Draft EMPs have been prepared for 12 River Basin Districts (11 in England and Wales and one in N. Ireland). The plans aim to describe the catchment, status of the eel stock, assess compliance with the 40% escapement target and, for those RBDs which are failing the target, set out management options to increase silver eel output. The plans conclude with a plan of actions that are to be achieved and associated delivery schedules.

In addition, various biological indicators of stock status have been considered during recent Environment Agency-, and Defra-funded research programmes (Knights *et al*., 2001; Knights, 2005; Knights, 2007; Bark *et al*., 2007; in press), though these indicators do not address the specific requirements of the EMPs.

Northern Ireland

Apart from the biological sampling efforts listed above, there are currently no eel stock assessment exercises within Northern Ireland. However, attempts have been made to predict future catches the L. Neagh fishery using biological data and catch statistics (Allen *et al*., 2006).

Stock assessment was carried out on the Erne as part of the 3 year Erne Eel Enhancement Programme which ended in 2001 (Matthews *et al*., 2001).

Scotland

No information.

UK.L Sampling intensity and precision

England and Wales

Knights *et al.*, 2001 examined variation in Severn eel population data from the early 1980s and late 1990s, and suggested that at least 25 sites should be surveyed throughout the first 50 km of river length (measured from the tidal influence) in order to determine the number of sites required to detect a temporal change in eel population density or biomass. Their analysis suggested that this intensity of sampling would be required if one wished to detect a ±50% change in density or biomass between two consecutive surveys, with 95% statistical confidence and 80% power.

Northern Ireland

No information.

Scotland

No information.

UK.M Standardisation and harmonization of methodology

UK.M.1 Survey technique

England and Wales

Knights *et al.*, 2001 provided recommendations for design of monitoring programmes to detect spatial and temporal changes in population status, including those on electrofishing method.

The Environment Agency has two standard work instructions in relation to eel, for survey in rivers and specifically for fykenetting.

UK.M.2 Sampling commercial catches

England and Wales

There is no routine sampling of commercial catches, although some sampling has occurred to characterize migrating silver eel populations sampled by commercial eel-rack fisheries (Knights *et al.*, 2001; Bark *et al.*, 2007; in press).

Northern Ireland

Methods described above. No Quality Assurance is undertaken within the sampling of the commercial catches.

Scotland

No commercial catches are reported.

UK.M.3 Sampling

England and Wales

See above.

Northern Ireland

Methods described in previous sections.

Scotland

No information.

UK.M.4 Age analysis

England and Wales

Ages reported in Knights *et al.*, 2001 were quality assured by the Environment Agency's National Fisheries Laboratory at Brampton. A similar QA method was employed by Bark *et al.*, 2007.

Northern Ireland

Age analysis is performed on yellow and silver eels sampled from the Lough Neagh fisheries using the grinding and polishing technique. The results have been quality assured against burning and cracking of sister otoliths performed at the Marine Institute labs in Newport. Results to date indicate mean yellow eel age of 14 years, male silvers 11 years and female silvers 18 years.

Scotland

No information.

UK.M.5 Life stages

England and Wales

No information.

Northern Ireland

All life stages on Lough Neagh are studied. Glass eels and yellow eels are periodically examined from those systems listed previously and as part of NS Share work.

For Northern Ireland in general, no analysis of glass eel developmental stage is undertaken. The difference between yellow eel and silver eel is determined by gross morphology, aided by length and time of year and was originally under the guidance of senior fisheries scientists and in the company of experienced fishers.

Scotland

No information.

UK.M.6 Sex determinations

England and Wales

No information.

Northern Ireland

The correct gender assignment was originally under the guidance of senior fisheries scientists and is based on *in situ* macroscopic examination.

Scotland

No information.

UK.N Overview, conclusions and recommendations

Acknowledging the concerns regarding the quality of catch data from England and Wales, all UK indicators continue to suggest that natural recruitment of glass eels and elvers is much lower than the peaks of the late 1970s and early 1980s. Indicators of natural yellow and silver eel production suggest similar trends.

There have been few attempts to assess the stock status of eel populations throughout the UK to date, but research and monitoring is underway to address this in light of the requirements set out in the Eel Recovery Plan and associated Eel Management Plans.

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Report on the eel stock and fishery in Portugal 2008

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Reporting period: This report was completed in August 2008 and contains data up to 2007.

PT.B Introduction

In Portugal, the European eel, *Anguilla anguilla*, is an important species for both commercial and recreational fisheries, which occur in different types of water bodies especially in lagoon coastal waters, estuaries and rivers.

The main river basins are international shared between Portugal and Spain, namely:

> Minho river, with a total surface area of 17 080 Km^2 (800 Km^2 in Portugal, 16 280 Km^2 in Spain) and 330 Km long; Lima river, with a total surface area of 2480 Km^2 (1177 Km^2 in Portugal, 1303 Km^2 in Spain) and 108 Km long; Douro river, with a total surface area of 97 290 Km^2 (18 338 Km^2 in Portugal, 78 952 Km^2 in Spain) and 897 Km long; Tejo river, with a total surface area of 80 600 Km^2 (24 850 Km^2 in Portugal, 55 750 Km^2 in Spain) and 1007 Km long; Guadiana river, with a total surface area of 66 800 Km^2 (11 580 Km^2 in Portugal, 55 220 Km^2 in Spain) and 810 Km long.

The main national river basins are:

> Cávado river, with a total surface area of 1600 Km^2 and 135 Km long; Ave river, with a total surface area of 1390 Km^2 and 94 Km long; Vouga river, with a total surface area of 3635 Km^{2}and 148 Km long;Mondego river, with a total surface area of 6644 Km^2 and 234 Km long; Lis river, with a total surface area of 945 Km^2 and 39,5 Km long; Sado river, with a total surface area of 7640 Km^2 and 180 km long; Mira river, with a total surface area of 1600 Km^2 and 145 Km long;Arade river with a total surface area of 229 Km^2 and 75 Km long.

Figure1. Main River Basin in Portugal: Minho, Lima, Cávado, Ave, Douro, Vouga, Mondego, Lis, Tejo, Sado, Mira, Arade and Guadiana.

In Portugal, the eel commercial exploitation comprises glass eel (Minho River) and yellow eel (all rivers) phases of its life cycle.

PT.C Fishing capacity

PT.C.1 Glass eel

The glass eel fishing is prohibited in all rivers of Portugal with exception of the Minho River. Because glass eel has a high economical value a strong illegal activity is going on in these rivers.

PT.C.1.1 Minho River

The Minho river which constitutes over 80 Km the northern boundary between Portugal and Spain has become one of the most important glass eel fisheries on the Iberian Peninsula over the last three decades. Management of the eel stock is under the responsibility of the "Ministério da Agricultura, do Desenvolvimento Rural e das Pescas". Two kinds of laws are implemented in the country concerning glass eels fishery. In the Minho River an agreement between Portuguese and Spanish authorities allow to fish glass eels between November and April (in the past), November and last New Moon of March (2006/2007), November and last New Moon of February (last season) using a stow net. In 2000/2001, the fishery was prohibited in all other Portuguese rivers, except for aquaculture and restocking programmes. The monitoring of glass eel recruitment has been carried out since the mid 1970s based in professional fishers catch values and declared annually to the authorities. The Portuguese catches are mainly sold to Spain for human consumption and aquaculture, and higher prices are attained before Christmas (on average 350 €/Kg, could attain 500 €/Kg). Because glass eel has a high economical value a strong illegal activity is going on in all other national rivers.

In the Minho River the glass eel fishery is permitted with a stow net. The stow net has the following maximum dimensions: 10 m of floatline, kept at the surface with 10–20 buoys, 8 m height, 15 m leadline, width of netend 2.5 m and mesh size of 1–2mm. Opening area is around 50 m^2. The net is anchored when the tide is rising, the end fastened to a boat, and glass eels are scooped out with a small dipnet frequently. This gear is exclusively used for glass eel fishing but the bycatch can be very important, including up to 49 species. From the river bank, glass eels can also be fished with a dipnet of 1.5 m maximum diameter and mesh size of 1–2 mm. In 1983 there were 450 licensed fishers in Spain and 750 in Portugal, corresponding to 300–400 nets in total. In 1988 approximately 600 boats in Portugal have permission to fish glass eels with one net each and in 1995, 455 Portuguese boat inscriptions were recorded. In 1999, 251 Spanish fishers were registered for the glass eel fishery. Actually, nearly 500 fishers from both countries have a professional licence to fish glass eel.

The fact that a fisher has a licence to fish glass eels in a certain year does not necessarily mean that he will actually fish. The seasonal occurrence of other, relatively abundant species, like lamprey, influences the effort in the glass eel fisheries in an unpredictable manner.

The fishery is always performed at night around new moon as it depends completely on the rising tidal current. Depending on weather conditions peaks may occur in winter or spring. Catches in summer are very low (Antunes, 1994a).

Fishers are obliged to inform the local authorities of their total annual catches. The official fishery statistics are kept by the responsible local authorities-*Capitania do porto de Caminha.* Total annual statistics have been recorded since 1974. Between 1974 and 2005, 13.4.tons of glass eels were caught annually (however we estimated that values are 80% underestimated). A maximum of 50 tons was declared in 1980/81 followed by a second peak of 30.3 tons in 1984. In the period of 1985 to 1988 the official yield dropped to 9,5 tons with a peak of 15.2 tons in 1995. In 2000/2001 low catches were obtained, probably as a consequence of bad weather conditions that prohibited the fishery during 3 months. After 2001/2002 season until 2006 the values decreased to 2.0 tons. The 2006/2007 season values from Spain are not yet available.

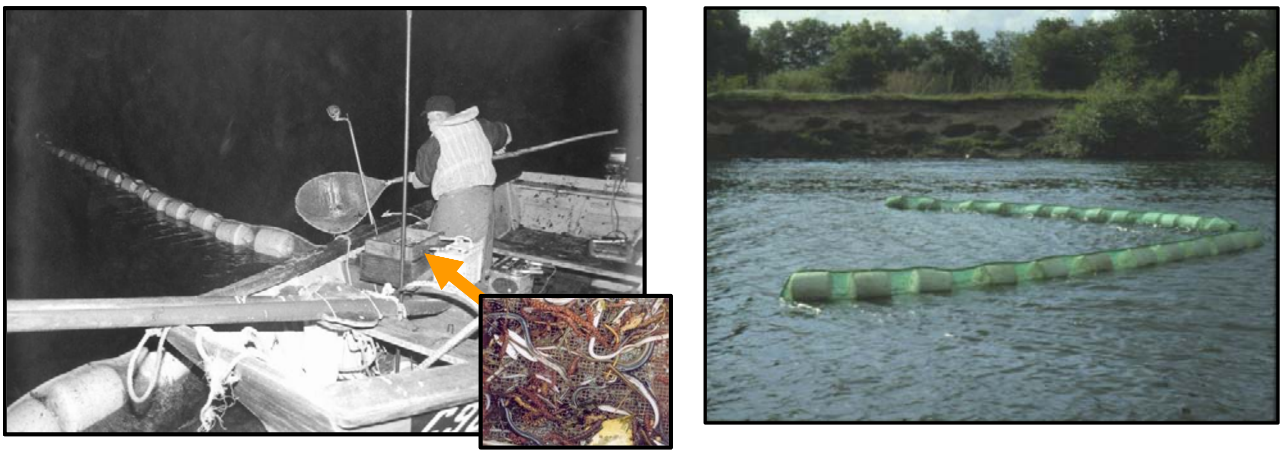


Figure 2. Stow net-“tela”.

Table 1. Official data of glass eel fishery between 1974 and 2007 in the Minho River.

YEAR	PORTUGAL	SPAIN	TOTAL (TONS)
1974	0,05	1,6	1,65
1975	5	5,6	10,6
1976	7,5	12,5	20
1977	15	21,6	36,6
1978	7	17,3	24,3
1979	13	15,4	28,4
1980	2,9	13	15,9
1981	32	18	50
1982	6,7	9,7	16,4
1983	16	14	30
1984	14,8	15,3	30,1
1985	7	6	13
1986	9,5	5,5	15
1987	2,6	5,6	8,2
1988	3	5	8
1989	4,5	4	8,5
1990	2,5	3,6	6,1
1991	4,5	2,4	6,9
1992	3,6	9,8	13,4
1993	2,9	2,1	5
1994	5,3	4,7	10
1995	8,7	6,5	15,2
1996	4,4	4,3	8,7
1997	4,5	2,9	7,4
1998	3,6	3,8	7,4
1999	3	3,8	6,8
2000	1,2	6,5	7,7
2001	1,1		1,1
2002	1,443	7,8	9,243
2003	0,814	1,6	2,414
2004	1,17	1,3	2,47
2005	2,7	0,32	3,02
2006	0,905	1,14	2,05
2007	0,750		

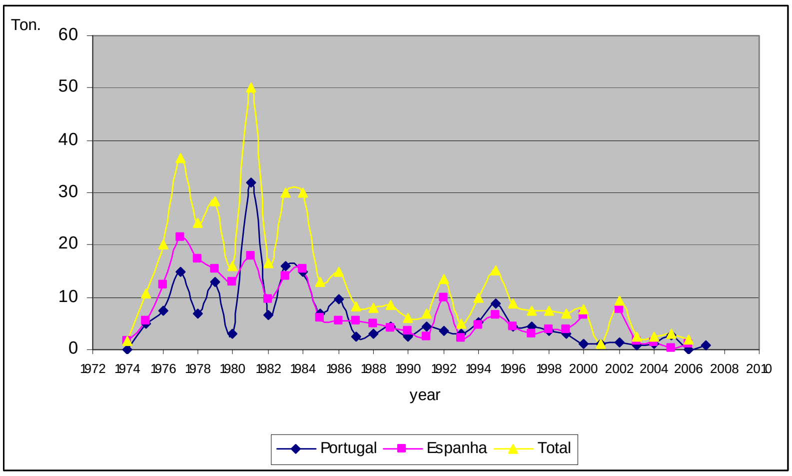


Figure 3. Official data of glass eel fishery between 1974 and 2007 in the Minho River (source: *Capitania do porto de Caminha* e *Comandancia Naval Tuy*).

PT.C.1.2. Illegal fishing

In the country, in all main rivers basin, with exception of the Minho River basin, an important illegal commercial glass eel fishing exists. In general there is no information concerning data of these fisheries. The information available is obtained directly through fishers and dealers. It is used an "invisible net"-stow net with bag that could be permanently in the water causing an important ecological impact.

Figure 4. Stow net with bag (17 meters long).

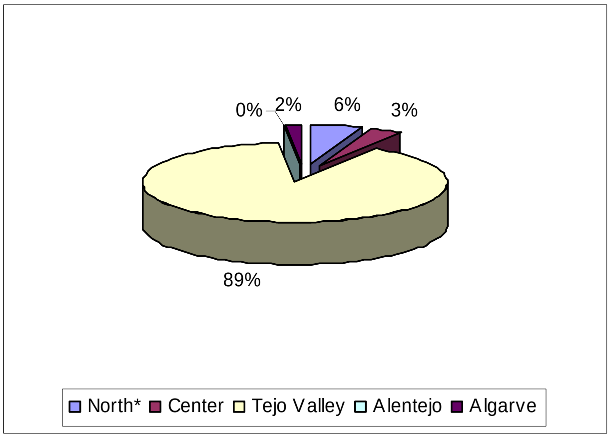
PT.C.2.Yellow eel

The yellow eel fishery management is from responsibility of "Ministério da Agricultura, do Desenvolvimento Rural e das Pescas" and there are differences among the national catchment areas. Generally are permitted longlines and fykenets to fish yellow eel, during all year with a minimum size that varies between 20 and 22 cm.

In the 1980s and concerning small-scale ("artesanal") fishery there was about 10 000 boats (15 000 fishers) which 80% were dedicated to the local fishery and 20% were to the coastal fishery. However, after one decade the number of the fishers was reduced to 12 000 (Franca *et al.*, 1988). We don't know the total number of professional of fishers fishing yellow eel. Only a partial data are declared, because a low percentage of yellow eel pass in the auction market for fish products.

Figure 5. Fykenet "galricho", Ria de Aveiro, Tejo River (Franca *et al.*, 1998).

Figure 6. Fykenet "nassa", Minho River.



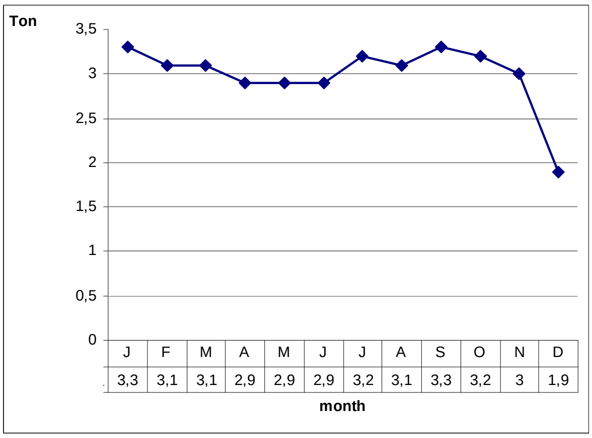


Figure 7. Percentage of declared values per region of the country. Total catch= 35,9 tons; Year-2002.

Figure 8. Monthly values declared for in all country regions. Total catch=35,9 tons; Year-2002.

The number of recreative fishers is estimated to be 600 000, of which 50% corresponds to inland fishing involving 100 M€/year.

PT.C.2.1 Minho River

In 1984 there were 1744 Portuguese fishers with licence to fish in the Minho River. The number decreased to around 800 at the beginning of 1990s. Actually the number of Portuguese and Spanish fishers is approximately 900 of which only 50% declared fish captures each year.

The yellow eel is captured using baited hooks and fykenets with the following legal fishing period: all year to the baited hooks and between September and November to fykenets.

Table 2. Yellow eel catch in the Minho River between 1983 and 2007.

YEAR	PORTUGAL	SPAIN	TOTAL
1983	2		2
1984	4,3		4,3
1985	3		3
1986	3,4		3,4
1987	3,1		3,1
1988	3		3
1989	3,8		3,8
1990	2,5		2,5
1991	2,984		2,984
1992	3,5		3,5
1993	5,6		5,6
1994	1,3		1,3
1995	1,5		1,5
1996	1,2		1,2
1997	0,75		0,75
1998	1,6		1,6
1999	0,65		1,02
2000	0,86	0,37	0,86
2001	0,316		0,316
2002	0,671		0,671
2003	1,014	0,265	1,279
2004	0,807	0,277	1,084
2005	0,95	0,32	1,27
2006	1,53	0,1	1,63
2007	1,51		1,51

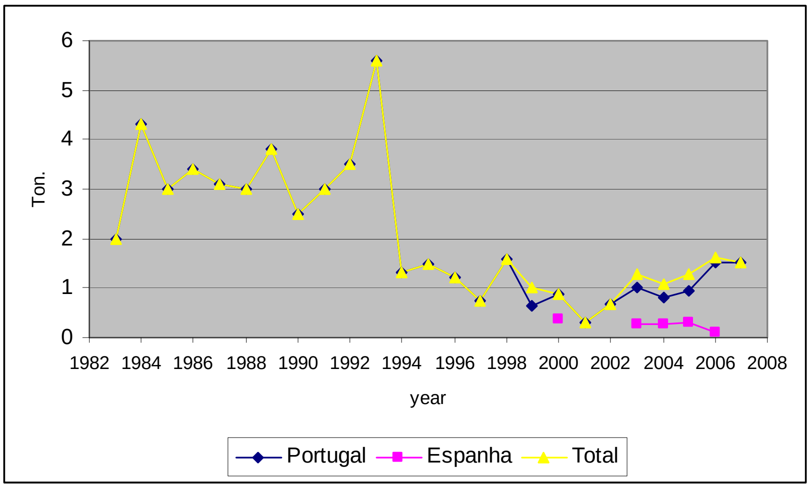


Figure 9. Yellow eel catches in the Minho River between 1983 and 2007 (source: *Capitania do porto de Caminha* e *Comandancia Naval Tuy*).

PT.D Fishing effort

Landings declarations don't include record for effort or gear. This kind of information is possible asking directly the fishers or dealers.

PT.E Catches and landings

Catch of glass eel-In the Minho River the monitoring of glass eels recruitment has been carried out since de mid 1970s based in professional fishers catch values and declared annually to the authorities.

Catch of yellow eel-There is no real data on landings of yellow eel in the country because usually the fish caught in estuaries and inland waters didn't pass in the auction market.

Aquaculture production-In Portugal the eel culture has no expression. Actually the available data means to extensive aquaculture practised in coastal lagoons and the values declared are below to 10 tons/year.

Re-stocking-There is no national programme for eel re-stocking.

Catch of recreational fisheries-There are no catch statistics from recreational fisheries.

The eel fishing activity in Portugal is not enough to the internal market. The main areas of eel consumption are in the Centre and South of the country, especially in the Tejo Valley region. No data exists about the amounts of eels alive that arriving Portugal from different origin markets like America, Marrocos, Tunisia, Spain, France, Belgium and the Netherlands.

PT.F Catch per unit of effort

Data on catch per unit of effort do not exist.

PT.G Scientific surveys of the stock

PT.G.1 Recruitment

Experimental glass eel fishery in the Minho River was initiated in 1981, supported by grants and projects, and conducted for several purposes, with no fixed stations in general (Weber, 1986; Antunes and Weber, 1990, 1993; Antunes, 1994ab). Occasional studies in Lis River, Mondego River, Guadiana River and Lima River were conducted for short periods (Jorge and Sobral, 1989; Jorge *et al.*, 1990; Domingos, 1992; Bessa, 1992; Bessa and Castro, 1994, 1995; Domingos, 2003). Generally the information available from scientific studies includes fishing time, yield, bycatch, biometric parameters, pigmentation, relation with moon's phase and time of the year.

Sites of experimental glass eel fishery	Period
Mondego River	1979–1983, 1988–1990
Lis River	1991–1994
Guadiana River	1998–1999
Lima River	2001–2002
Minho River	1981-

PT.G.2 Minho River

The statistics on the commercial fishery have been used as indicator of the recruitment strength. Underreporting is rather likely. Nevertheless, they will be indicative for the trend in glass eel recruitment to the Minho River for the past 30 years. Experimental fishing in Minho River has been operated since 1981 in several periods. Although monitoring was not the primary objective, this research has contributed to our knowledge of the fish stock and fisheries. The experimental fishing trend is in agreement with official data. In the last two years experimental fishing was done included in the INDICANG project. The work concerning glass eel entrance comprised:

- monthly experimental glass eel fishery (biometric and pigmentation stage, environmental data and in some periods the bycatch analyses);
- accurate fishing data from fishers to apply in glass eel estimation entrance.

PT.H Catch composition by age and length

Portugal has not sampled the landings/catches of eel.

PT.I Other biological sampling

PT.I.1 Yellow eel

PT.I.1.1 Eco-toxicological

At national level several eco-toxicological studies using eels from different catchment areas, were published, e.g.. Aveiro lagoon (Pacheco and Santos, 2001), Pateira de Fermentelos (Maria *et al.*, 2006; Teles *et al.*, 2007); Iqbal *et al.*, 2004, 2006.

PT.I.1.2 Contaminants

Information about trace metals in several fish species of the Ria de Aveiro, included eels is given by Cid *et al.*, 2001 and PCB's in Minho River by Santillo *et al.*, 2005. Neto, 2008 analysed and compared Cd, Cu, Pb and Zn concentrations in muscle and liver of eels and sediment of the Tejo estuary.

PT.I.1.3. Parasites

Different works dedicated to eel parasites are available:

Nematoda-Ria de Aveiro (Cruz *et al.*, 1992), Douro River catchment (Saraiva *et al.*, 2002; Saraiva *et al.*, 2002).

Intestinal Helminth communities-Lima, Cavado, Ave and Douro catchment areas (Saraiva *et al.*, 2005).

Protozoa-Âncora, Lima, Cávado, Douro and Tejo catchment areas (Carvalho-Varela, 1984; Cruz and Davies, 1998); Cruz and Eiras, 1997.

Parasite fauna in general including *Anguillicola* – Minho River catchment (Antunes, 1999; Aguilar *et al.*, 2005; Hermida *et al.*, 2006), Tejo river estuary (Neto, 2008), several rivers (Saraiva and Molnar, 1990; Silva, 1994; Saraiva, 1994, 1995, 1996; Saraiva and Chubb, 1996; Saraiva and Eiras, 1996; Rodrigues and Saraiva, 1996; Cardoso and Saraiva, 1998).

PT.I.1.4 Ecology

Age and growth-Aveiro lagoon (Gordo and Jorge, 1991).

Interaction with other species-*Halobatrachus didactylus* in Mira River estuary (Costa *et al.*, 2006).

Population structure, feeding and condition-Minho River basin (Antunes, 1990); Tejo River basin (Costa *et al.*, 2007).

Size structure, spatio-temporal variations-Mondego River (Domingos *et al.*, 2006).

PT.I.1.5 Predators

Great cormorant, *Phalacrocorax carbo* in Minho River estuary during two consecutive wintering periods. The estimates suggest that *P. carbo* ate 2,8 tonne of eels (Dias, 2007).

PT.J Other sampling

No data.

PT.K Stock assessment

No regular stock assessment.

PT.L Sampling intensity and precision

PT.M Standardisation and harmonization of methodology

At national level nothing is done about standardization and harmonization of methodology concerning eel scientific surveys; however the Minho river basin was in the Indicang project. Indicang was a network with participants spreading from UK to Northern Portugal and the main objective was to establish like a “net abundance indicators of European eel in its repartition central area”. One of the most important phases of the project was to publish different methodological guides with the objective to produce scientific and technical basis to estimate, from the descriptors chosen by the project, the relevant indicators to follow and evaluate the status of the eel resources and its environment.

PT.N Overview, conclusions and recommendations

Specific regulations exist in Portugal for the glass eel and yellow eel fisheries but they are not supported by any kind of management programme.

In the Minho River the fisheries Law was made in agreement between Portuguese and Spanish authorities and the fishers have to declare the catch values annually. These data are the common source concerning management programme.

Because glass eel has a high economical value, the fishery management is difficult in all rivers, being the Minho River the exception, and that is why a strong illegal activity is going on. The Minho is the only river where the "tela"-net is authorized by the two governments. The improvement of the rules associated with efficient surveillance by local authorities will help for a proliferation of illegal nets, as it happen in the other national rivers, and as we know causes eel damages and have a stronger ecological impact compared with "tela"-net. The distribution areas concerning eel migration in inland waters, was reduced by building dams and no re-stocking and fish pass programmes were implemented.

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Report on the eel stock and fishery in Sweden 2007

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SE.B Introduction

Eel fisheries in Sweden occur in most coastal waters from the Norwegian border in Skagerrak to about 61°N in the Baltic Sea. In the beginning of the 20th century eel fishery was practised also along the northern most parts of the Baltic Sea. There is also a considerable eel fishery in a number of fresh-water lakes. Both yellow and silver eels are fished, but there is no tradition (it is also against the law) to catch glass eels or elvers. The Government manages and controls the fishery in most marine areas and in the five largest lakes using a few management instruments like minimum legal size, gear restrictions, etc. There was also a substantial fishery for eels in privately owned waters both in coastal areas as in fresh water. In most lakes, except the five largest ones, the Government has almost no jurisdiction to regulate the fishery for any species. However, since 1st May, 2007 fishing for eels is prohibited in Sweden. There are some exceptions to this general ban as professional fishers that could prove they have fished more than 400 kg of eel on average during 2003–2005 or had a corresponding income from processed eel products could apply for a special permit (during 2007). At the same time this rule was imposed the minimum legal size was raised from 600 to 650 mm in fresh water and along the Baltic Coast. On the Swedish West Coast this size was raised from 370 to 400 mm. These minimum legal sizes now include also silver eels that were earlier exempted. The total number of fykenets allowed is now limited to 500 single or double fykes. To avoid an unwanted bycatch of eels, fykenets used by non-eel fishers should be equipped with two escape openings in each codend. As the mortality in eels passing several hydropower turbines probably is very high, eel fishing at sites (rivers and lakes) above three turbines without safe passages for descending silver eels is still allowed. In most fisheries the eels are fished in combination with other species. Depending on the type of water (fresh or brackish, west or east coast, etc.) species as pike-perch, perch, pike, cod, turbot, whitefish and flounders are important bycatch in the eel fisheries, though not worth enough alone for a viable fishery without eel as the main target species. The distribution of the commercial Swedish eel fishery could be simplified as in the following.

SE.B.1 The present division in eel fishing areas

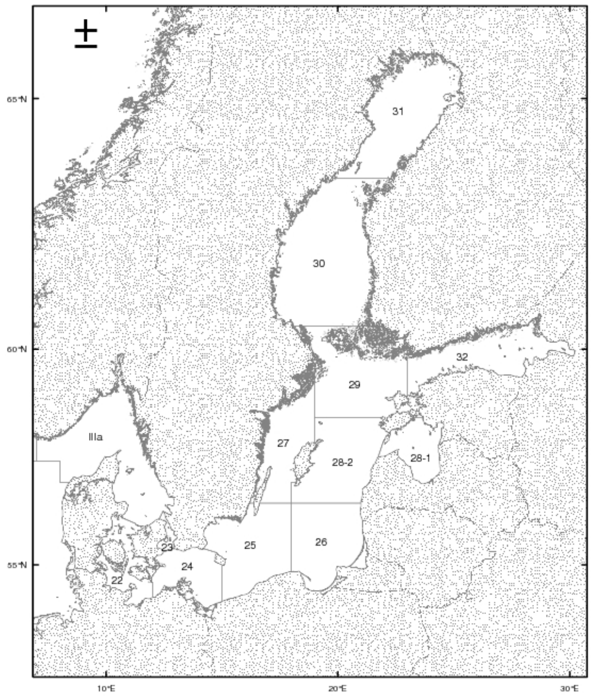


Figure SE.1 ICES Subdivisions in the Baltic area

SE.B.1.1 The Swedish West Coast from the Norwegian border (59°N, 11°E) to Öresund (56°N, 13°E), i.e. 320 km in Skagerrak and Kattegat (ICES Subdivisions 20 and 21)

Along this open coast there is an important fishery for yellow eels. Accordingly the minimum legal size is still as small as 400 mm. Mostly fykenets (single or double) are used, but also baited pots during certain periods of the year. The landings in this fishery are reported through the EU-logbook system as well as from contract notes delivered from authorized wholesaler to the Board of Fisheries. During the last nine years the annual commercial catch of mostly yellow eels was about 210 tons.

SE.B.1.2 Öresund, i.e. a 110 km long Strait between Sweden and Denmark (ICES Subdivision 23)

In this area both yellow and silver eels are caught using fykenets and some large poundnets. The northern part of Öresund is the last place where silver eels originating in the Baltic Sea could be caught before they disappear into the open seas. In recent times about 50 tons of yellow and silver eels were caught annually by Swedish fishers in Öresund. As Öresund is shared with Denmark special rules apply, among other things a very small minimum legal size (350 mm).

SE.B.1.3 The Swedish South Coast from Öresund to about 56°N, 15°E (approximately ICES Subdivisions 24 and 25)

This is a 315 km long coastal stretch of which more than 50% is an open and exposed coast. Silver eels caught in a traditional fishery using large poundnets dominate the catch. This is the "Swedish Eel Coast" where there are a lot of activities, restaurants and tourism based on the eel and the eel fishery. Some yellow eels are also caught, mainly in the archipelagos to the east. The minimum legal size in this area is now 650 mm. In recent years about 113 tons of yellow and silver eels were caught annually by commercial fisheries in this area.

SE.B.1.4 The Swedish East Coast from about 56°N, 15°E to 59°30′N, 18°50′°E (approximately ICES Subdivision 27)

Along this 450 km long stretch both silver and yellow eels are fished using both fykenets and large poundnets. Also in this area 650 mm is the new minimum legal size for eels. About 139 tons of yellow and silver eels are caught annually in this area.

SE.B.1.5 Freshwater lakes

There are sparse stocks of eels in most drainage basins all over Sweden except in the high mountain areas. However, nowadays most eels are fished with poundnets in Lakes Mälaren, Vänern and Hjälmaren. A number (at least 17) of smaller lakes, mainly situated in the southern part of the country, add another 25% to the catch in the large lakes. In total about 110 tons of eels are caught annually by the commercial eel fishery in lakes. In the five largest lakes where the Government has jurisdiction 650 mm is the new minimum legal size for both yellow and silver eels.

The fishery in fresh water is probably to a large extent based on stocked eels (about 90% in Lakes Hjälmaren and Mälaren) since the natural immigration to these lakes should be small today. Stocking material is either yellow eels in the size of 0.1 kg that has been caught on the Swedish West Coast or imported newly pigmented eels. In the three large lakes Vänern, Mälaren and Hjälmaren the fishers must have a permit from their respective County Board to fish with fykenets as soon they are deeper than 1,5 m. With that they are also obliged to leave catch statistics to the Board of Fisheries on a monthly basis. In the smaller lakes the professional fishers fish in privately owned waters but as they have a fishing license they have to deliver catch statistics but only on a yearly basis. The fishing is usually carried out from small boats with a length of 5–6 m.

Eel fishing may also occur in additional lakes and some streams where traps have been built. The extent of this fishery is unknown, but it is probably of minor importance today. However, a recent inventory for the European Dipper (*Cinclus cinclus*) discovered numerous eel traps in small streams in Halland and Västra Götaland Counties (Lundberg, 2008). In the investigated area on the Swedish West Coast there was one eeltrap in every km^2. It has been estimated that those 5000–10 000 traps might catch as much as 25–100 tonne silver eels annually (Westerberg, pers. comm.). Most if not all traps are illegal with the new eel fishing legislation. The recreational fishing of eel in small fresh waters is probably of even smaller importance, even if longline fishing exists in some lakes (cf. the 20 tons mentioned below). Probably most of such eel fisheries have now stopped as a consequence of the new restrictions imposed.

Besides what is described above there is a more or less unknown and uncontrolled fishery by non-commercial fishers, by recreational fishers using professional fishing gears and by true anglers (rod and line). This fishery has been estimated four times since 1990 by using questionnaires and amounts according to the most recent poll in 2005 to 491 tons of which 388 came from the sea and 103 from fresh water (Fiskeriverket, 2005). As the estimates for eel are based on very few replies the uncertainties are large.

The commercial catch of eels in Sweden in 2004 was then about 473 tons from the sea and 100 tons from fresh water, i.e. about 573 tons in total. The recreational catch adds another 491 tons making a grand total of about 1000 tons. A very recent correction of the estimate of the recreational catch is discussed in Section SE.E.5. In short the new estimate of the recreational catch is 250 tons only. Thus the grand total might be about 800 tons.

Preliminary results from a similar questionnaire for 2006 give ca. 280 tons of eel as total recreational catch of which ca. 20 tons were taken by anglers. This estimate corresponds quite well with the figures from 2004, although the catch was differently distributed between coastal stretches. However, it is stressed that standard errors are very high and that very few recreational fishers reported on eel catches. Most of this fishery is now (since 1st May, 2007) prohibited as a consequence of the new legislation.

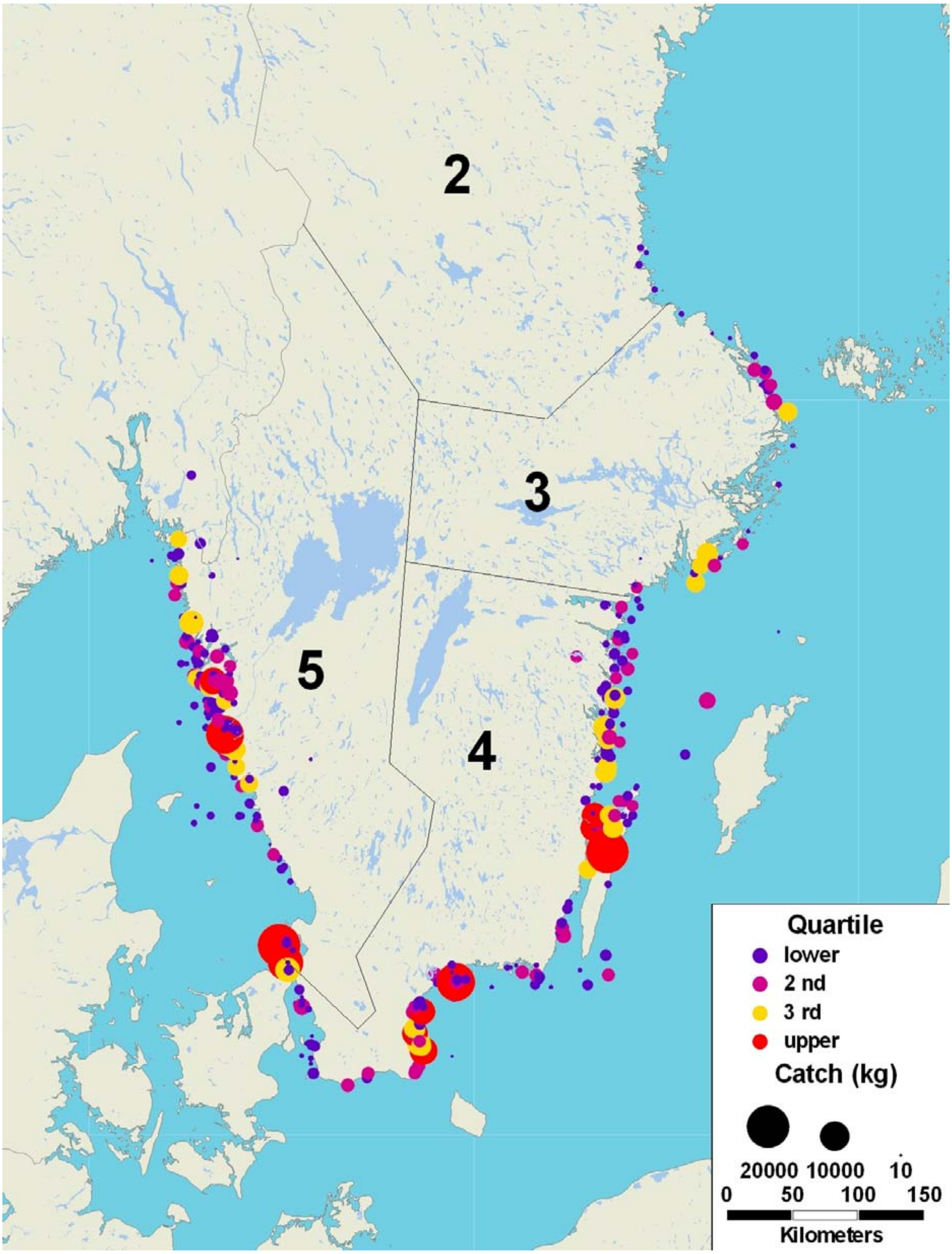


Figure SE.2 The commercial catch in year 2007 expressed per unit area (squares of 1 minute latitude * 1 minute longitude). The sizes of the circles are proportional to the catch. Colour coding indicates where most eels are caught. The River Basin Districts are schematically indicated (as 2–5).

SE.B.2 River Basin Districts (RBD)

The Water Framework Directive subdivides Sweden into five separate River Basin Districts, of which two extend to some importance beyond our borders (Figure SE.2). These are the RBD numbers:

1. **Bottenvikens vattendistrikt** (or BBAY) shared with Finland (small part to the north). This RBD includes all drains to **the northern part of the Gulf of Bothnia**. Eels do occur in this RBD, but are nowadays quite rare. A few successful stocking experiments were performed in this RBD during the 1970s and 1980s. Drainage area: 154 702 km^2.
2. **Bottenhavets vattendistrikt** (or BSEA) that drains into **the southern part of the Gulf of Bothnia**. Eels occur also in this area. During the early 20th century there was a substantial eel fishery in the southern parts of this RBD. At the present time the commercial catches are small. Drainage area: 146 667 km^2.
3. **Norra Östersjöns vattendistrikt** (or NBAL) drains **the central parts of Sweden**, including two of the five largest lakes in Sweden. Eels and eel fisheries are quite abundant in this RBD and in addition to a reduced natural recruitment both lakes and coastal areas are frequently stocked with imported elvers. Drainage area: 44 212 km^2.
4. **Södra Östersjöns vattendistrikt** ("**the Southern Baltic Sea**") (or SBAL) drains a large part of southern Sweden and includes a vast number of lakes with eel and also the coastal waters where there was and still is an important and traditional fishery for silver eels. Several lakes are stocked annually also in this RBD. Drainage area: 59 939 km^2.
5. **Västerhavets vattendistrikt** ("**the North Sea**") (or WEST) shared with Norway (to a minor part). This RBD includes the large Lake Vänern and numerous lakes and streams were eels still are quite abundant. Several lakes are stocked annually in this RBD. Drainage area: 73 330 km^2.

The main parts of the eel fisheries in Sweden are concentrated to RBD 3, 4 and 5. However, the catch of silver eels along the coast of RBD 4 is known to come from eels that have lived and grown in almost any part of the Baltic Basin. However, a majority have grown up in brackish water. This knowledge is based on tagging studies and otolith chemistry.

SE.C Fishing capacity

SE.C.1 Coastal waters

Table SE.a Number of fishers by RBD with eel landings (all gears).

	BBAY	BSEA	NBAL	SBAL	WEST	ALL
1999	0	27	37	169	172	405
2000	3	28	35	141	134	341
2001	0	27	27	140	138	332
2002	1	26	28	126	145	326
2003	1	29	28	144	132	334
2004	1	32	29	134	127	323
2005	0	30	33	158	132	353
2006	2	28	29	188	124	371
2007	2	4	35	181	100	322
Mean	**1**	**26**	**31**	**153**	**134**	**345**

Reliable information on fishing capacity can only be presented as the number of individual fishers reporting catches in the official statistics. The numbers in Table SE.a do not consider the size of the reported catch of the individual fisher or which life stage is the primary target. The Southern Baltic and the West Coast RBD´s were the dominating districts with equal shares in 1999–2007.

SE.C.2 Freshwater

From the inland eel fishery, statistics exists from all fishers that have fishing licenses or a permit to use deeper fykenets and poundnets in Lakes Vänern, Mälaren and Hjälmaren. There are no companies operating in the lakes but the fishing is carried out by single fishers or in very few cases by two fishers together. The number of fishers in the lakes that reported catch of eels is demonstrated below, per lake or group of lakes and per RBD. The total number of eel fishers has decreased from 104 to 77 in a few years with a sudden step from 93 in 2006 to 77 in 2007. This decrease is probably as a consequence of the new legislation since May 2007.

Table SE.b

Lake	Vänern	Mälaren	Hjälmaren	Other lakes	Total
Number of fishers in 2007	14	22	24	17	77

RBD	3	4	5	Total
Number of fishers in 2007	47	8	22	77

SE.D Fishing effort

SE.D.1 Coastal waters

The official catch statistics at present do not give reliable information on the effort in the fishery for eel. Detailed information on effort is available locally from industrial recipient programmes in some sites in the Baltic. The Baltic eel fishery is dominated by poundnets targeting silver eel, to a great extent on private waters. In one area in the central Baltic, effort, as expressed by numbers of poundnets multiplied by fishing days, was reduced from 6000 in the late 1960s to less than 2000 around the turn of the millennium. This change is mainly explained by single enterprises closing down the fishery as a consequence of old age of the fishers. The development is probably representative for the entire region.

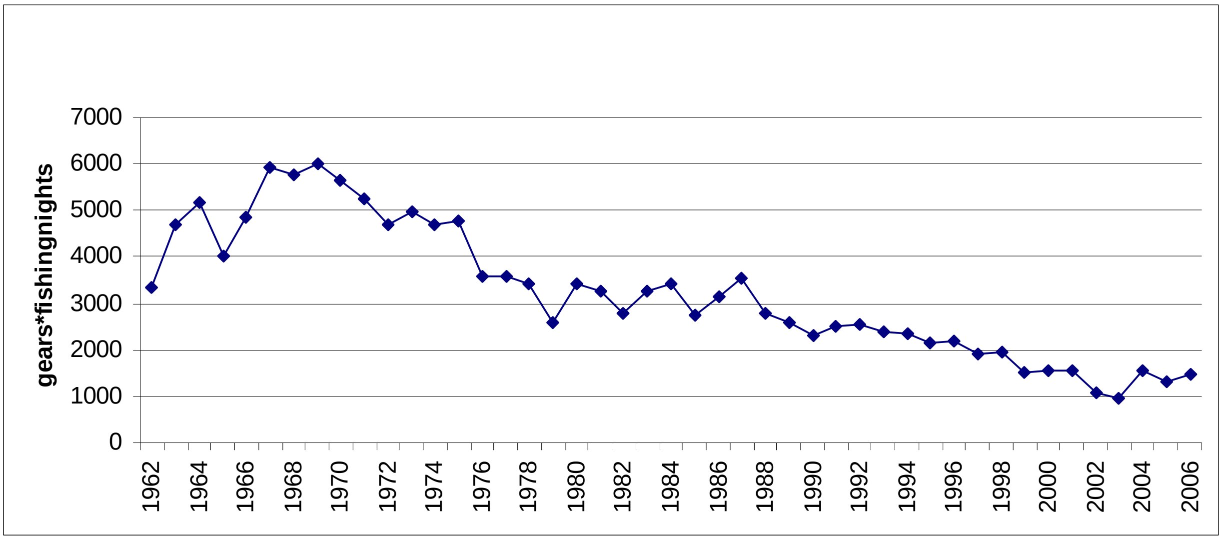


Figure SE.3 Effort in poundnet fishery for silver eel in one area on the Swedish coast in ICES Subdivision 27. The unit is number of gears*number of fishing nights.

SE.D.2 Freshwater

In the eel fisheries in the three lakes mentioned above, the type of net used varies both between and within lakes. There is no other information than that the nets are deeper than 1, 5 m. The nets have a leader which may be 50–300 m long and the depth of the nets varies between 3 and 20 m.

The temporal resolution of the statistics is on a daily basis in the larger lakes and on a yearly basis in the smaller lakes. The maximum number of all kinds of fykenets used in 2006 is demonstrated in the Table below.

Table SE.c

Lake	Vänern	Mälaren	Hjälmaren	Other lakes	Total
Number of net permits	101	165	167	133	566

During 2007 the following numbers of poundnets (“bottengarn”) were used on a daily average in four of our lakes.

Table SE.d

LAKE	NUMBER OF POUNDNETS USED (DAILY AVERAGE OVER THE YEAR)
Vänern	45
Vättern	5
Mälaren	75
Hjälmaren	87
Total	212

The abundance of fykenets is largest in the shallow Lake Hjälmaren, which area is about 20% of the area of Lake Vänern and 40% of the area of Lake Mälaren.

SE.E Catches and landings

SE.E.1 Catch of glass eel/elver

Not valid as there are no glass eel fisheries in Sweden (neither viable nor legally allowed).

SE.E.2 Restocking

Restocking inland and coastal waters with glass eels, elvers, bootlace or medium-sized yellow eels, is practised since many years in Sweden, in order to improve the local eel fishery. Already at the beginning of the 20th century elvers were imported from England (via Hamburg, Germany). Since the beginning of the 1970s a more regular restocking programme has been in operation. From the beginning mostly medium-sized yellow eels from the Swedish West Coast were used but the proportion of imported and quarantined elvers has slowly increased. Most of the costs are covered by the Government using different funds destined for fish stock management (e.g. funds imposed by the water-rights courts), but also the commercial fishers' association and local societies make a substantial contribution. In 1998 ca. 1.1 million € was spent on restocking while only about 0,5 million € was spent in 2005. A database over the amounts of stocked eels in separate water bodies is almost finalized. During 2000–2007 the following quantities of eels were restocked:

Table SE.e Restocked quantities as numbers of glass and yellow eels per River Basin District (fresh water) and year 2000–2007.

RBD	2		3		4		5		Σ
Stage	G	Y	G	Y	G	Y	G	Y	
Year									
2000	43 750	0	249 955	266 013	233 180	275 308	846 295	35 618	1 950 119
2001	60 405	0	183 420	149 050	210 265	170 698	389 632	59 784	1 223 254
2002	282 100	0	374 390	59 268	298 618	79 365	561 264	32 241	1 687 246
2003	163 860	0	324 810	73 964	118 360	177 298	1 736	21 560	881 588
2004	214 190	0	114 292	46 200	245 468	103 675	696 179	18 469	1 438 473
2005	32 000	0	185 496	40 282	308 667	21 864	399 072	3 212	990 593
2006	32 000	0	287 140	0	340 021	0	352 949	0	1 012 110
2007	144 787	0	174 235	0	246 783	0	288 352	0	854 157
Σ	973 092	0	1 893 738	634 777	2 001 362	828 208	3 535 479	170 884	10 037 540

Table SE.e Restocked quantities as numbers of glass and yellow eels per River Basin District (coastal areas) and year 2000–2007.

RBD	2		3		4		5		Σ
Stage	G	Y	G	Y	G	Y	G	Y	
Year									
2000	0	0	0	0	0	90 970	0	0	90 970
2001	0	0	0	0	0	60 643	0	0	60 643
2002	171 000	0	0	0	0	85 294	0	0	256 294
2003	111 460	0	52 400	0	61 000	0	0	0	224 860
2004	0	0	3 702	0	0	16 170	15 000	0	34 872
2005	0	0	0	0	89 604	0	0	0	89 604
2006	0	0	0	0	128 723	0	0	0	128 723
2007	0	0	69 060	0	80 426	0	7 500	0	156 986
Σ	282 460	0	125 162	0	359 753	253 077	22 500	0	1 042 952

Today "glass eels" (**G**) implies quarantined and pre-grown elvers of about one gramme each and the medium-sized yellow eels (**Y**) are about 90 grammes each. For the first time in many years no medium-sized yellow eels were stocked in 2006 and 2007.

SE.E.3 Catch of yellow and silver eel

SE.E.3.1 Landings (data from contract notes)

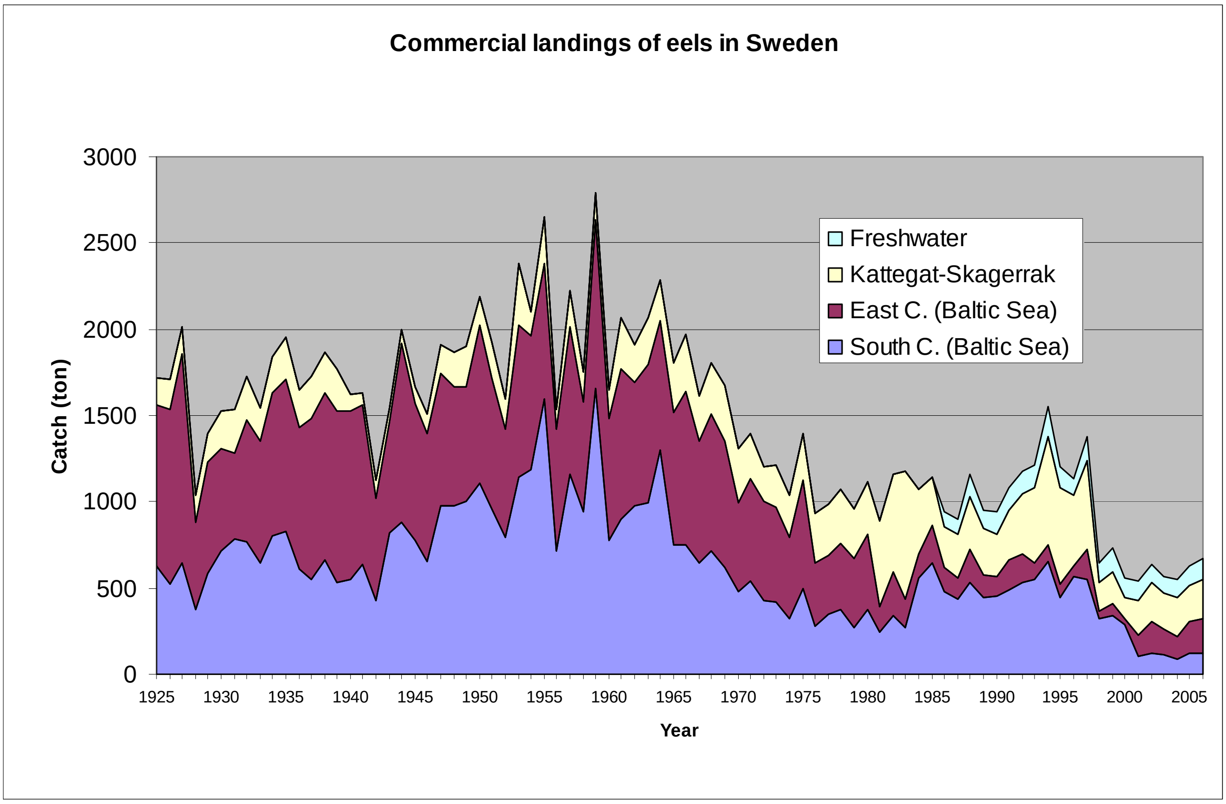


Figure SE.4 Commercial landings of eel in Sweden (data come from the contract notes, Kattegat-Skagerrak corresponds to RBD 5). The data behind this figure is given in the Appendix (Table SE.n).

SE.E.3.2 Freshwater

In inland waters the catch statistics is reported and stored at the Swedish Board of Fisheries. No distinction is made of different life stages of the eels caught. A recent sample from the commercial catch in six lakes demonstrated that about 80% were silver eels and 20% yellow or half-silver. The average size was 0,96 kg with a range from 0,25 to 2,5 kg. Eels do silver at different sizes in different lakes. Yearly catches for the period 2000–2007 is shown below.

Table SE.f Commercial catch in fresh water (tons).

Year	Vänern	Mälaren	Hjälmaren	Other lakes	Total
2000	22	38	20	34	114
2001	25	38	23	32	118
2002	22	34	18	29	103
2003	23	31	16	26	96
2004	23	38	18	28	107
2005	21	42	18	29	111
2006	21	45	21	36	124
2007	19	41	20	31	111

The catches have varied fairly little during the period.

SE.E.3.3 Freshwater per RBD:

RBD 1. There are no data or catches reported from fresh water in this district. This is in accordance with the low natural recruitment to this remote part of Sweden and to the fact there are no regular restocking activities in operation. There are more than 15 157 lakes with a total area of 9919 km^2 in this RBD.

RBD 2. Eels do occur in this area, but there is only a small fishery for them. There are no data from fresh water available. There are more than 12 132 lakes with a total area of 10 212 km^2 in this RBD.

RBD 3. From this district there are catch data from four lakes, Mälaren, Hjälmaren, Sottern. The total reported catch was 61,4 tons in 2007. There are more than 2474 lakes with a total area of 3375 km^2 in this RBD.

RBD 4. In this district there are catch data from 9 lakes. In total 9,6 tons were caught in 2007. There are more than 3970 lakes with a total area of 4899 km^2 in this RBD.

RBD 5. There are commercial eel fisheries in six lakes in this district. The main part comes from the huge Lake Vänern (5650 km^2) with 19,0 tons and the total reported catch was 39,7 tons in 2007. There are more than 4900 lakes with a total area of 9734 km^2 in this RBD.

SE.E.3.4 Coastal waters

Total eel catches reported to the logbook system averaged 520 tons in 1999–2007. As the system allows reports of undefined eel catches, the relation between life stages is not exactly known. It is estimated that the shares are equal for yellow- and silver eel. The duty to present logbooks was not mandatory for fishing on private waters until 2005. This implies that catches in the Baltic Sea silver eel fishery were underestimated. The degree of underestimation is not known. However, during the last three years reported catches were considerably higher than the preceding years. That might be an effect by this new legislation. In addition, the new legislation requiring license for eel fishing in 2007 has probably further reduced underestimation of catches.

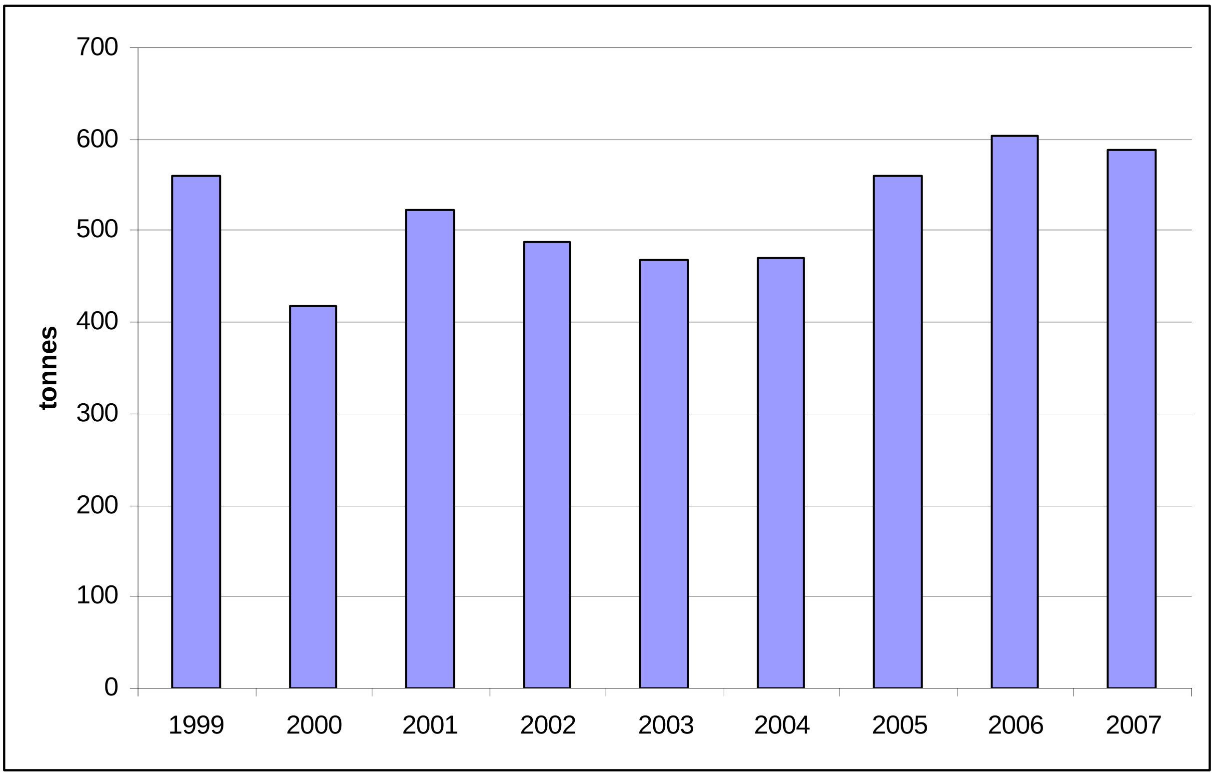


Figure SE.5 Total landings (tonnes) in the Swedish eel fishery as reported in logbooks in 1999–2007.

When catches are separated on RBD´s, the dominance for the Southern Baltic and the West Coast districts is evident (see Figure SE.6). The catches in Southern Baltic RBD are dominated by silver eel from poundnets, while the catches from the West coast RBD concerns mainly fykenet catches of yellow eel.

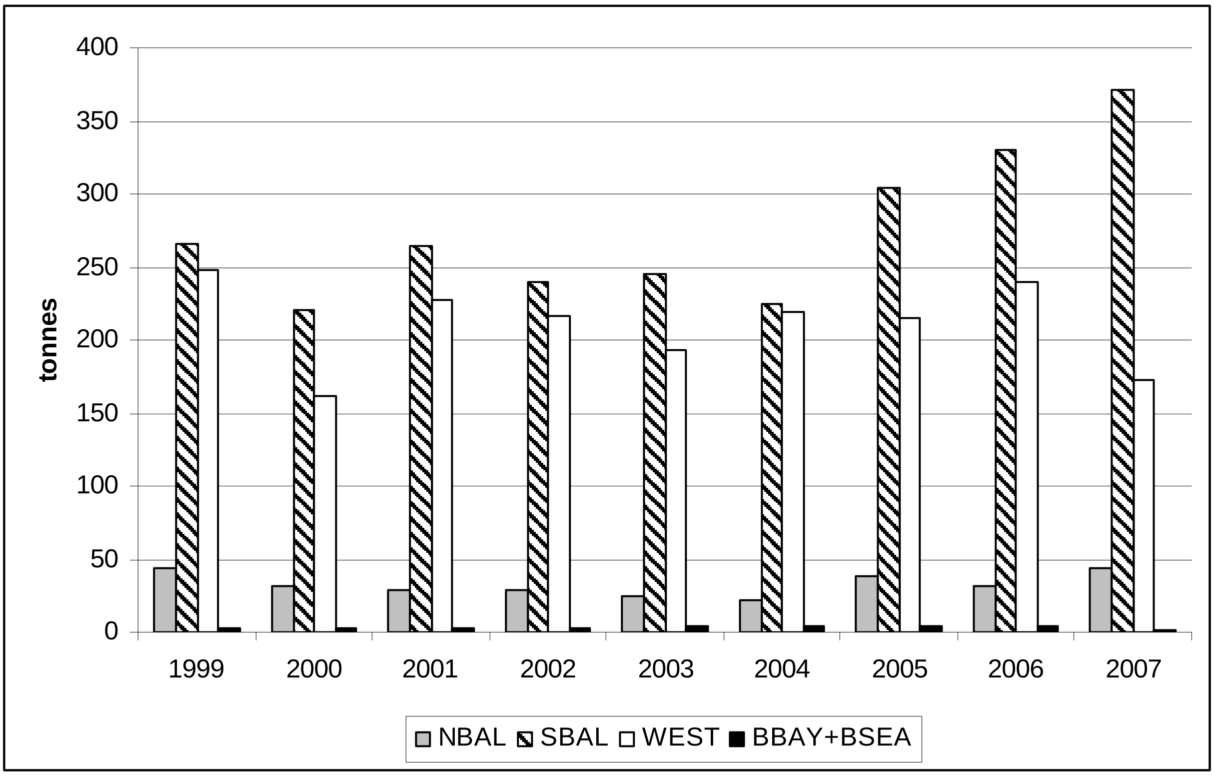


Figure SE.6 Total logbook landings in 1999–2007 approximately separated on RBD´s.

SE.E.4 Aquaculture

Today there are two eel cultures running, one based on imported elvers from the UK and the second one on medium-sized yellow eels from the Swedish West Coast. Different sources reported slightly diverging results for the Swedish eel aquaculture industry:

Table SE.g Production of eels in aquaculture from 1983 in Sweden. (SCB 1 and SCB 2 denote one official (SCB 1) and one "unofficial" (SCB 2) version (SCB 2007).

Aquaculture production (tons/year)	Data source		
	*SCB 1	*SCB 2	FAO Fishstat
1983	2	2	2
1984	12	15	12
1985	41	47	41
1986	51	59	51
1987	90	104	90
1988	203	233	203
1989	166	190	166
1990	157	179	157
1991	141	160	141
1992	171	195	171
1993	169	192	169
1994	160	182	160
1995	139	158	139

Aquaculture production (tons/year)	Data source		
	*SCB 1	*SCB 2	FAO Fishstat
1996	161	184	161
1997	189	215	189
1998	204	232	204
1999	222	253	222
2000	273	311	273
2001	200	228	200
2002	167	190	167
2003	170	194	170
2004	158	158	158
2005	222		222
2006	191		191
2007	175		

***SCB (Statistics Sweden) is the official source of statistics in Sweden.**

SE.E.5 Recreational fisheries

In addition to commercial fisheries, the sports/recreational/household fisheries did contribute significantly to the total landings of eel. The recreational fisheries have been studied in four surveys, most recently in 2005, by means of questionnaires (Fiske 2005-Report by the Swedish Board of Fisheries and Statistics Sweden). Although biased when it comes to the representativeness in the collected data (those who do fish tend to answer questionnaires whereas those who do not fish do not bother) the amount of eel caught by sport/recreational/household fishery in the whole country is estimated to 491±218 tonnes per year-about the same amount as the commercial fisheries.

The results and conclusions from this study have recently been subject for a provisional recalculation. It seems that as a consequence of the problems mentioned above the recreational catch of eels was overestimated with 97%. The new and corrected results are displayed below.

Table SE.h

Fishing district	Skagerrak & Kattegat	The Sound	S. Baltic Sea	Middle Baltic Sea	the Gulf of Bothnia	Others	Total
Corresponding RBD	5	4	4	~3	~1-2	na	
Corrected estimated catch (kg)	18 283	19 765	60 549	81 597	3364	65 840	249 398

Adding up these 249 tons of eel from recreational fisheries (Table SE.h) to the commercial catch ends in a total Swedish catch of about 800 tons.

A fifth survey has just been carried out and the preliminary results concerning eel and 2006 give ca. 281 tons of which 22 tons were taken by anglers. 38 tonnes of the total recreational catch were reported as coming from fresh water.

Using the most recent but preliminary data above for the recreational fishery in 2006, the corresponding total Swedish catch was about 950 tons. The legislation from May

2007 made most recreational fishing for eel illegal.

It has been estimated that the total catch of eels have decreased by about 35% since the new legislation came into force in May 2007. As the development in landings were different along the East Coast compared to the West Coast, normalized data from a subsampled population of individual eel fishers were used to correct the estimates (Westerberg, pers. comm.). The main reason to this decline is probably that the number of active eel fishers decreased by 10%.

SE.F Catch per unit of effort

SE.F.1 Freshwater

In inland eel fisheries cpue data can be calculated on a yearly basis in respective lake, but the dataset is not available. As the type of nets may shift over time it may, however not seem to be very meaningful to do that. In Lake Mälaren and Hjälmaren for example the fishers tend to replace fine mesh fykenets, which catch pike, pikeperch and perch in addition to eel, with nets with a coarser mesh size to be able to fish for pikeperch more effectively. The data has never been used for stock assessment as the fishery is based mainly on stocked individuals.

SE.F.2 Marine areas

Selected companies have provided detailed catch statistics from the poundnet fishery for silver eel in the Baltic Sea since the late 1950s. The trend in cpue is negative in the longest time-series from ICES Subdivision 27 (Figure SE.7 upper and middle panel, N. Småland and N. Kalmarssund), corresponding to a 50% decrease from the 1960s to recent years. The trend is negative also in the Hanöbukten area, but catches increased more evidently in that area in recent years (Figure SE.7 lower panel). No trend exists in the southern Östergötland area (Figure SE 7. upper panel). The time-series are based on an arithmetic average of a set of fixed fishing stations in all areas but N Kalmarsund. This may induce a bias as a consequence of optimizing the effort over time, such that stations giving lower catches are abandoned. When the three most significant stations were tested in the S. Östergötland area, considering contribution to total catch and representation over time, a negative trend was observed in two cases, corresponding to the decrease in areas further south along the coast. In the third case no trend was found (Figure SE.8).

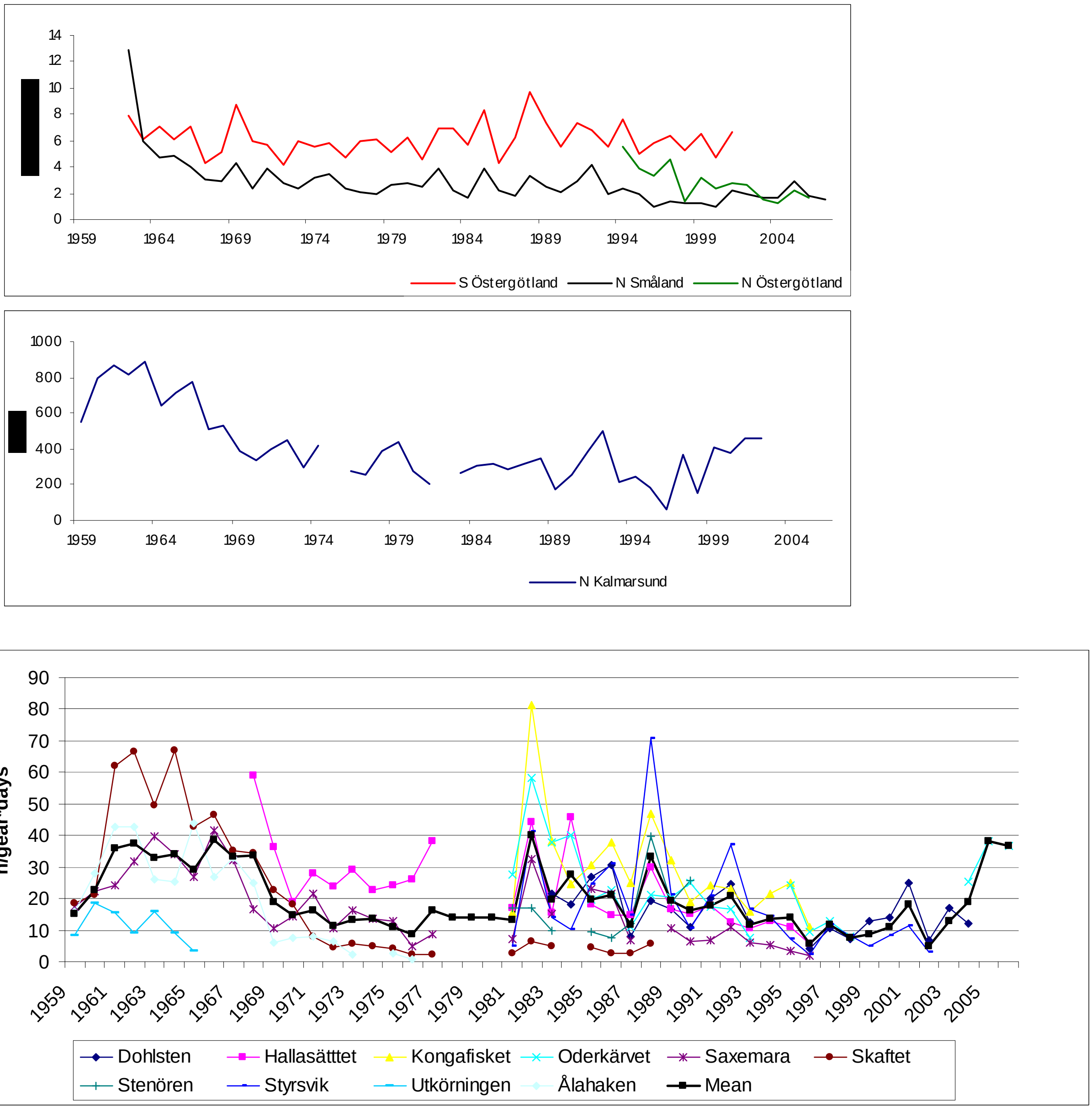


Figure SE.7 Time trends in poundnet catches of silver eel in five subareas in Swedish RBD 4 (Southern Baltic). Four subareas (upper and middle panel) are all located in ICES Subdivision 27 on the Swedish coast of the Baltic Proper. The Hanöbukten area (lowest panel) is located in ICES SD 25 on the SE coast of Sweden.

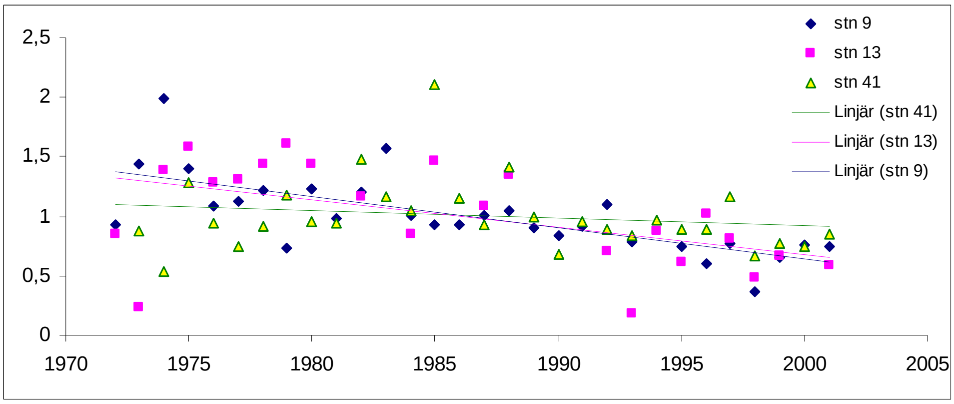
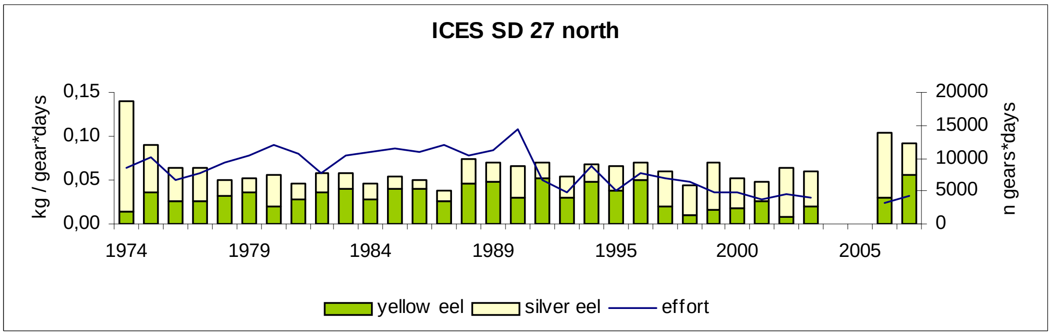


Figure SE. 8 Trend in silver eel cpue in three specific poundnet stations in the S Östergötland area. Individual observations were divided by the long-term mean.

Fishing for eel with fykenets is of minor importance compared to poundnets on the Swedish coast of the Baltic Proper. Nevertheless it operates in a rather conservative way since several decades and long time-series exist from a few companies. Since determination of life stages by the fishers may be influenced by market demands rather than being based on biology, catch per unit of effort is presented for yellow- and silver eel together (Figure SE.9). The cpue was stable in both areas over the years. In SD 27 north (the southern Östergötland area) yellow eel became less abundant in the mid 1990s, but this decrease was compensated by a larger proportion of silver eels. The cpue in 2006–2007 of both life stages together was the highest since 1974. In SD 27 south (the northern county of Kalmar), silver eel became more abundant in fykenet catches in the early 1990s. In this area the silver eel catches in 2005–2007 were the biggest ever recorded in fykenets, and fishers all over the area reported good catches. The good catches of silver eels in recent years may have induced a change in practice in the fykenet fishery, more towards targeting silver eel.

From 1990 the minimum legal size for landing of yellow eel was raised in two steps from 53 to 60 cm. This probably had an influence on the cpue in fykenets. From 1 May, 2007 the minimum legal size was raised to 65 cm for both yellow and silver eels. The mean weight of yellow eel landings was close to 600 g in recent years.



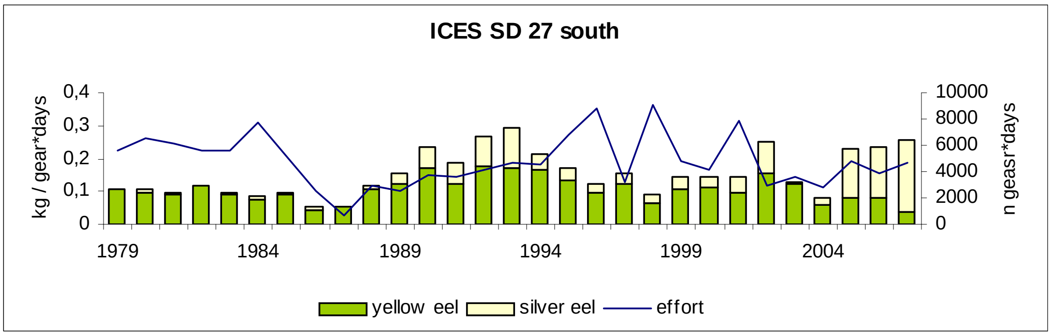


Figure SE.9 Time trends in cpue and effort for fykenet catches of silver and yellow eel in two subareas in Swedish RBD 4 (Southern Baltic). The subareas are all located in ICES Subdivision 27 on the Swedish coast of the Baltic Proper. Southern part of the county of Östergötland (upper) and northern part of the county of Kalmar (lower).

SE.G Scientific surveys of the stock

SE.G.1.1 Recruitment surveys/ascending young eels

Recruitment of young eels (from glass eels and elvers to quite large bootlace eels) in Swedish waters is monitored in eel passes (equipped with collecting boxes) at the most downstream hydropower dam in a number of rivers along the Swedish coasts. Eels caught are weighed (or counted) before being released in upstream areas. Data from the most reliable eel passes, four in the Baltic Sea and four in Skagerrak-Kattegat, are given in the table below (see Wickström, 2002 for a more complete description).

During the last years the recruitment has generally been low or very low compared to historical levels until the 1960s. So far unexplained, there are sudden peaks in the amount of ascending eels during certain years and in different rivers. In e.g. River Kävlingeån there was an unusually high catch in 2004 when all the remaining rivers were still very low. Since 2006 the catch in the River Göta Älv eel pass is negligible and the reason behind is still unclear. Technical inefficiencies at the eel pass can be one reason. Reconstruction work at the most downstream dam might as well have affected the upstream run of eels in the river.

Additional recruitment series on glass eels come from an experimental trawl fishery (with an IKMWT) in the intake channel for cooling water at the Ringhals Nuclear Power Plant (in Kattegat) and from the ICES-IBTS (formerly YFS) using an MIK-trawl in Skagerrak-Kattegat (cf. Section SE.G.1.2).

Table SE.i Amounts (kg) of ascending young eels caught in eight rivers along the Swedish coasts.

RIVER	DALÄLVEN	MOTALA STRÖM	MÖRRUMSÅN	KÄVLINGEÅN	RÖNNE Å	LAGAN	VISKAN	GÖTA ÄLV
YEAR/RBD	RBD 2	RBD 4	RBD 4	RBD 4	RBD 5	RBD 5	RBD 5	RBD 5
1900								530,0
1901								5100,0
1902								340,0
1903								858,0
1904								552,0
1905								8700,0
1906								2000,0
1907								275,0
1908								na
1909								na
1910								na
1911								5728,0
1912								6529,0
1913								20,0
1914								2828,0
1915								na
1916								na
1917					45,0			na
1918					4,5			na
1919					na			1465,0
1920					na			800,0
1921					na			1555,0
1922					na			455,0
1923					na			1732,0
1924					na			4551,0
1925					na	331,3		5463,0
1926					49,0	357,8		3893,0
1927					445,0	581,1		4796,0
1928					0,0	211,9		47,0
1929					0,0	4,5		756,0
1930					147,0	268,0		5753,0
1931					na	316,0		2103,0
1932					na	408,0		7238,0
1933					na	303,5		6333,0
1934					na	236,0		6338,0
1935					na	53,5		1336,0
1936					na	24,5		2537,0
1937					na	0,5		8711,0
1938					na	106,5		3879,0
1939					na	36,0		4775,0

RIVER	DALÄLVEN	MOTALA STRÖM	MÖRRUMSÅN	KÄVLINGEÅN	RÖNNE Å	LAGAN	VISKAN	GÖTA ÄLV
1940					na	684,0		1894,0
1941					na	321,0		2846,0
1942		14,0			na	454,0		427,0
1943		283,0			na	1248,0		1848,0
1944		773,0			na	1090,0		2342,0
1945		406,0			na	1143,0		2636,0
1946		280,0			29,7	766,5		2452,0
1947		272,5			5,8	440,8		675,0
1948		120,0			6,0	494,7		1702,0
1949		43,0			39,4	603,6		1711,0
1950		304,5			93,5	419,9		2947,0
1951	210,0	2713,0			1,0	281,8		1744,0
1952	324,0	1543,5			9,1	379,1		3662,0
1953	241,5	2698,0			70,0	802,4		5071,0
1954	508,5	1030,0			2,7	511,3		1031,0
1955	550,0	1871,0			42,6	506,9		2732,0
1956	215,0	429,0			14,1	501,6		1622,0
1957	161,5	826,0			46,8	336,1		1915,0
1958	336,7	172,0			73,2	497,2		1675,0
1959	612,6	1837,0			80,0	910,5		1745,0
1960	289,0	799,0	29,0		93,0	552,4		1605,0
1961	303,0	706,0	665,5		143,7	314,8		269,0
1962	289,0	870,0	534,8		113,0	261,9		873,0
1963	445,4	581,0	241,2		32,5	298,1		1469,0
1964	158,0	181,6	177,8		34,7	27,5		622,0
1965	276,4	500,0	292,3		87,1	28,0		746,0
1966	157,5	1423,0	196,3		48,5	216,5		1232,0
1967	331,8	283,0	353,6		6,6	24,4		493,0
1968	265,5	184,0	334,8		398,0	74,4		849,0
1969	333,7	135,0	276,8		85,7	117,1		1595,0
1970	149,8	2,0	80,4		29,8	24,7		1046,0
1971	242,0	1,0	141,1		53,3	45,3	12,0	842,0
1972	87,6	51,0	139,9		249,0	106,2	88,0	810,0
1973	159,7	46,0	375,0		282,3	107,1	177,0	1179,0
1974	49,5	58,5	65,4		120,7	33,6	13,0	631,0
1975	148,7	224,0	93,3		206,7	78,4	99,0	1230,0
1976	44,0	24,0	147,2		17,1	20,2	501,0	798,0
1977	176,4	353,0	89,6		32,1	26,4	850,0	256,0
1978	35,1	266,0	168,4		10,8	75,8	532,6	873,0
1979	34,3	112,0	61,4		56,1	165,9	505,2	190,0
1980	71,2	7,0	36,5		165,7	226,0	72,5	906,0
1981	6,8	31,0	72,8		49,2	78,0	513,1	40,0
1982	0,5	22,0	129,0		40,0	90,8	472,0	882,0
1983	112,1	12,0	204,6		37,6	87,8	308,4	113,0

RIVER	DALÄLVEN	MOTALA STRÖM	MÖRRUMSÅN	KÄVLINGEÅN	RÖNNE Å	LAGAN	VISKAN	GÖTA ÄLV
1984	33,9	48,0	189,9		0,5	68,0	20,7	325,0
1985	69,7	15,2	138,1		0,0	234,1	211,5	77,0
1986	28,4	26,0	220,3		8,6	2,5	150,9	143,0
1987	73,5	201,0	54,5		84,8	69,8	140,9	168,0
1988	69,0	169,5	241,0		4,9	191,7	91,9	475,0
1989	na	35,2	30,0		0,0	44,0	32,7	598,0
1990	na	21,0	72,5		32,0	21,6	42,1	149,0
1991	na	2,0	151,0	na	na	161,3	0,4	264,0
1992	9,6	108,0	14,0	12,5	na	42,2	70,3	404,0
1993	6,6	89,0	45,7	25,8	na	8,7	43,4	64,0
1994	71,9	650,0	283,0	4,0	na	30,7	76,1	377,0
1995	7,6	32,0	72,4	2,9	na	11,6	5,5	0,0
1996	17,5	14,0	51,9	13,5	na	2,8	10,0	277,0
1997	7,5	8,1	148,0	19,4	10,4	31,7	7,6	180,0
1998	14,7	5,5	12,9	15,3	24,0	62,6	5,0	0,0
1999	15,5	85,0	84,2	22,2	4,2	49,5	1,8	0,0
2000	12,4	270,1	1,0	5,0	na	13,0	14,1	0,0
2001	8,2	177,5	19,3	34,5	1,8	26,8	1,8	0,0
2002	58,6	338,8	37,4	19,3	27,0	102,0	26,2	693,0
2003	126,1	19,0	11,0	9,7	9,1	31,7	45,1	266,0
2004	26,4	42,0	1,5	248,3	2,0	29,0	5,0	125,0
2005	30,9	24,8	2,5	3,4	0,1	20,5	25,8	105,0
2006	35,1	25,9	2,5	94,4	0,1	38,1	2,7	0,04
2007	19	>30	112,6	76	4,45	77	2,1	0
2008	>30,5	na	na	na	na	>25	>3,4	>0

The ascent in River Viskan is totally dominated by elvers that arrived as glass eels the same year. Also in River Lagan there is a considerable proportion of "glass eels" but in the remaining rivers there is a mix of year classes, with eels up to more than 300 mm in TL. No data available = na. 0 for River Göta Älv in recent years (except in 2007) is as a consequence of the fact the eel pass was closed in those years. Data for 2008 are only indicated as the season is not over yet.

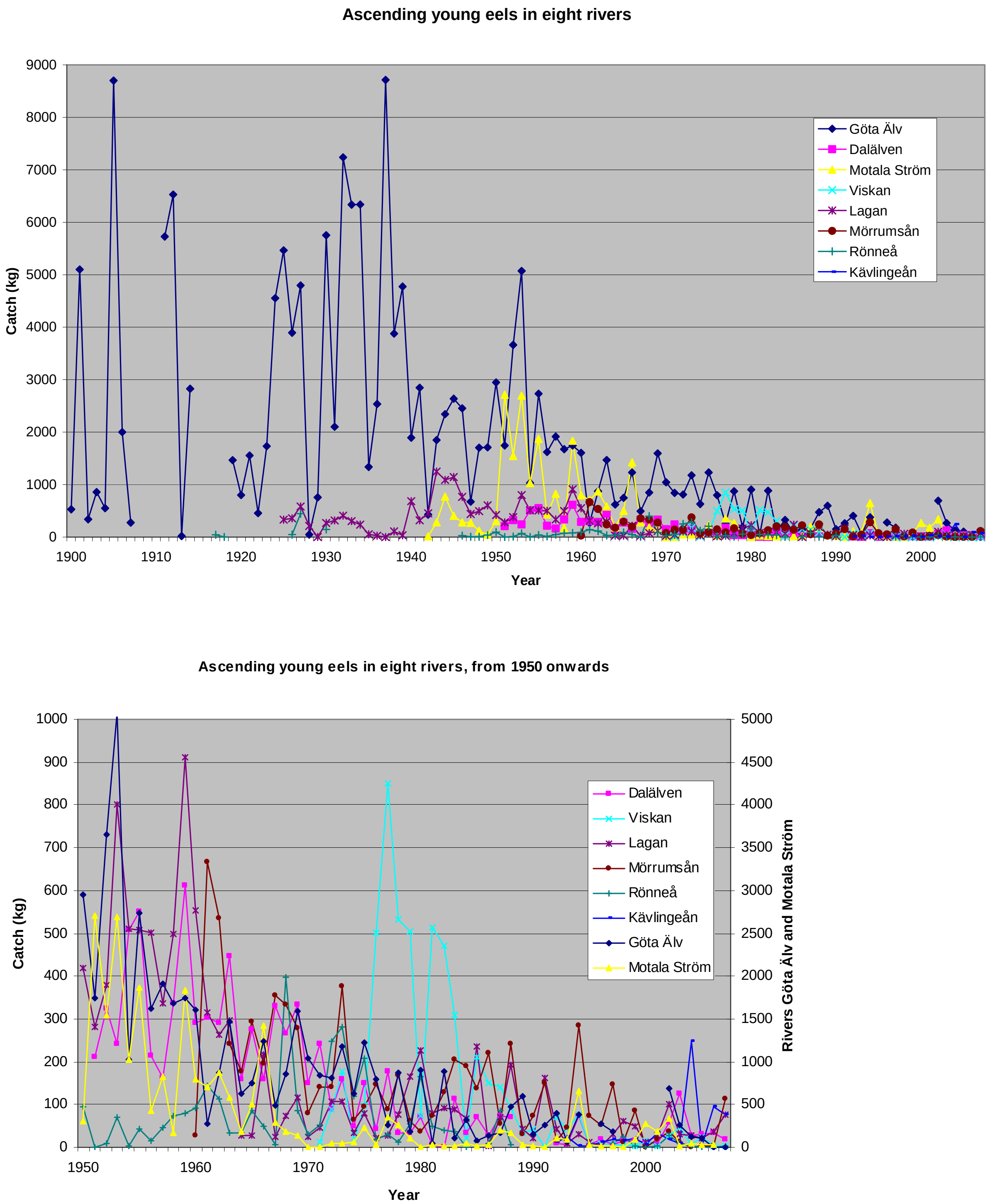


Figure SE.10 a and b Long-term trends in the catches of young eels at various places along the Swedish coast. The lower panel is a magnified version of the upper one from 1950 onwards.

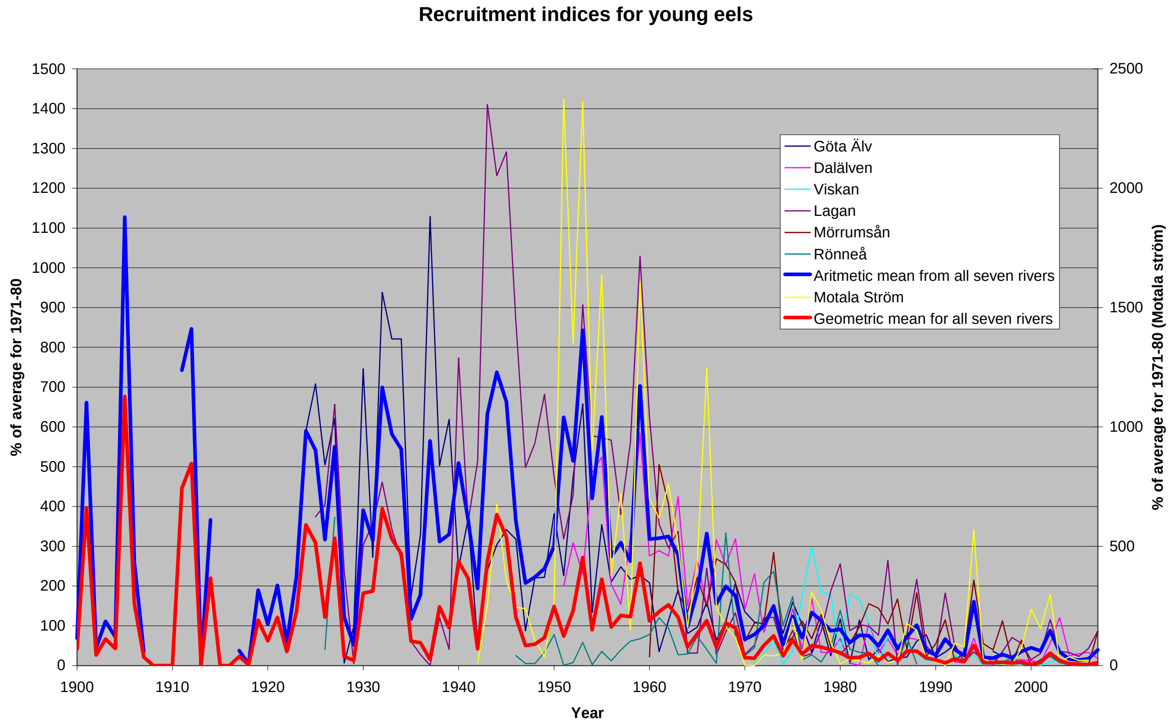


Figure SE.11 Recruitment indices from seven Swedish rivers. Data are presented as percentages of the averages for 1971 to 1980 in the same rivers, respectively.

SE.G.1.2 Recruitment surveys/marine data

The abundance of glass eels in the open sea (Kattegat and Skagerrak) is surveyed by trawling with either an Isaacs-Kidd Midwater trawl (IKMT) or with a modified Methot-Isaacs-Kidd Midwater trawl (MIKT). The former trawl is used in a fixed position in the intake canal for cooling water to the condensers at the Ringhals Nuclear Power Station (e.g. Westerberg, 1998a; 1998b). The latter method is used from RV Argos during the ICES-International Young Fish Survey (since 1993 called the International Bottom trawl Survey (IBTS Quarter 1) (Hagström and Wickström, 1990).

When the glass eels have settled they and larger eels can be monitored on soft and shallow bottoms using a "Drop Trap" technique (Westerberg *et al.*, 1993). This was successfully done during a number of years but is now a resting series. This approach made it possible to roughly estimate the total recruitment of young eels to the Swedish coast.

From all three methods recruitment series could be compiled:

Recruitment of glass eel to the Swedish west coast is monitored at the intake of cooling water to the nuclear power plant at Ringhals in the Kattegat (**Figure SE.12** and **Table SE.j**). The time of arrival of the glass eels to the sampling site varies between years, probably as a consequence of hydrographical conditions, but the peak in abundance normally occurred in late March to early April. Abundance has decreased by 90% if recent years are compared to the peak in the early 1980s. Applying a transition function to the data suggests a break in the trend in the early 1980s (Figure SE.13).

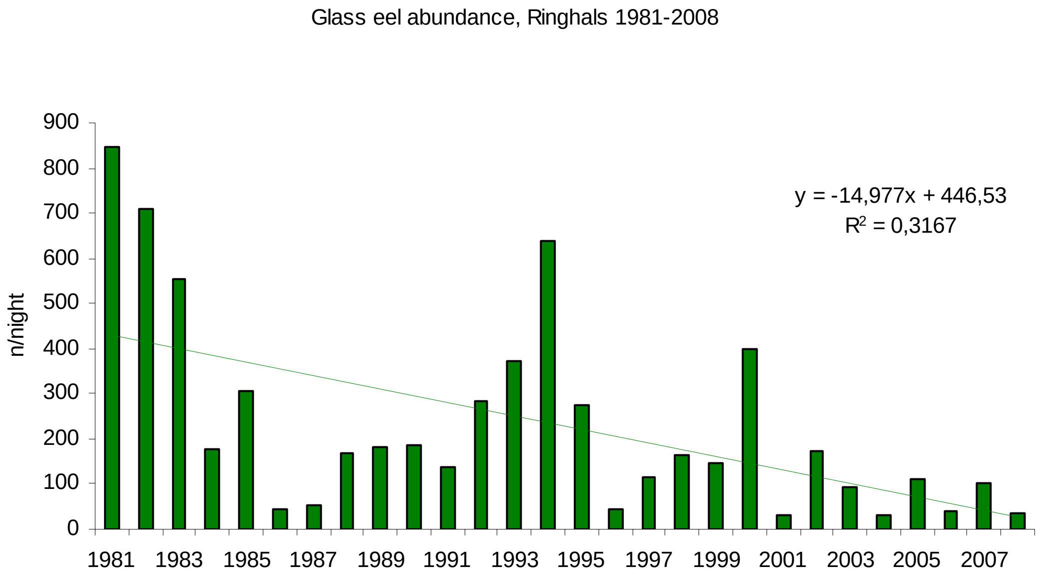


Figure SE.12 Time trend in glass eel recruitment at the Ringhals nuclear power plant on the Kattegat coast in Swedish RBD 5 (Västerhavet).

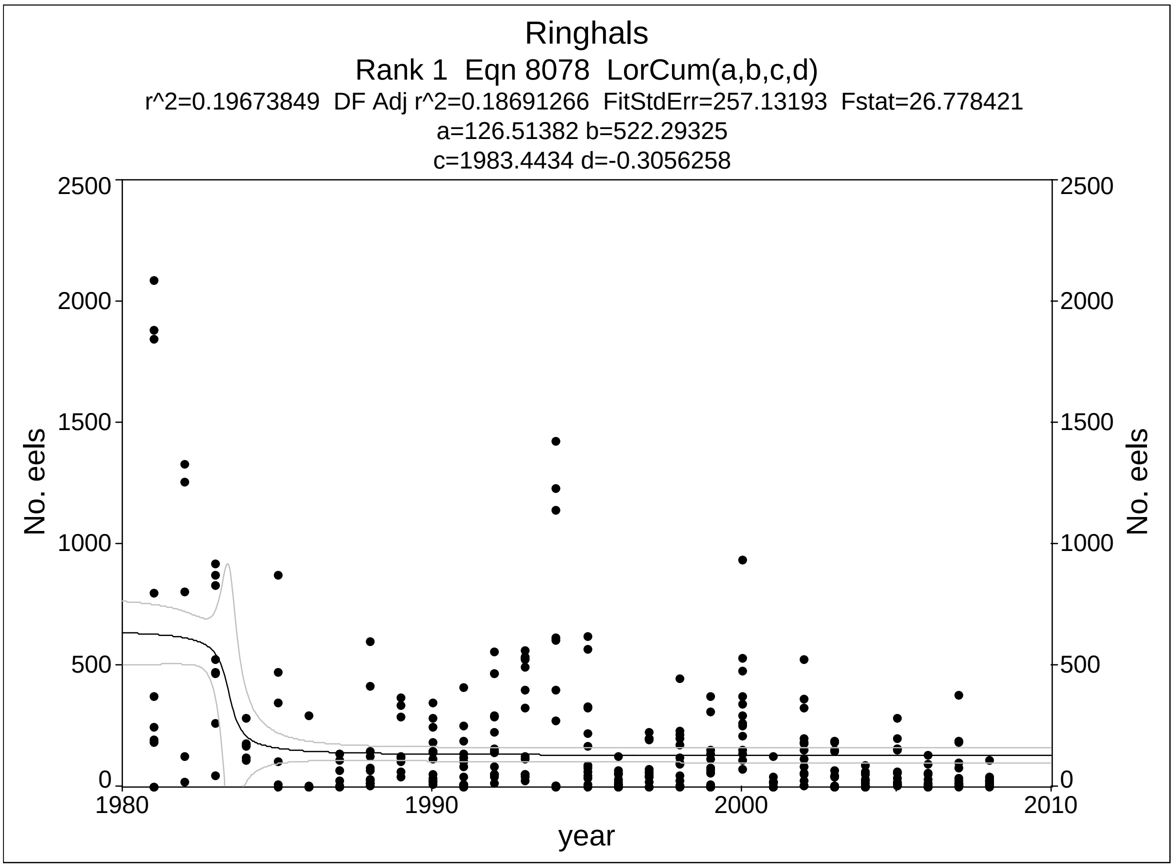


Figure SE.13 A transition function fitted to the glass eel data from Ringhals.

Table SE.j Annual indices of glass eel recruitment at the intake canal for cooling water to reactors 1 and 2 at the Ringhals nuclear power plant. Mean of weekly means of numbers of glass eels collected with a modified Isaacs-Kidd midwater trawl during March and April (weeks 9–18). Data were corrected for variations in water flow.

week	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
3	3													1														
4	0							17			1			4					0									
5	4							8		15	14	18	30	5	4	0	0	1	0	74	2	27	6		20		10	
6								28		27	13	56	45	7	11	0	1	1	0	142	0	86	5	1	12	2	42	8
7								6		22	9	85	331	7	41	0	22	9	8	267	3	154	2	2	62	3	4	27
8	1							34		57	3	44	57	8	48	11	3	50	12	115	5	327	5	0	22	2	12	17
9	187		51			3		36	342	185	3	160	55	3	172	0	68	125	62	344	5	117	5	1	15	6	11	10
10	199	24				2		80	372	150	15	471	118	7	224	4	200	100	121	377	3	200	10	3	10	2	29	31
11	250	130	528	176		4		19	129	150	88	290	130	610	333	13	198	8	72	533	22	366	44	3	39	1	81	114
12	374	806	835	289	14	6	2	16	107	145	42	469	535	400	569	25	60	177	158	214	24	530	53	18	162	13	382	38
13	1886	1258	265	122	109	1	0	72	291	251	110	562	495	1430	331	60	42	220	2	479	16	59	185	35	153	17	186	30
14	2093	1335	469	181	0	3	31	149	121	351	138	151	403	1236	625	33	77	448	314	942	22	185	192	65	162	55	101	43
15	1849		878	112	878		141	603	67	284	414	298	540	1145	91	128	201	237	377	154	45	184	151	55	202	97	191	26
16			925		476		69	416	42	120	254	142	527	619	64	73	49	96	79	299	25	53	74	90	286	132	20	13
17	804		477	171	350		6	127		37	193	231	564	278	80	56	44	202	141	257	128	8	158	32	66	62	18	2
18	0					297	114				124	55					230	31				9	46	8	10	36	7	
mean 9-18	849	711	553	175	305	45	52	169	184	186	138	283	374	636	277	44	117	164	147	400	32	171	92	31	110	42	102	34

The numbers of glass eels caught during the Swedish parts of the International Bottom trawl Survey (IBTS Quarter 1) are given in Figure SE.14.

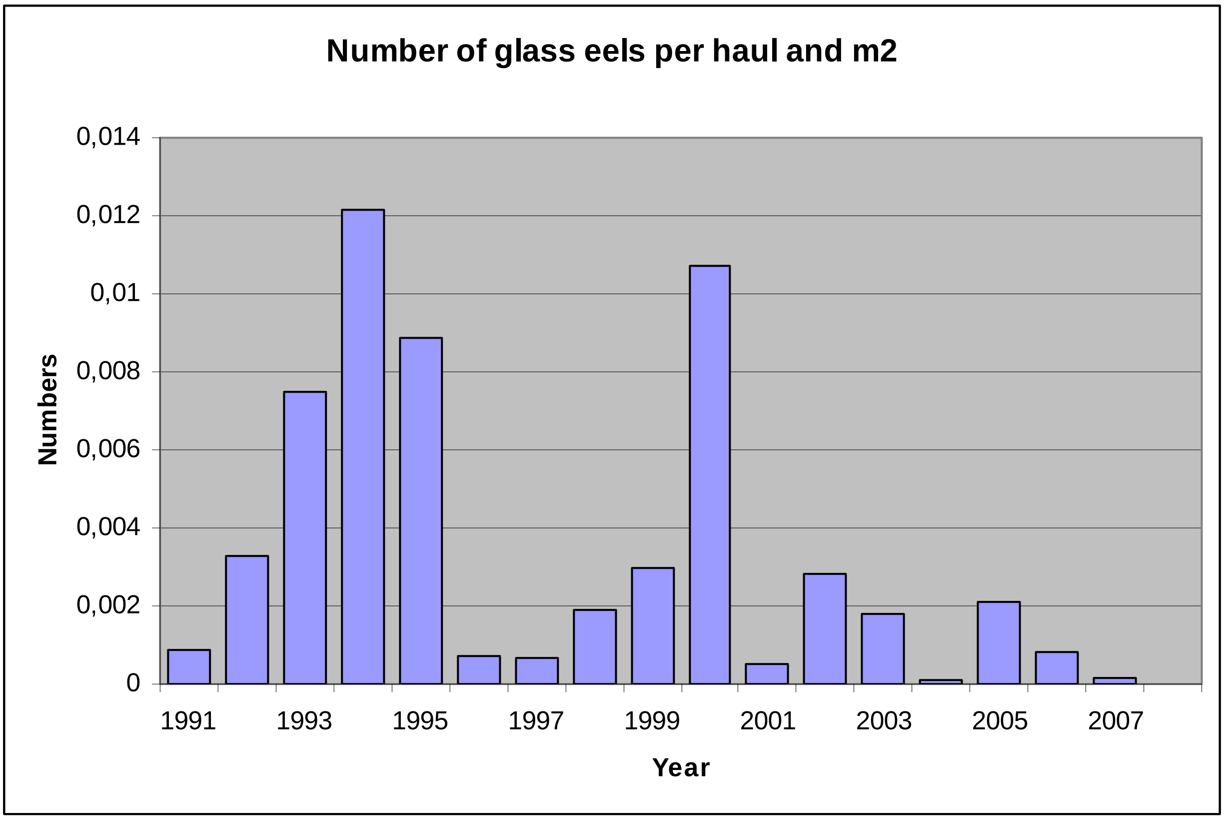


Figure SE.14 Catch of glass eels by a modified Methot-Isaacs-Kidd Midwater trawl (MIKT) in the Skagerrak-Kattegat 1991–2008. Numbers have been corrected for the flow through the net. There were no glass eels caught in 2008.

SE.G.1.3

Another way of estimating the occurrence of young eels ascending in smaller streams is by electro-fishing (Degerman, 1985; Fiskeriverket & Laxforskningsinstitutet, 1999; CEN 2002). Normally this is done with salmonids in focus with eels as secondary product or spin-off.

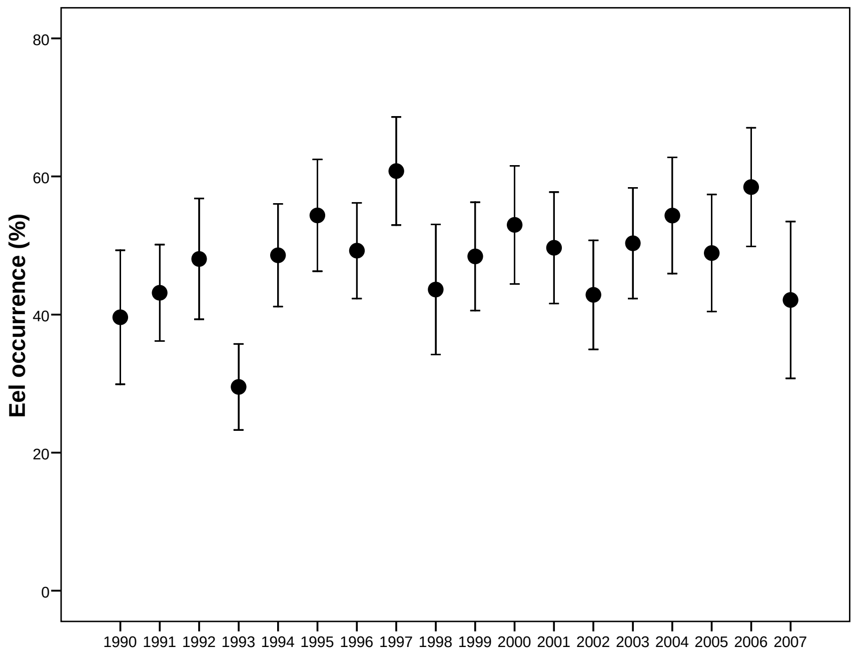


Figure SE.15 Proportion of electro-fished stations (%) with eel occurrence (+/-95% CI) along the West Coast (only the county of Halland). The stations that were fished in 1990–2007 are situated from 0 to 100 m asl. Note that local abundance is not given here, only presence/absence. Data from SERS (Swedish Electrofishing Register). ***The trend is not significant (Pearson correlation, n=18, r=0,36, p=0,144).***

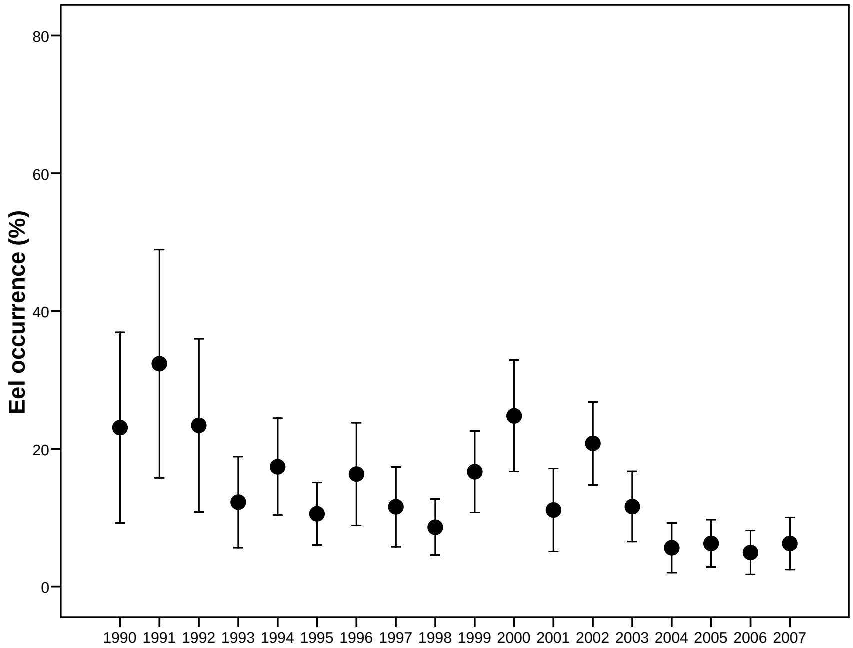


Figure SE.16 Proportion of electro-fished stations (%) with eel occurrence (+/-95% CI) along the East Coast. Stations that were fished in 1990–2007 in this figure are situated from 0 to 100 m asl in six counties along the Baltic Sea Coast. Note that local abundance is not given here, only presence/absence. Data from SERS (Swedish Electrofishing Register). ***The negative trend is significant (Pearson correlation, n=18, r=-0,68, p=0,002)***

SE.G.2 Yellow eel surveys

SE.G.2.1 Yellow eel surveys in coastal waters

The coastal fish communities on the Swedish west coast are monitored by standardized fishing with fykenets in shallow water (2–5 m). Yellow eel was among the dominating fish species in August most years. Barsebäck in the SW part of the area belongs to RBD SE Baltic, other areas to RBD Västerhavet. The trend for the longest time-series from Vendelsö in N Kattegatt is significantly positive. A negative tendency for the Barsebäck area was broken by increasing catches in 2006 and 2007. In the other areas the period of sampling was too short to be examined for biologically significant trends. The magnitude of cpue though, was similar to that of the longer series. The interannual variations in cpue were influenced by water temperature at the time of sampling, but no time-trends in temperature were observed for the period with available data (1988–2007).

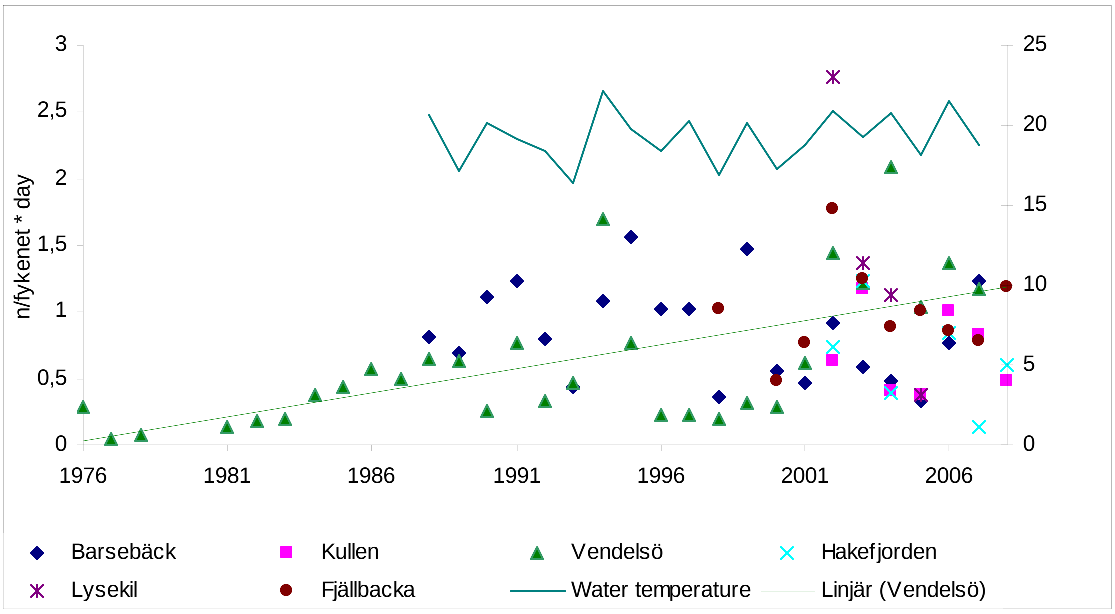


Figure SE.17 Time trend in the yellow eel catches in coastal fish monitoring with fykenets in August on the Swedish west coast. RBD SE Baltic (Barsebäck) and RBD Västerhavet (others). Annual mean water temperature at the fishing gears is presented for the Vendelsö area in central Kattegat.

SE.G.2.2 Yellow eel surveys in fresh water

There are no routine stock surveys for yellow eels in fresh water. The nearest equivalents are the surveys dedicated to stocked populations of eels. These are mostly performed in smaller lakes but also at one site in the large Lake Mälaren where glass eels were stocked in both 1980 and 1997. The aim is to follow the development of the introduced stock and individual growth of young eels stocked in nature. The eels that were stocked in 1997 were marked with Alizarin Complexone. Such marked eels are now dominating the local eel population. Their proportion of the catch has increased from 4% in 2000 to 69% in 2007. In 2007 the stocked eels were 494 mm (+/-75 SD) which corresponds to a growth rate of 39,8 mm/year (+/-7,5 SD) after stocking. Another 96 eels from the sampling in 2008 are still waiting to be processed.

SE.G.3 Silver eel surveys

There are no regular silver eel surveys in Sweden. However, in 2003 the Institute of Freshwater Research collected large samples from the commercial fisheries in eight lakes and at two sites where most silver eels try to leave the Baltic Sea, i.e. in the Sound (Öresund). In 2005 and 2006 silver eels from additional sites along the Baltic Coast were collected for a tagging study. All these eels (except tagged but not recaptured individuals) have now been analysed with respect to e.g. their fat content and to their chemical background (by otolith microchemistry). This extensive study might together with a now realized tag-recapture study be the baseline for recurrent sampling of silver eels. A complementary tag-recapture study is planned for 2008, where silver eels from both Lake Mälaren and the Stockholm Archipelago will be tagged. Useful data from individual eels will by that be collected.

The Coastal Institute is sampling the commercial catch with the purpose to collect length and age data. This is done within the DCR (Data Collection Regulation Programme). See also Section SE.H below.

SE.H Catch composition by age and length

SE.H.1 Catch composition by age and length in coastal areas

In 2002–2007 over 8800 yellow eel were sampled for individual length, total and somatic weight, sex and prevalence of *Anguillicola crassus*. All but 80 were female and the males were mainly recorded on the Skagerrak coast in SD 20. Age readings exist for 2700 individuals, but the major part of the otolits were stored and not analysed after the year of catch 2005 (Table SE.k(b)). The sampling programme started as an initiative of the Swedish Board of Fisheries and is now part of the Swedish contribution to the DCR. Sampling of silver eel in poundnet catches started in 2005. So far length and weight recordings and otoliths were collected from 2500 silver eels and 1200 age readings were performed.

Table SE.k Swedish sampling of yellow eel in commercial catches with fykenets.

a. total number sampled for size and age

	Year of catch						
ICES SD	**2002**	**2003**	**2004**	**2005**	**2006**	**2007***	**Total**
20	202	201	200	729	670	723	2725
21	205	198	200	202	100	104	1009
23	202	201	200	200	197	200	1200
25	409	405	414		1	23	1252
27	392	426	469	465	478	392	2622
Total	**1410**	**1431**	**1483**	**1596**	**1446**	**1442**	**8808**

*in database 20080814

b. total number of age records

	Year of catch						
ICES SD	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**Total**
20	97	96	98	433			724
21	98	99	98	201	100		596
23	96	96	198	199			589
25		97	99		1		197
27			390	188			578
Total	**291**	**388**	**883**	**1021**	**101**	**0**	**2684**

Sampling for length in commercial fykenet catches demonstrate a similar size composition of yellow eel in the Kattegat, the Öresund area and on the southern Baltic coast (SD 21, 23 and 25). Sizes in the interval 40–50 cm were most abundant. In Subdivision 20 on the Skagerrak coast, the negative slope of the size spectrum starts just above 40 cm. Sampling in Subdivision 27 in the central Baltic Proper demonstrates a population with considerably higher mean length and with single individuals reaching almost 90 cm in length (Figure SE.18).

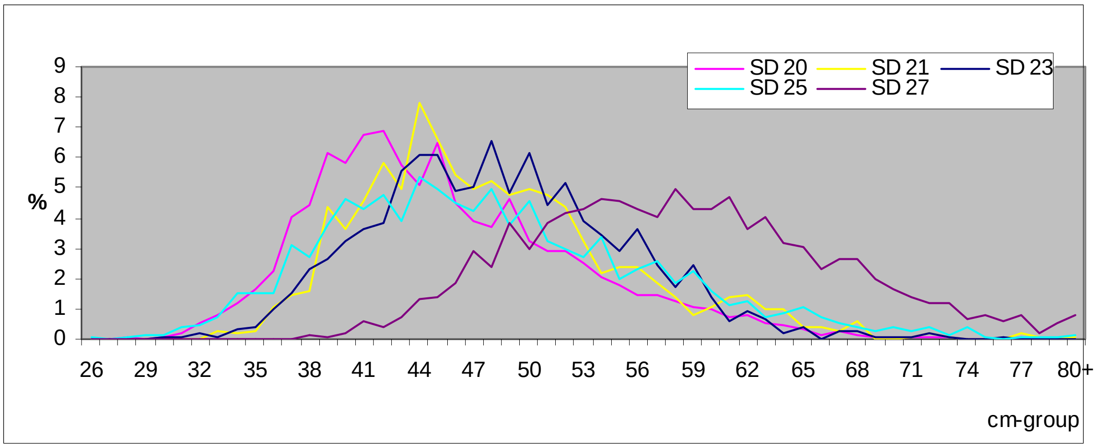


Figure SE.18 Length composition of yellow eel from commercial fykenet catches in samples collected in 2002–2007 in RBD SE Västerhavet (ICES SD 20–21) and RBD SE Baltic (ICES SD 23,25 and 27). Samples from subdivisions 25 and 27 are based on an unsorted mixture of landings and discard.

There is a gradient in mean length of silver eel from 77 cm SD 27 in central Baltic to 65 cm in SD 23, Öresund. Since May 2007 the minimum legal landing size is 65 cm in the Baltic. The length distributions in SD 24–25 in the southern Baltic indicate a potential for a considerable reduction of the fishing mortality in the poundnet fishery in this area with the new size limit.

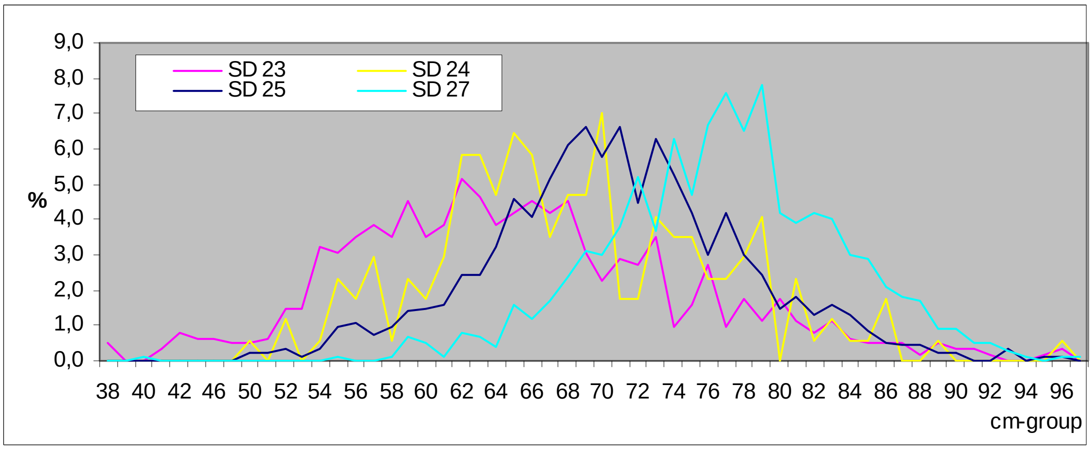


Figure SE.19 Length composition of silver eel from commercial poundnet catches for samples collected in 2005–2007 in RBD SE Baltic (ICES SD 23, 24, 25 and 27).

In the three western subdivisions, Öresund, Kattegat and Skagerrak, the average age of the yellow eel in commercial landings varied between 8 and 10 years. The samples from SD 25 represent the first proper habitat for yellow eel recruits on their path of migration from the west coast into the Baltic Sea. The relatively low mean age in unsorted fykenet landings in SD 25 indicate that migrants on transit might make up a considerable proportion of the catches. Although the yellow eels from SD 27 in the Central Baltic were considerably larger, they were only 1–2 years older compared to the western sampling sites. Silver eel ages varied from 14 years on average in SD 27 to 10–12 years in SD 23–25.

Table SE.l Mean age of yellow eel in the Swedish coastal fykenet fishery.

ICES SD	Year of catch					
	2002	2003	2004	2005	2006	Total
20	9,0	8,9	9,6	8,7		8,9
21	8,7	8,2	8,7	7,9	9,2	8,4
23	8,6	9,6	9,4	8,9		9,1
25		7,2	6,8			7,0
27			9,8	10,9		10,1

In SD 20, 21 and 23 (West Coast) eels were recruited to the fishery at the age of 4 to 5 years and the oldest individuals recorded had reached the age of 18. On the southern Baltic coast the age span in unsorted landings was 3–12 years. The age distribution in SD 27 was similar to those from the west coast, although shifted one year to the right in Figure SE.20.

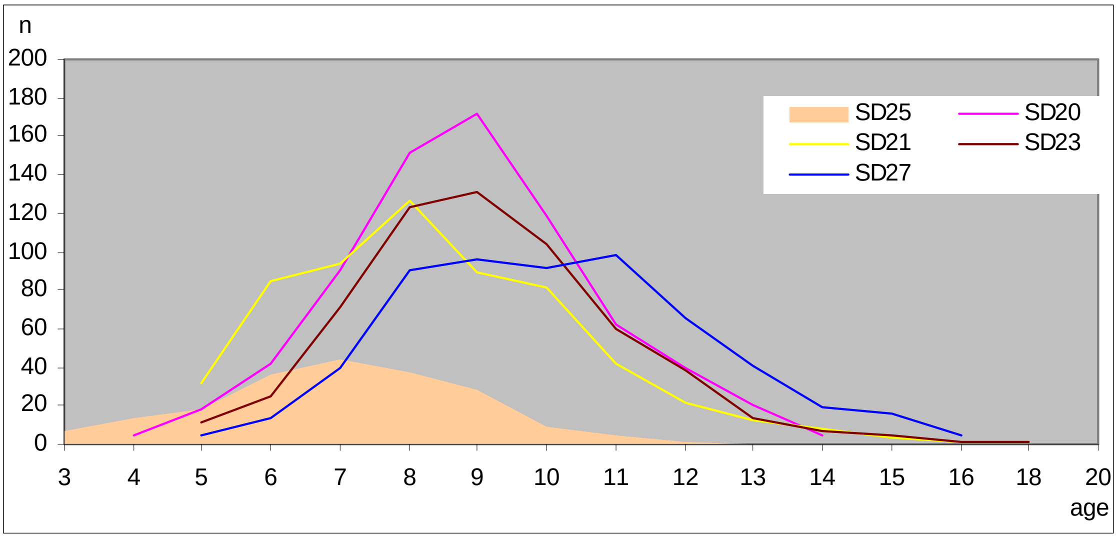


Figure SE.20 Age distribution of yellow eel from commercial fykenet catches for samples collected in 2005–2006 in RBD SE Västerhavet (ICES SD 20–21) and RBD SE Baltic (ICES SD 25 and 27).

The growth pattern is close to linear for both length and weight in all areas (Figure SE.21). Bias is probably introduced for younger ages as a consequence of gear selectivity and in higher ages as a consequence of silvering. Yellow eel from SD 27 in central Baltic were considerably longer and heavier than in other areas, a 10-year-old female being 57 cm and 314 g in the former area compared to 49,5 cm and 192 g on the Skagerrak coast (SD 20). Comparing the most abundant ages, somatic condition is higher in the Baltic samples and increases with increasing age. The possibly transiting eels in SD 25 thus were in better condition than eels from the west coast, but had otherwise grown at approximately the same speed. Condition increasing with increasing age is seen in all areas but SD 20.

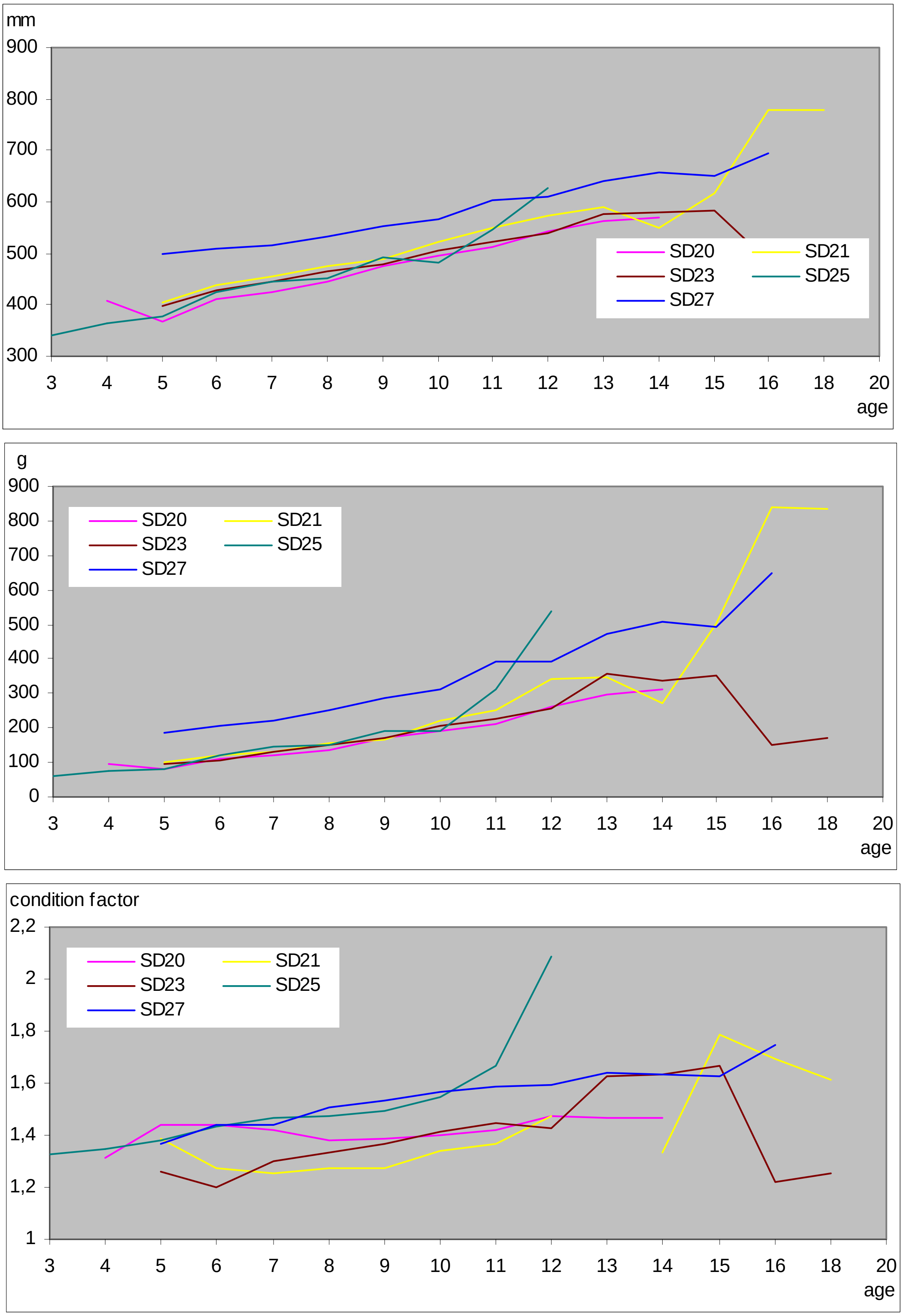


Figure SE.21. Length, weight and condition factor at age of yellow eel from commercial fykenet catches in samples collected in 2005–2006 in RBD SE Västerhavet (ICES SD 20–21) and RBD SE Baltic (ICES SD 25 and 27).

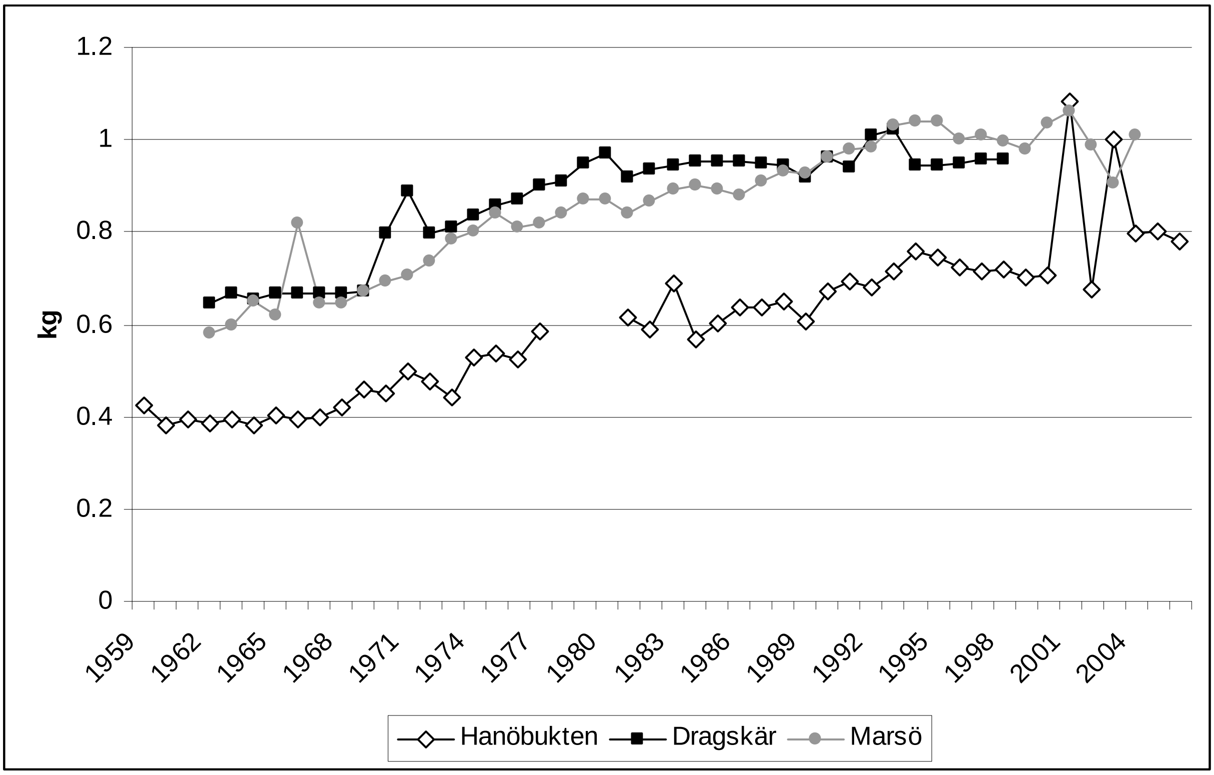


Figure SE.22 Changes over time in mean total weight of silver eels from SD 25 (Hanöbukten) and SD 27 (Dragskär+Marsö).

Mean weight of silver eels in commercial poundnet catches have increased over time (Figure SE.22) from 0.6 kg in the 1960´s to 1 kg in recent years. The trend is the same in both SD 25 and SD 27 although the mean weight of silver eels is generally lower in SD 25. There are some uncertainties in the data before 1970 such that some yellow eel could be included in the statistics.

SE.H.2 Freshwater

In addition to the programme mentioned under Section SE.G.3 no data on catch composition is collected in fresh waters.

SE.I Other biological sampling

SE.I.3 Parasites

The swimbladder parasite (*Anguillicola*) does occur in eels from most sites. All eels dissected at the Swedish Board of Fisheries are analysed macroscopically for the prevalence (at both Institutes involved) and intensity (at the Institute of Freshwater Research only) of *Anguillicola* in their swimbladders. The prevalence in coastal waters in 2002–2005 was close to 10% in the marine habitats of RBD 5 and about 60% in the central parts of RBD 4. The straight between Sweden and Denmark (Öresund, SD 23) took an intermediate position.

SE.H.2 Freshwater

In addition to the programme mentioned under Section SE.G.3 no data on catch composition is yet collected in fresh waters. However, the intention is to monitor both catch and the yellow eel stock within the coming DCR-programme.

Prevalence of *Anguillicola crassus* is a mandatory variable in all coastal sampling of eel in Sweden, including the DCR sampling. The rate of infestation in the pooled data from 2002–2006 was less than 15% in the most marine areas, 47% in Öresund and close to 60 in the Baltic sites.

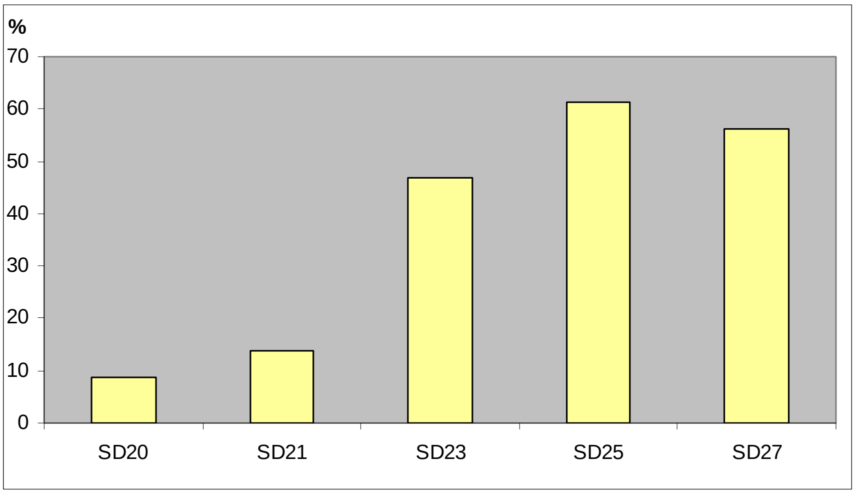


Figure SE.23 Prevalence of the swimbladder parasite (*Anguillicola crassus*) in yellow eel from commercial fykenet catches for samples collected in 2005–2006 in RBD SE Västerhavet (ICES SD 20–21) and RBD SE Baltic (ICES SD 25 and 27).

Table SE.m Prevalence of *Anguillicola crassus* in yellow eel from Swedish coastal waters in 2002–2005. ICES Subdivisions 20–21 represent RBD 5, other Subdivisions represent RBD 4.

	ICES Subdivision				
	20	**21**	**23**	**25**	**27**
Not infested	723	611	442	475	493
Infested	80	93	361	753	794
Grand Total	803	704	803	1228	1287
Prevalence	**0.10**	**0.13**	**0.45**	**0.61**	**0.62**

Between 2000 and 2008 the Institute of Freshwater Research analysed 3608 eels from 41 different fresh-water sites. Infested eels were found in all sites and the prevalence varied from 37% to 91%.

SE.I.4 Contaminants

The National Food Administration in Sweden has analysed both yellow and silver eels sampled in 2000 and 2001 from nine different sites in Sweden with respect to 17 dioxins and furans and 10 dioxin-like PCB congeners (www.slv.se). Pooled samples revealed that eels had less than 1 pg TEQ/g fresh weight of sum TCDD/F in muscle (TEQ = Toxic Equivalents, TCDD = $C_{12}H_4O_2Cl_4$). To this came about 3.8 pg PCB-TEQ/g fresh weight. Silver eels had higher levels than yellow ones. Compared to the other fish species analysed, eels have a higher ratio of PCB to dioxins. Due to the high costs for this type of analyses only few eels will be sampled regularly in future.

Recently yellow eels from the Sound (between Sweden and Denmark) outside a heavily loaded industrial area in Helsingborg were analysed for dioxins and dioxin-like PCBs. Pooled samples from 2005 contained 5.7 WHO-PCDD/F-TEQ pg/g and 11 WHO-PCB-TEQ pg/g, both based on fresh weights. In 2006 another five pooled samples from the same area were analysed. The dioxins varied between 0.9 and 4.7 with an average of 2,2 WHO-PCDD/F-TEQ pg/g. The PCBs varied between 3.9 and 12.7 with an average of 6,6 WHO-PCDD/F-PCB-TEQ. At some sites the level of dioxins in eel muscle exceeded by that the 4 p/g level of dioxins or the 12 pg/g level of summed up dioxins and dioxin-like PCBs, set as maximum allowed levels in eel by the Commission of the European Communities. In 2007 further samples were analysed from this area. Both yellow and silver eels were analysed in seven pooled samples. The dioxin levels varied between 0,6 and 2,7 pg/g and the summed up dioxins and dioxin-like PCBs between 2.3 and 8.3 pg/g, i.e. all below the maximum allowed levels. However, the sample sites were not exactly the same as in 2005 and 2006 (Source: SLV (The National Food Administration)).

Recent analyses of mercury (Hg) in eels from a number of lakes did demonstrate very low levels.

SE.I.5 Predators

Cormorants

Cormorants are believed to predate substantially on eels. As about 2900 young eels stocked in Lake Ymsen 1998–2000 were equipped with PIT-tags in spring 2004 we took the opportunity to scan the ground below the only cormorant colony in that lake for tags. In total 30 PIT-tags were found corresponding to a minimum loss by cormorant predation of 1%.

An extensive study of the stomach content of cormorants at three sites along the Kattegat-Skagerrak coast revealed that eels were taken by about 5% of the cormorants. That was equivalent to about 1% of their diet. Despite the low percentage, it corresponds to a total annual predation of 310 000 yellow eels, i.e. one fourth of the commercial catch on this coast (Lunneryd and Alexandersson, 2005).

Pellets from cormorants were analysed from a colony outside River Dalälven. No remains from eel were discovered. However, it is known that this approach is not that suitable for eel as their otoliths are easily eroded (Bostrom *et al.*, in press).

Seals

Along the Swedish West Coast there is substantial damage on eel fykenets done by harbour seal (*Phoca vitulina*) Königson *et al.*, 2006. The cost of the damage estimates to several per cent (up to 18%) of the catch (Königson *et al.*, 2003). There are circumstances that indicate that the raiding seals are a minor part of the population. It is demonstrated that those seals have strong preference for eel compared with cod or flatfish in the fykenets (Königson *et al.*, 2006). Old diet studies indicate that a “normal” seal seldom eat eel (Härkönen and Heide-Jørgensen, 1991) but obvious is that the specialised seals that damage the fykenets cause an additional mortality on the eel population of several per cent of the catches.

There is only one minor diet study of grey seals (*Halichoerus grypus*) in the Baltic proper. The material consists of fish remains from 54 stomachs and intestines which reflect maximum one day’s food. Remains were found from two eels (Lundström *et al.*, in press). It is from those figures impossible to calculate an accurate figure of how important eels are fore the grey seals.

SE.J Other sampling

SE.J.2 Obstacles to eel migration

During 2005 and 2006 an inventory of obstacles for eels migrating both up- and downstream was performed. Not only are the obstacles as such studied but also the occurrence of fish passes, by-passes, deflecting screens, etc. and their suitability for eels were noted. The purpose is to achieve a database to be used as background when installing new or improving existing eel passes and deflecting devices. Parts of the Swedish eel management plan are based on data in this database. Water Courts decisions might also be reconsidered with this database as argument.

SE.K Stock assessment

So far the collected data has not by routine been used for stock assessment.

Published mortality estimates from Subdivision 20 and 21 (Svedäng, 1999) (approximating RBD 5, Västerhavets vattendistrikt ("the North Sea")) have been used in a simple length based mortality rate model to assess the effect of present yellow eel exploitation on spawner escapement in relation to present and estimated past unexploited levels of spawner escapement (Åström and Wickström, 2004). The relation between the present and past population levels has been estimated using the longer dataseries on ascending elvers and young eels, indicating that the present population probably is less than 10% of the one in the mid-1900s.

An attempt has also been made to use the length sampling from the yellow eel fishery in fives areas in ICES Subdivision 25 and 27 (part of RBD 4, Södra Östersjöns vattendistrikt ("the Southern Baltic Sea" or SBAL)) in a catch-at-length analysis to estimate natural and yellow eel fishery induced instantaneous mortality rates, in terms of mortality rate per unit length increment. The result from analyses of a large number of mark recapture studies on silver eels has been used as a rough estimate of the silver eel fishery mortality rate. Data on average length of female silver eels in the subdivisions were also needed for the analyses. Males have been disregarded because of their very low prevalence in Swedish waters. The simple length based mortality rate model has then been used to assess the effect of present yellow and silver eel exploitation on spawner escapement in subdivision 25 and 27 in relation to present and estimated past unexploited levels of spawner escapement (Åström, 2004).

The above analyses indicate that the yellow eel exploitation allows at most 15% of the present possible escapement to the silver eel stage. This applies both to Subsections 20 and 21 (~ RBD 5) as well as to areas where yellow eels are fished in Subsections 25 and 27 (part of RBD 4), and indicates a severe overexploitation. In the latter area (the coast of the Baltic Sea) the yellow eel exploitation is however only occurring scattered and locally (in 2006 approximately 187 600 kg was caught), so the over all effect of the yellow eel fishery in subsection 25 and 27 is not as severe as on the Swedish west coast. The silver eel fishery in Subsections 25 and 27 then reduces the spawner escapement by about 36%, so that only about 11% of the currently possible spawner escapement remains of eels from areas where yellow and silver eel fishery occur. In perspective of past possible spawner escapement this would only amount to about 1% of the spawner escapement possible in the mid-1900s.

Using additional data on the amounts of yellow and silver eels caught in the different subdivisions have allowed for analyses of the possible effects of fishing restrictions and re-stocking of elvers on spawner escapement using the same conceptual model (Åström, 2005).

SE.N Overview

To some extent Sweden has a good data situation, particularly regarding coastal yellow eels. At the same time much remains to be filled in order to be able to establish a sustainable management in accordance with the EU regulation regarding eel management. The Department of Research and Development of the Swedish Board of Fisheries has recently changed its system for planning and prioritizing allowing for coherent planning, collection of data and analyses. The planning for the sampling of the fishery, monitoring of population status and evaluation of management efforts remain to be done during autumn of 2008.

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Appendix

Table SE.n Commercial landings of eel in Sweden (Kattegat-Skagerrak corresponds to RBD 5 and the data come from the contract notes). (cf Figure SE.4).

Year	South C. (Baltic Sea)	East C. (Baltic Sea)	Kattegat-Skagerrak	Freshwater	Total Sweden
1925	624	936	155		1715
1926	520	1011	176		1707
1927	642	1216	152		2010
1928	373	509	157		1039
1929	582	644	167		1393
1930	716	596	216		1528
1931	782	497	252		1531
1932	769	701	253		1723
1933	645	704	196		1545
1934	798	830	215		1843
1935	829	880	240		1949
1936	608	818	226		1652
1937	548	931	244		1723
1938	666	969	235		1870
1939	535	988	248		1771
1940	553	974	98		1625
1941	633	926	69		1628
1942	426	592	110		1128
1943	820	648	77		1545
1944	879	1042	79		2000
1945	778	790	96		1664
1946	658	738	116		1512
1947	980	761	169		1910
1948	979	689	194		1862
1949	999	671	229		1899
1950	1109	911	168		2188
1951	962	755	212		1929
1952	791	627	180		1598
1953	1146	879	353		2378
1954	1186	780	140		2106
1955	1599	780	272		2651
1956	714	707	112		1533
1957	1158	856	211		2225
1958	938	642	171		1751
1959	1658	977	154		2789
1960	778	703	165		1646
1961	896	870	300		2066
1962	980	713	215		1908
1963	997	802	272		2071

Year	South C. (Baltic Sea)	East C. (Baltic Sea)	Kattegat-Skagerrak	Freshwater	Total Sweden
1964	1303	749	236		2288
1965	749	768	285		1802
1966	748	893	328		1969
1967	646	703	268		1617
1968	713	794	301		1808
1969	622	733	320		1675
1970	476	515	318		1309
1971	545	587	259		1391
1972	425	582	197		1204
1973	419	553	240		1212
1974	322	470	242		1034
1975	494	629	276		1399
1976	283	363	289		935
1977	346	340	303		989
1978	376	385	315		1076
1979	267	404	285		956
1980	371	438	303		1112
1981	243	153	491		887
1982	342	250	569		1161
1983	267	171	735		1173
1984	559	136	378		1073
1985	647	213	280		1140
1986	479	138	234	92	943
1987	439	119	250	89	897
1988	532	190	304	136	1162
1989	447	132	264	109	952
1990	452	119	242	129	942
1991	486	181	285	132	1084
1992	534	162	352	132	1180
1993	550	93	438	129	1210
1994	654	98	630	171	1553
1995	444	79	555	127	1205
1996	564	67	406	97	1134
1997	546	181	513	142	1382
1998	318	50	165	112	645
1999	339	69	186	140	734
2000	286	39	123	113	561
2001	107	123	195	118	543
2002	126	183	222	102	633
2003	115	145	209	96	565
2004	84	134	227	106	551
2005	119	187	211	111	628
2006	125	195	227	123	670
2007	126	178	153	111	568

Table SE.o Total commercial landings (tonnes) in coastal fishery by RBD. (cf Figure SE.2).

YEAR	BBAY	BSEA	NBAL	SBAL	WEST	BBAY+BSEA
1999	0	3.0446	44.2675	265.5355	247.427	3.0446
2000	0.028	2.7171	31.5765	221.2225	161.4925	2.7451
2001	0	3.1427	28.1985	263.8105	227.71	3.1427
2002	0.015	3.05	29.337	239.6801	216.791	3.065
2003	0.003	4.2107	25.0735	244.5234	193.616	4.2137
2004	0.0015	4.2873	22.3375	224.2218	219.357	4.2888
2005	0	3.5522	38.0145	303.818	215.2515	3.5522
2006	0.109	3.5769	30.8573	329.8463	240.3054	3.6859
2007	0.0645	1.207	43.4387	371.4447	172.287	1.2715

Table SE.p Total effort (number of gears* number of fishing nights) in pound nest in a Subarea in SD 27. (cf Figure SE.3).

YEAR	GEARS*NIGHTS
1962	3334
1963	4710
1964	5186
1965	4004
1966	4834
1967	5915
1968	5749
1969	6001
1970	5659
1971	5232
1972	4697
1973	4958
1974	4689
1975	4756
1976	3596
1977	3563
1978	3438
1979	2566
1980	3404
1981	3260
1982	2771
1983	3269
1984	3435
1985	2762
1986	3158
1987	3559
1988	2772
1989	2587
1990	2290
1991	2517
1992	2538
1993	2397
1994	2362
1995	2157
1996	2206
1997	1894
1998	1964
1999	1493
2000	1558
2001	1532
2002	1062
2003	973
2004	1535
2005	1311
2006	1464

Table SE.q Mean length-at-age with standard deviation in Swedish samples of yellow eel from commercial fykenet catches in 2002–2005.

Mean length in mm

	SD 20				SD 21				SD 23			SD 25		SD 27	
	Stenungsund				Kullen				Öresund			Valjeviken		Simpevarp	Kvädöfjärden
	2002	2003	2004	2005	2002	2003	2004	2005	2003	2004	2005	2003	2004	2004	2004
3												336	341		
4		403		407								357	385		
5	396	342		376	403	374	423	428		399	409	369	381	499	
6	378	375	375	396	429	427	449	447	464	444	412	413	435	526	413
7	419	396	441	436	446	447	463	465	432	418	471	414	466	535	485
8	416	418	471	466	451	462	484	499	460	448	491	444	461	549	525
9	459	428	478	513	454	500	501	508	485	457	504	496	484	564	545
10	436	496	484	572	492	525	511	576	508	497	524	477	492	591	553
11	493	502	497	565	541	549	546	590	534	512	527	529		654	559
12	484		543	668	523	524	655	654	521	566	524	628		639	599
13	523	561	573	711		576	561	635	579	562	614			675	609
14	475		547		496	604	565	614	582	568	589			682	645
15					726	512			585	606	568			693	624
16				617										678	
17															
18						778									
20															778

Standard Devation

	SD 20				SD 21				SD 23			SD 25		SD 27	
	Stenungsund				Kullen				Öresund			Valjeviken		Simpevarp	Kvädöfjärden
Age	2002	2003	2004	2005	2002	2003	2004	2005	2003	2004	2005	2003	2004	2004	2004
3												72	37		
4		-		19								37	42		
5	-	20		30	91	18	14	17		61	80	28	33	62	
6	45	45	49	30	61	64	18	35	49	68	22	55	37	45	41
7	38	53	44	53	65	51	51	34	44	40	61	34	55	64	56
8	49	66	44	60	59	56	44	60	33	50	41	33	54	72	50
9	70	54	46	56	39	78	43	69	48	50	53	48	37	62	59
10	56	67	49	51	74	70	71	68	64	56	50	49	43	62	67
11	62	48	32	55	59	70	49	57	41	63	64	111		87	61
12	26		34	67	72	63	102	49	38	77	92	-		100	60
13	95	80	41	-		70	-	-	15	98	64			58	58
14	-		2		56	-	101	-	15	6	16			68	82
15					-	-			-	-	-			112	38
16				-										-	
17															
18						-									
20															-

Table SE.r Mean weight (kg) of silver eels in SD 25 (Hanöbukten) and SD 27 (Dragskär+Marsö). (cf Figure SE.22).

	Hanöbukten	Dragskär	Marsö
1959	0.4257096		
1960	0.3812911		
1961	0.3944881		
1962	0.3841353	0.646057	0.581714
1963	0.3933078	0.66662	0.596092
1964	0.381971	0.656284	0.6516
1965	0.4028978	0.668809	0.617855
1966	0.3956977	0.66507	0.818465
1967	0.3982816	0.666319	0.64349
1968	0.4206718	0.665281	0.643382
1969	0.45799	0.669758	0.67301
1970	0.4487651	0.797074	0.693331
1971	0.4985409	0.888208	0.704245
1972	0.4767305	0.795598	0.737115
1973	0.4437471	0.809352	0.785968
1974	0.5302373	0.836614	0.803108
1975	0.5363621	0.857662	0.842197
1976	0.5226509	0.86879	0.80943
1977	0.5831722	0.9	0.818641
1978		0.910007	0.840489
1979		0.949199	0.869809
1980		0.968704	0.868633
1981	0.6134633	0.9166	0.84257
1982	0.5912612	0.934878	0.866136
1983	0.6886279	0.943427	0.890408
1984	0.5686305	0.952998	0.899468
1985	0.601751	0.95387	0.894093
1986	0.6386582	0.951868	0.8808
1987	0.6384719	0.947937	0.909734
1988	0.6478994	0.946292	0.929888
1989	0.6082842	0.919714	0.928396
1990	0.6707184	0.960589	0.963711
1991	0.694523	0.941953	0.980984
1992	0.678391	1.010102	0.985237
1993	0.7145674	1.023795	1.029801
1994	0.7589975	0.944953	1.038153
1995	0.7438935	0.942792	1.039462
1996	0.7227103	0.949406	1.002065
1997	0.7161557	0.956877	1.011255
1998	0.7193059	0.958333	0.995137
1999	0.7029799		0.980412
2000	0.7044675		1.034976

	HANÖBUKTEN	DRAGSKÄR	MARSÖ
2001	1.0817297		1.059891
2002	0.6769622		0.98806
2003	0.9994292		0.904513
2004	0.7962425		1.007576
2005	0.801855		
2006	0.7786137		

Table SE.s Time trends in poundnet catches of silver eel in four subareas in Swedish RBD Southern Baltic. (cf Figure SE.7). The subareas are all located in ICES Subdivision 27 on the Swedish coast of the Baltic Proper. (gears*nights).

YEAR	N KALMARSUND	S ÖSTERGÖTLAND	N SMÅLAND	N ÖSTERGÖTLAND
1959	553			
1960	797			
1961	871			
1962	812			
1963	886			
1964	646			
1965	712			
1966	774			
1967	509			
1968	526			
1969	392			
1970	335			
1971	401			
1972	444	3,4	2,8	
1973	301	4,8	2,3	
1974	416	4,6	3,2	
1975	313	5,1	3,4	
1976	278	3,9	2,4	
1977	257	4,9	2,1	
1978	392	5,5	2,0	
1979	434	4,3	2,6	
1980	279	5,4	2,8	
1981	199	3,6	2,4	
1982	263	6,0	3,9	

YEAR	N KALMARSUND	S ÖSTERGÖTLAND	N SMÅLAND	N ÖSTERGÖTLAND
1983	268	5,6	2,2	
1984	305	5,1	1,7	
1985	321	7,0	3,9	
1986	282	3,5	2,2	
1987	315	5,4	1,8	
1988	350	8,7	3,3	
1989	175	5,2	2,4	
1990	258	3,3	2,0	
1991	391	5,7	2,9	
1992	500	6,8	4,1	
1993	218	5,4	1,9	
1994	241	8,4	2,4	5,5
1995	185	4,9	2,0	3,9
1996	57	5,7	1,0	3,4
1997	364	6,4	1,4	4,5
1998	149	5,3	1,2	1,4
1999	411	6,4	1,3	3,1
2000	374	4,7	0,9	2,4
2001	455	6,6	2,2	2,7
2002	460		2,0	2,6
2003			1,6	1,5
2004			1,7	1,3
2005			2,9	2,3
2006			1,8	1,7

Table SE.t Catch per unit effort in poundnets (number of silver eels per gear*days) in SD 25 Hanöbukten. (cf Figure SE.7).

YEAR	DOHLSTEN	HALLASÄTTTET	KONGAFISKET	ODERKÄRVET	SAXEMARA	SKAFTET	STENÖREN	STYRSVIK	UTKÖRNINGEN	ÅLAHAKEN	MEAN
1959					17.544444	18.67213			8.433333	15.9	15.13748
1960					22.196721	21.36066			18.47541	27.98361	22.5041
1961					24.327869	61.85246			15.4918	42.57377	36.06148
1962					31.863388	66.54098			8.967213	42.77049	37.53552
1963					39.63388	49.47541			15.93443	26.16393	32.80191
1964					33.846995	67.09836			9.098361	25.45902	33.87568
1965					26.814208	42.80328			3.557377	43.78689	29.24044
1966					41.726776	46.65574				26.98361	38.45537
1967					31.961749	35.2459				32.81967	33.34244
1968		58.96721311			16.508197	34.44262				24.98361	33.72541
1969		36.18032787			10.737705	22.62295				6.098361	18.90984
1970		18.76229508			14.233607	18.2459				7.57377	14.70389
1971		27.96721311			21.536885	7.846995				7.836066	16.29679
1972		23.8852459			10.692623	4.628415				6.442623	11.41223
1973		28.94262295			16.127049	5.540984				2.147541	13.18955
1974		22.68852459			13.590164	4.923497					13.73406
1975		24.37704918			12.709016	4.295082				2.680328	11.01537
1976		26.09016393			4.8401639	2.31694				0.885246	8.533128
1977		38.37704918			8.7131148	2.202186					16.43078
1978											14.1283
1979											14.1283
1980											14.1283
1981		17.16393443	15.6	27.5666667	7.3155738	2.566667	16.85556	4.922222			13.14152
1982		44.26229508	81.3770492	58.1639344	32.666667	6.409836	16.95628	41.2418			40.15398
1983	21.5737705	15.40983607	38.3278689	37.9180328	15.076503	4.754098	9.688525	13.80328			19.56899
1984	18.1311475	45.91803279	24.5409836	39.9180328				10.34973			27.77158

YEAR	DOHLSTEN	HALLASÄTTTET	KONGAFISKET	ODERKÄRVET	SAXEMARA	SKAFTET	STENÖREN	STYRSVIK	UTKÖRNINGEN	ÅLAHAKEN	MEAN
1985	26.852459	18.18032787	30.7704918	19.4754098	23.131148	4.36612	9.459016	24.63388			19.60861
1986	30.704918	14.83606557	37.9344262	22.7868852	21.568306	2.622951	7.557377	30.86885			21.10997
1987	8.01639344	14.93442623	25.0163934	10.8360656	6.6557377	2.480874	12.09836	14.67213			11.8388
1988	19.3442623	29.73333333	46.7868852	21.3442623		5.52459	39.86667	70.70492			33.32927
1989	16.5901639	16.57377049	32.1803279	20.2622951	10.688525		18.77049	21.06557			19.44731
1990	10.9508197	14.96721311	18.7704918	25.0163934	6.6174863		25.80328	10.7377			16.12334
1991	20.0983607	17.60655738	24.1803279	17.2459016	6.6338798			20.63934			17.73406
1992	24.6229508	12.45901639	22.9836066	16.7540984	11.054645			36.91803			20.79872
1993	12.4262295	10.73770492	15.8360656	7.73770492	6.1693989			16.7377			11.60747
1994		13	21.704918		5.2677596			14.52459			13.62432
1995		11.06557377	24.8032787	24.1639344	3.3715847			7.147541			14.11038
1996	4.04098361	5.573770492	11.0819672	9.59016393	1.9945355			2.213115			5.749089
1997	10.6639344			12.7377049				11.55738			11.65301
1998	7.00819672			7.80327869				8.344262			7.718579
1999	12.704918							5.016393			8.860656
2000	13.8934426							8.327869			11.11066
2001	25.0983607							11.34426			18.22131
2002	6.86885246							2.918033			4.893443
2003	16.9672131										12.8541
2004	12.0819672			25.4344262							18.7582
2005				38.1557377							38.15574
2006				36.8114754							36.81148

Table SE.u Time trends in cpue and effort for fykenet catches of silver and yellow eel in two subareas in Swedish RBD Southern Baltic. The subareas are all located in ICES Subdivision 27 on the Swedish coast of the Baltic Proper. Northern part of the county of Kalmar and southern part of the county of Östergötland. (effort = unit gear*days) (cf Figure SE.9).

N Kalmar	CPUE				
	Silver eel (N)	Silver eel (kg)	Yellow eel (N)	Yellow eel (kg)	Effort
1979	0,01	0,00	0,19	0,11	5569
1980	0,01	0,01	0,18	0,10	6511
1981	0,01	0,01	0,15	0,09	6106
1982	0,01	0,00	0,21	0,12	5655
1983	0,01	0,01	0,17	0,09	5629
1984	0,01	0,01	0,15	0,08	7709
1985	0,00	0,00	0,15	0,09	5240
1986	0,01	0,01	0,08	0,04	2475
1987	0,00	0,00	0,10	0,05	684
1988	0,01	0,01	0,19	0,11	2901
1989	0,03	0,03	0,24	0,12	2488
1990	0,08	0,06	0,32	0,17	3767
1991	0,08	0,07	0,21	0,12	3581
1992	0,11	0,09	0,32	0,18	4138
1993	0,14	0,12	0,34	0,17	4641
1994	0,05	0,05	0,28	0,17	4474
1995	0,04	0,04	0,25	0,13	6755
1996	0,03	0,02	0,17	0,10	8820
1997	0,03	0,03	0,23	0,12	3173
1998	0,03	0,02	0,12	0,06	9104

N Kalmar	CPUE				
	silver eel (n)	silver eel (kg)	yellow eel (n)	yellow eel (kg)	effort
1999	0,04	0,03	0,19	0,11	4745
2000	0,04	0,03	0,19	0,11	4094
2001	0,05	0,05	0,16	0,09	7808
2002	0,11	0,10	0,25	0,15	2987
2003	0,01	0,01	0,22	0,12	3655
2004	0,03	0,02	0,10	0,06	2766
2005	0,17	0,15	0,13	0,08	4830
2006	0,17	0,15	0,14	0,08	3908

S Östergötland	CPUE				
	silver eel (n)	silver eel (kg)	yellow eel (n)	yellow eel (kg)	effort
1974	0,17	0,12	0,04	0,01	8419
1975	0,06	0,05	0,10	0,04	10088
1976	0,05	0,04	0,06	0,03	6774
1977	0,05	0,04	0,07	0,03	7667
1978	0,03	0,02	0,07	0,03	9355
1979	0,03	0,02	0,08	0,04	10360
1980	0,05	0,04	0,05	0,02	11967
1981	0,03	0,02	0,06	0,03	10713
1982	0,03	0,02	0,08	0,04	7826
1983	0,02	0,02	0,09	0,04	10404
1984	0,03	0,02	0,06	0,03	10860
1985	0,02	0,01	0,08	0,04	11396

S Östergötland	CPUE				
	Silver eel (N)	Silver eel (kg)	Yellow eel (N)	Yellow eel (kg)	Effort
1986	0,01	0,01	0,09	0,04	10831
1987	0,01	0,01	0,06	0,03	12131
1988	0,04	0,03	0,10	0,05	10396
1989	0,03	0,02	0,10	0,05	11116
1990	0,05	0,04	0,06	0,03	14508
1991	0,03	0,02	0,10	0,05	6565
1993	0,03	0,02	0,06	0,03	4867
1994	0,03	0,02	0,09	0,05	8667
1995	0,03	0,03	0,06	0,04	5045
1996	0,02	0,02	0,09	0,05	7607
1997	0,04	0,04	0,03	0,02	6961
1998	0,04	0,03	0,02	0,01	6334
1999	0,05	0,05	0,03	0,02	4830
2000	0,04	0,03	0,03	0,02	4858
2001	0,02	0,02	0,04	0,03	3815
2002	0,06	0,05	0,02	0,01	4641
2003	0,05	0,04	0,02	0,02	4123
2004					
2005					
2006	0,09	0,08	0,06	0,03	3157

Table SE.v Time trend in the yellow eel catches in coastal fish monitoring with fykenets in August on the Swedish west coast. RBD SE Baltic (Barsebäck) and RBD Västerhavet (others). Annual mean water temperature at the fishing gears is presented for the Vendelsö area in central Kattegat. (cf Figure SE.17).

	NUMBERS/FYKENET*DAY						
	BARSEBÄCK	KULLEN	VENDELSÖ	HAKEFJORDEN	LYSEKIL	FJÄLLBACKA	TEMPERATURE
1976			0,29				
1977			0,05				
1978			0,08				
1981			0,13				
1982			0,18				
1983			0,19				
1984			0,38				
1985			0,44				
1986			0,57				
1987			0,49				
1988	0,80		0,64				20,6
1989	0,69		0,63				17,1
1990	1,10		0,26				20,1
1991	1,24		0,77				19,2
1992	0,80		0,33				18,4
1993	0,43		0,47				16,4
1994	1,08		1,69				22,1
1995	1,56		0,77				19,7
1996	1,02		0,23				18,4
1997	1,02		0,23				20,3
1998	0,35		0,19			1,02	16,8

	NUMBERS/FYKENET*DAY						
	BARSEBÄCK	KULLEN	VENDELSÖ	HAKEFJORDEN	LYSEKIL	FJÄLLBACKA	TEMPERATURE
1999	1,46		0,32				20,2
2000	0,55		0,29			0,48	17,3
2001	0,47		0,61			0,77	18,7
2002	0,92	0,63	1,44	0,73	2,76	1,77	20,9
2003	0,59	1,17	1,22	1,23	1,36	1,24	19,3
2004	0,47	0,41	2,09	0,39	1,13	0,88	20,7
2005	0,34	0,37	1,03	0,37	0,38	1,01	18,1
2006	0,77	1,01	1,37	0,84		0,86	21,4
2007	1,24			0,14		0,78	

Table SE.x Length composition of silver eel from commercial poundnet catches in samples collected in 2005–2006 in RBD SE Baltic (ICES SD 23, 24, 25 and 27). (cf Figure SE.19).

	ICES Subdivision			
CM-CLASS	SD 23	SD 24	SD 25	SD 27
38	3			
39				
40				1
41				
42	4			
43	3			
46	2			
48	2			
50	2	1		
51	3			
52	7	2	2	
53	5			
54	15	1		
55	12	4	7	1
56	18	3	5	
57	17	5	3	
58	18	1	4	
59	13	4	7	5
60	13	3	9	3
61	16	5	12	1
62	24	10	16	4
63	22	10	10	4
64	16	8	19	1
65	17	11	31	6
66	15	10	24	6
67	19	6	28	8
68	18	8	39	9
69	14	8	40	14
70	10	12	32	18
71	13	3	44	17
72	12	3	29	24
73	15	7	43	17
74		6	35	27
75	3	6	27	22
76	13	4	20	30
77	4	4	29	38
78	6	5	22	24
79	1	7	22	29
80	8		14	19
81	3	4	16	22
82	3	1	12	25

	ICES Subdivision			
cm-class	SD 23	SD 24	SD 25	SD 27
83	4	2	15	24
84	4	1	12	12
85	2	1	8	16
86	3	3	5	9
87	2		4	7
88	1		4	9
89	2	1	2	1
90	2		2	3
91	1			2
92	1			2
93			3	2
94				1
95			1	
96	1	1	1	1
102				1
Total	412	171	658	465

Table SE.y Swedish sampling of silver eel in commercial catches with poundnets.

Number of samples		
	Year of catch	
	2005	**2006**
SD 23	206	206
SD 24	72	99
SD 25	299	353
SD 27	312	149
Totalt	894	810
	Year of catch	
Number of ages	**2005**	**2006**
SD 23	200	200
SD 24	71	
SD 25	292	198
SD 27	236	
Total	799	398

Table SE.z Average age of silver eel from commercial poundnet catches in samples collected in 2005–2006 in RBD SE Baltic (ICES SD 23, 24, 25 and 27).

	Year of catch		
	2005	2006	Totalt
SD 23	11,6	10,4	11,0
SD 24	12,3		12,3
SD 25	12,0	12,1	12,0
SD 27	13,8		13,8
Totalt	12,4	11,3	12,0

Table SE.aa Length-at-age of silver eel from commercial poundnet catches in samples collected in 2005–2006 in RBD SE Baltic (ICES SD 23, 24, 25 and 27). s = standard deviation.

	Age																	
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
SD 23	536	640	614	612	616	636	648	681	691	711	696	679	657	685	828			
s	104	118	107	88	88	92	83	98	97	103	78	72	51	81				
SD 24				629	632	646	721	703	694	752	662	701	732	829	857	730		
s				47	36	64	109	76	78	56	148	49	120	45				
SD 25	654	593	645	702	677	683	688	708	709	743	735	727	755	793	753	780		
s	37		33	63	61	59	61	65	64	63	53	58	54	94		33		
SD 27				839	704	740	759	740	758	775	772	783	805	825	758	790	828	833
s					87	88	62	66	71	50	68	45	51	62	55	75	70	
Total	587	636	622	634	640	665	686	706	717	748	734	744	755	773	776	779	828	833
s	100	113	92	94	81	83	79	79	81	71	77	67	72	94	58	49	70	

Table SE.ab Weight-at-age of silver eel from commercial poundnet catches in samples collected in 2005–2006 in RBD SE Baltic (ICES SD 23, 24, 25 and 27). s = standard deviation.

	AGE																	
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
SD 23	333	567	520	470	479	527	542	659	713	743	667	615	562	608	987			
s	194	267	309	225	214	282	225	340	312	347	238	223	102	174				
SD 24				481	542	577	878	721	703	914	720	685	792	1051	1308	662		
s				163	84	256	509	246	230	265	507	145	361	50				
SD 25		407	522	694	658	660	676	724	719	817	762	758	871	1007	756	853		
s	104		103	142	182	201	201	214	219	241	163	230	269	342		96		
SD 27				1143	685	865	886	836	908	941	978	1008	1056	1091	846	877	1112	1177
s					318	280	272	247	267	203	282	197	280	236	218	312	298	
Total	447	554	521	527	548	612	671	726	770	852	810	847	881	912	903	845	1112	1177
s	207	258	263	244	214	263	270	268	274	262	274	259	293	310	237	187	298	

Table SE.ac Somatic condition at age of silver eel from commercial poundnet catches in samples collected in 2005–2006 in RBD SE Baltic (ICES SD 23, 24, 25 and 27). s = standard deviation.

	Age																	
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
SD 23	1,87	1,89	1,94	1,84	1,85	1,82	1,83	1,86	1,96	1,88	1,84	1,80	1,92	1,81	1,68			
s	0,21	0,26	0,38	0,18	0,20	0,20	0,18	0,21	0,30	0,22	0,25	0,25	0,32	0,17				
SD 24				1,80	2,03	1,90	2,01	1,88	1,93	1,93	2,04	1,85	1,87	1,78	1,98	1,63		
s				0,24	0,17	0,35	0,28	0,20	0,26	0,33	0,34	0,14	0,03	0,18				
SD 25	2,04	1,88	1,86	1,89	1,98	1,93	1,93	1,90	1,87	1,86	1,81	1,84	1,90	1,88	1,70	1,72		
s	0,15		0,12	0,10	0,19	0,21	0,18	0,19	0,19	0,17	0,15	0,17	0,23	0,22		0,16		
SD 27				1,84	1,77	1,97	1,88	1,91	1,93	1,91	1,98	1,97	1,91	1,84	1,83	1,65	1,86	1,94
s					0,21	0,13	0,20	0,17	0,17	0,18	0,22	0,19	0,26	0,22	0,21	0,14	0,01	
Total	1,95	1,89	1,92	1,85	1,90	1,88	1,90	1,89	1,92	1,88	1,89	1,90	1,90	1,83	1,81	1,69	1,86	1,94
s	0,20	0,24	0,32	0,17	0,20	0,21	0,20	0,19	0,22	0,19	0,22	0,20	0,23	0,19	0,19	0,14	0,01	

Table SE.ad Length composition of yellow eel from commercial fykenet catches in samples collected in 2002–2006 in RBD SE Västerhavet (ICES SD 20–21) and RBD SE Baltic (ICES SD 23,25 and 27). Samples from subdivisions 25 and 27 are based on an unsorted mixture of landings and discard. (cf Figure SE.18).

	ICES Subdivision				
cm-class	SD 20	SD 21	SD 23	SD 25	SD 27
26				1	
27					
28	1			1	
29				2	
30	1		1	2	
31	2		1	5	
32	11		2	6	
33	14	3	1	9	
34	25	2	4	19	
35	29	3	5	19	
36	49	11	9	19	
37	85	15	15	39	
38	96	16	23	34	3
39	119	42	29	47	1
40	110	34	33	58	4
41	127	42	35	54	11
42	117	57	33	60	8
43	114	49	56	49	14
44	96	70	59	67	29
45	119	60	63	62	26
46	105	48	50	56	40
47	78	44	51	53	63
48	85	46	65	62	56
49	97	39	46	47	89
50	70	37	67	57	68
51	55	45	40	40	90
52	60	39	55	37	93
53	56	27	41	32	104
54	44	19	35	42	106
55	32	20	31	23	104
56	29	21	37	29	98
57	29	15	25	29	88
58	27	12	17	18	110
59	17	8	24	28	98
60	25	9	10	19	98
61	15	14	7	12	108
62	17	14	10	15	80
63	12	10	6	6	89
64	11	10	1	10	74

ICES Subdivision					
65	8	4	5	12	67
66	1	4		9	51
67	6	3	2	6	54
68	2	5	1	5	58
69	1		1	3	45
70				5	37
71	1	1	1	3	30
72	1	2	1	5	27
73	2	1	1	2	25
74				5	12
75				1	15
76			1		10
77	1	2		1	17
78		1		1	4
79				1	7
80+	0	1	0	2	19
Total	2002	905	1000	1229	2230

Table SE.ae Annual mean age of yellow eel from commercial fykenet catches in samples collected in 2002–2006 in RBD SE Väserhavet (ICES SD 20–21) and RBD SE Baltic (ICES SD 23, 25 and 27). Samples from Subdivisions 25 and 27 are based on an unsorted mixture of landings and discard. s = standard deviation.

	Year of catch					
	2002	2003	2004	2005	2006	Total
SD20	9,0	8,9	9,6	8,7		8,9
s	1,69	1,65	1,80	1,91		1,86
SD21	8,7	8,2	8,7	7,9	9,2	8,4
s	2,03	2,28	1,99	2,04	1,96	2,11
SD23	8,6	9,6	9,4	8,9		9,1
s	2,15	1,95	1,73	1,85		1,91
SD25		7,2	6,8			7,0
s		1,99	1,60			1,83
SD27			9,8	10,9		10,1
s			2,17	2,08		2,20

Table SE.af Age distribution of yellow eel from commercial fykenet catches for samples collected in 2005–2006 in RBD Västerhavet (ICES SD 20–21) and RBD SE Baltic (ICES SD 23,25 and 27). Samples from subdivisions 25 and 27 are based on an unsorted mixture of landings and discard.

	Age															
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	20
SD20		4	18	42	90	151	172	119	62	40	20	5		1		
SD21			32	85	94	127	89	81	42	21	12	8	3	1	1	
SD23			11	25	71	123	131	104	60	38	13	7	4	1	1	
SD25	7	13	18	36	44	37	28	9	4	1						
SD27			4	14	39	90	96	91	98	65	41	19	16	4		1
Total	7	17	83	202	338	528	516	404	266	165	86	39	23	7	2	1

Table SE.ag Length-at-age of yellow eel from commercial fykenet catches for samples collected in 2005–2006 in RBD Västerhavet (ICES SD 20–21) and RBD SE Baltic (ICES SD 23,25 and 27). Samples from subdivisions 25 and 27 are based on an unsorted mixture of landings and discard. s = standard deviation.

	Age															
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	20
SD20		407	369	412	426	444	476	495	513	543	563	570		617		
s		11,63	37,26	40,96	42	56,91	65,16	65,64	56,64	68,08	73,86	71,34				
SD21			405,4	439,4	455,1	475,1	490,1	522,4	548,5	572	590,7	550	616,7	777	778	
s			32,57	50,41	50,08	59,01	61,33	78,75	57,18	107,9	62,89	78,69	107,1			
SD23			397,3	427,3	445,7	464,3	480,2	505,9	522,5	538,7	577,9	580,7	582,5	487	506	
s			68,25	43,64	54,31	47,38	53,3	56,26	60,76	66,71	77,16	14,67	17,33			
SD25	339,1	366	376	425	445	453	491	482	547	628						
s	49,07	39,34	30,78	46,7	53,97	45,91	43,5	45,28	97,7							
SD27			499,3	509,6	516	533,6	552,6	567,2	601,8	608,6	641,6	657,5	649,9	695,5		778
s			50,63	59,27	65,59	59,77	63,21	61,97	80,28	66,28	61,81	69,21	60,65	78,8		
Total	339,1	375,4	394,6	434,5	451,1	472,1	494,5	519,3	554	572,1	606,7	610,5	633,8	666,1	642	778
s	49,07	38,9	48,48	52,64	57,44	62,74	66,41	70,5	77,47	79,06	74,78	78,95	65,55	107,1	192,3	

Table SE.ah Weight-at-age of yellow eel from commercial fykenet catches for samples collected in 2005–2006 in RBD Västerhavet (ICES SD 20–21) and RBD SE Baltic (ICES SD 23,25 and 27). Samples from subdivisions 25 and 27 are based on an unsorted mixture of landings and discard. s = standard deviation.

	AGE															
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	20
SD20		94,58	81,51	112,1	119,3	135,6	169,9	191,8	213,2	263,9	295,9	310,6		392		
s		17,87	34	41	41	58	83	89	85	120	126	135				
SD21			99,75	121,1	129,8	154,7	167,8	220,9	248,9	341	348,1	270,2	501	839	833,7	
s			32	71	50	84	80	134	99	263	137	128	386			
SD23			96	105	130	148	169	206	229	257	358	338	350	149	169,3	
s			74	47	65	66	66	82	93	134	165	52	75			
SD25	57,86	73,46	79	121	145	150	193	189	310	537						
s	23,41	26,16	19	44	64	51	61	63	163							
SD27			186	208	223	254	286	314	390	392	473	509	493	649		665
s			62,47	67,99	95,35	106,9	114,5	113,3	188,2	140	166	183,8	192,4	252,9		
Total	57,86	78,43	95	123,2	139,8	164,3	192,1	228,8	288,9	324,1	397	407,5	469,4	567,9	501,5	665
S	23,41	25,65	44,98	62,54	67,2	86,42	95,67	113,1	156,8	166,2	168,9	180,4	206,6	288,1	469,8	

Table SE.ai Condition factor-at-age of yellow eel from commercial fykenet catches for samples collected in 2005–2006 in RBD Västerhavet (ICES SD 20–21) and RBD SE Baltic (ICES SD 23,25 and 27). Samples from subdivisions 25 and 27 are based on an unsorted mixture of landings and discard. s = standard deviation.

	Age															
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	20
SD20		1,31	1,44	1,44	1,42	1,38	1,39	1,40	1,42	1,47	1,47	1,47		1,59		
s		0,19	0,25	0,20	0,21	0,18	0,20	0,19	0,18	0,22	0,18	0,29				
SD21			1,38	1,27	1,25	1,27	1,27	1,34	1,36	1,47		1,33	1,78	1,69	1,61	
s			0,25	0,23	0,18	0,22	0,19	0,22	0,21	0,32	0,32	0,14	0,51			
SD23			1,26	1,20	1,30	1,33	1,37	1,41	1,44	1,43	1,63	1,63	1,66	1,22	1,25	
s			0,15	0,19	0,18	0,20	0,19	0,19	0,18	0,23	0,22	0,21	0,22			
SD25	1,33	1,35	1,38	1,43	1,47	1,47	1,49	1,55	1,67	2,08						
s	0,05	0,11	0,13	0,13	0,20	0,16	0,14	0,19	0,06							
SD27			1,37	1,44	1,44	1,51	1,54	1,57	1,58	1,59	1,64	1,63	1,63	1,75		1,34
s			0,11	0,16	0,16	0,16	0,16	0,20	0,17	0,18	0,19	0,19	0,21	0,23		
Totalt	1,327	1,339	1,379	1,338	1,357	1,371	1,395	1,433	1,481	1,513	1,582	1,55	1,654	1,641	1,433	1,338
s	0,05	0,12	0,21	0,22	0,21	0,21	0,20	0,21	0,20	0,24	0,22	0,23	0,25	0,25	0,25	

Table SE.aj Prevalence of *Anguillicola crassus* in yellow eel from commercial fykenet catches for samples collected in 2005–2006 in RBD Västerhavet (ICES SD 20–21) and RBD SE Baltic (ICES SD 23,25 and 27). Samples from subdivisions 25 and 27 are based on an unsorted mixture of landings and discard. (cf Figure SE.23).

	Not infested N	Infested N	Total N	Prevalence %
SD20	1829	173	2002	9
SD21	782	124	906	14
SD23	530	470	1000	47
SD25	476	753	1229	61
SD27	975	1255	2230	56
Total	4592	2775	7367	38

Table SE.ak (cf Figure SE.14).

	Number of glass eels per m2
1991	0,000887
1992	0,003287
1993	0,007485
1994	0,012144
1995	0,008874
1996	0,000702
1997	0,000653
1998	0,0019
1999	0,00297
2000	0,010742
2001	0,000516
2002	0,002831
2003	0,001771
2004	9,94E-05
2005	0,002121
2006	0,000815
2007	0

Table SE.al (cf Figure SE.15 and 16). Underlag vid körning av ålförekomst ostkusten ICES-rapport 2005 (körning i januari 2006).

Case Processing Summary

Year		Cases					
		Valid		Missing		Total	
		N	Per cent	N	Per cent	N	Per cent
ÅIKLASS	1990	39	100,0%	0	,0%	39	100,0%
	1991	34	100,0%	0	,0%	34	100,0%
	1992	47	100,0%	0	,0%	47	100,0%
	1993	98	100,0%	0	,0%	98	100,0%
	1994	115	100,0%	0	,0%	115	100,0%
	1995	180	100,0%	0	,0%	180	100,0%
	1996	98	100,0%	0	,0%	98	100,0%
	1997	121	100,0%	0	,0%	121	100,0%
	1998	186	100,0%	0	,0%	186	100,0%
	1999	156	100,0%	0	,0%	156	100,0%
	2000	113	100,0%	0	,0%	113	100,0%
	2001	108	100,0%	0	,0%	108	100,0%
	2002	177	100,0%	0	,0%	177	100,0%
	2003	155	100,0%	0	,0%	155	100,0%
	2004	126	100,0%	0	,0%	126	100,0%
	2005	111	100,0%	0	,0%	111	100,0%

Underlag för körning av ålförekomst ICES-rapport 2006 (körning i juli 2007).

Case Processing Summary

YEAR		Cases					
		Valid		Missing		Total	
		N	Per cent	N	Per cent	N	Per cent
Eel occurrence (%)	1990	39	100,0%	0	,0%	39	100,0%
	1991	34	100,0%	0	,0%	34	100,0%
	1992	47	100,0%	0	,0%	47	100,0%
	1993	98	100,0%	0	,0%	98	100,0%
	1994	115	100,0%	0	,0%	115	100,0%
	1995	180	100,0%	0	,0%	180	100,0%
	1996	98	100,0%	0	,0%	98	100,0%
	1997	121	100,0%	0	,0%	121	100,0%
	1998	186	100,0%	0	,0%	186	100,0%
	1999	156	100,0%	0	,0%	156	100,0%
	2000	113	100,0%	0	,0%	113	100,0%
	2001	108	100,0%	0	,0%	108	100,0%
	2002	178	100,0%	0	,0%	178	100,0%
	2003	155	100,0%	0	,0%	155	100,0%
	2004	160	100,0%	0	,0%	160	100,0%
	2005	192	100,0%	0	,0%	192	100,0%
	2006	162	100,0%	0	,0%	162	100,0%

Report on the eel stock and fishery in Lithuania 2007

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Reporting Period: This report was completed in August 2008, and contains data up to 2007 and some provisional data for 2008.

LT.B Introduction

LT.B.1 Fishery

Yellow and silver eels are exploited in the coastal waters of the Baltic Sea, the Curonian Lagoon, in some inland lakes, rivers and ponds.

Naturally recruited eels occur in the Curonian Lagoon and coastal waters, however some part of eels inhabiting the Curonian Lagoon are of the restocked origin; in the coastal waters natural recruits fully predominate over restocked eels (Shiao *et al.*, 2006). Professional or semi-professional fishers may have an income from eels as a bycatch mainly. Usually, eels are caught as bycatch in fykenets, very rarely could be caught using longlines. In the coastal waters eels are caught by longlines during summertime, however catches during the last three years are negligible and for the professional fisheries eel is of nearly no importance as a species. The eel fishery in the Curonian Lagoon is regulated by commercial size limit (>45 cm) and gear (fykenet) quota.

Eel fishery in the inland water bodies fully depends on elver restocking from France or the UK. At the beginning of the 20th century and until 1938 eels were caught in the inland waters, indicating that natural recruitment to the inland waters took place at least at the beginning of the century.

Eel fishery in the inland water bodies mostly depends on migrating silver eel landings during spring; however in four lakes small-scale yellow eel fishery still exists. Trapnets in streams or small rivers are used to capture downstream migrating eels. Such eel fishery is regulated by licensing and closed seasons.

Lithuanian eel fishery could be divided into:

- Inland fishery: exploits restocked eels;
- Curonian Lagoon fishery: exploits natural recruits mostly, however eels of restocked origin consist about 20% of the landings;
- Baltic Sea fishery: very small-scale, exploits natural recruits mostly.

Commercial capture of glass eel or elvers never took place in Lithuania water bodies. Last findings reveal that eels arrive in the southeastern Baltic at age 1–10 years (5.1 ± 2.1 yrs) after glass eel stage (Shiao *et al.*, 2006). High variability in the age at first entry to fresh water indicates that some eels might migrate quickly and arrive in the Baltic Sea within few years, while some eels revealed very slow migration eastward.

Figure LT.1. A. Northern Europe, showing the North and Baltic Seas, B Lithuania, Baltic Sea, Curonian Lagoon and Lake Baluošai.

LT.B.2 River Basin Districts (RBD)

Table LT.1. Freshwater habitatas within Lithuania teritory.

Habitats	Number	Lengh or area
Rivers	4418	37 636 km
Lakes	2618 (>0,5 ha)	687,5 km2
Ponds	1159 (>0,5 ha)	212,9 km2

Table LT.2. Rivers have basins within Lithuania teritory according to EU Directive 2000/60/EC four.

RBD	Lithuania teritory, 100%
Nemunas	73.9%
Dauguva	2,8%
Lielupe	13,7%
Venta	9,6%

The Curonian Lagoon is defined as a transitional water body; 415 km^2 (26%) of the Lagoon bellongs to Lithuania, the rest for Kaliningrad (Konigsberg) region, Russia.

Table LT.3. Nemunas RBD.

	Lithuania	Byelorussia	Poland	Russia	Latvia
Area	47,5% (47670 km2)	46,4%	2,6%	3,2%	0,1%
Lakes (>0,5 ha)	2239 (495 km2)				
Ponds (>0,5 ha)	927 (148 km2)				

Table LT.4. Dauguva RBD.

	Lithuania	Beylorussia	Russia	Latvia
Area	2,8% (1857 km2)	37,9%	32,5%	26,8%
Lakes (>0,5 ha)	235 (154 km2)			
Ponds (>0,5 ha)	5 (31 km2)			

Table LT.5. Lielupe RBD.

	Lithuania	Latvia
Area	51% (8939 km2)	49%
Lakes (>0,5 ha)	65 (33 km2)	
Ponds (>0,5 ha)	112 (26 km2)	

Table LT.6. Venta RBD.

	Lithuania	Latvia
Area	44% (6278 km2)	56%
Lakes (>0,5 ha)	79 (37 km2)	
Ponds (>0,5 ha)	115 (25 km2)	

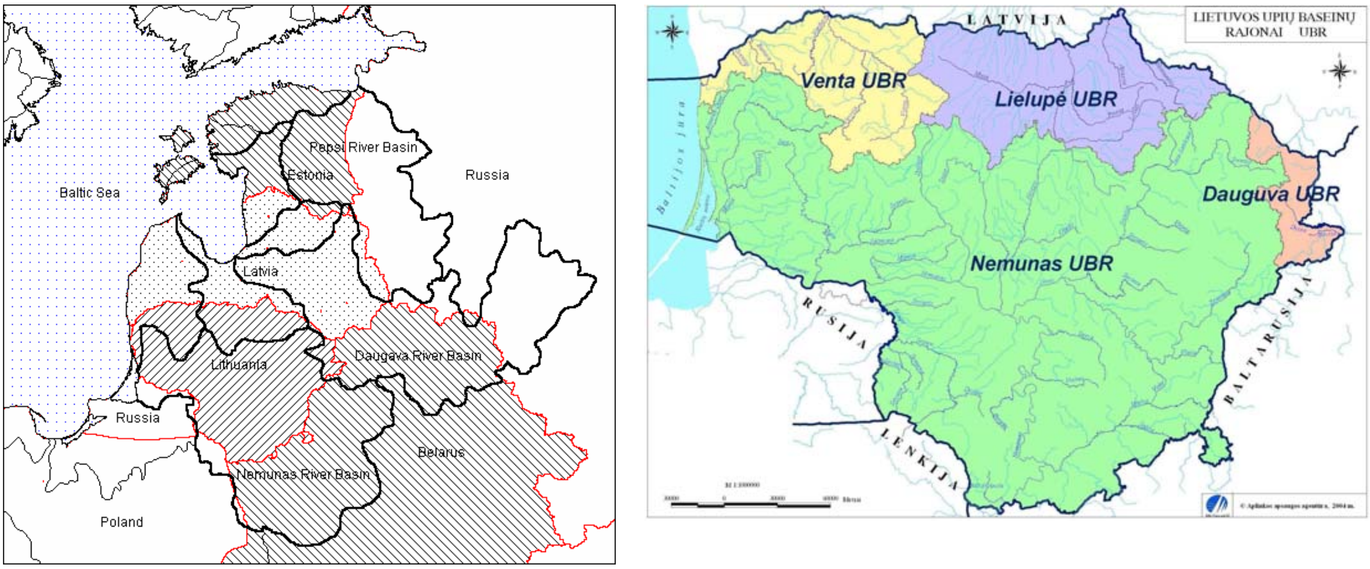

Figure LT.2. River basin districts (RBD) in Lithuania and neighbouring countries.

LT.C Fishing capacity

LT.C.1 Curonian Lagoon

The biggest eel landings in Lithuania are registered in the Curonian Lagoon. Northern part of the Curonian Lagoon belongs to Lithuania (413 km^2), while southern part for Kaliningrad region (Russia; 1171 km^2). In the Lithuanian part of the Lagoon operate 75 fisheries companies (Fisheries Department, 2004). These companies are small and usually employ only few (2–3) people. During some periods when fishery activities increase, companies can employ some more people. Some people are employed for fish processing and selling fish. Most enterprises operate up to 10 m, but a few up to 20 m boats. Usually a company has 1–2 boats. About 40 enterprises get some incomes from caught eels (during late spring, summer and early autumn). These companies use fykenets and very rarely longlines to catch eels. However, fykenets are used to catch other fish species mainly, e.g. roach (*Rutilus rutilus*), perch (*Perca fluviatilis*), bream (*Abramis brama*), pikeperch (*Sander lucioperca*), vimba (*Vimba vimba*), while eels consist only about 0.1% from total biomass in landings obtained by fykenets.

LT.C.2 Baltic Sea

In the Baltic Sea eel fishery occurs in the coastal waters. Lithuania coastline is 99 km long. During the Soviet occupation Baltic Sea coastal waters in Lithuania were restricted for fishery. Some companies operated in the open areas of the Sea. According to the personal communications of former fishers it could be presumed that there were eels in landings obtained using longlines. However, these data were largely misreported and any data are not available on eel landings during that time. After restoration Republic of Lithuania independence in 1991, coastal waters became available for fishers again. Nearly 100 (Fisheries Department, 2004) small companies were involved in coastal fishery activities, however during the last few years the number of companies has steeply declined. The majority operate using only small boats (up to

10 m length). Companies are small, employ only 2–3 fishers and own 1–2 boats. The majority of the people involved in fishery are part time fishers. Some people are associated to the coastal fishery indirectly but are involved into processing and selling fish. Few companies (about 10) seasonally use longlines, however during the last few years the main target using the gear is cod.

LT.C.3 Inland waters

In the inland waters (lakes) about 100 small fishery enterprises operate. All are small, employ 1–3 fishers. Most people involved in fishery activities are part time fishers; they operate 1–2 up to 10 m boats. Some can operate even without boats, just use trapnets to catch migrating silver eels on streams. Licences for fishing eels might be issued by Ministry of Environment or by Ministry of Agriculture.

LT.D Fishing effort

Fishery enterprises must report their landings monthly for the Regional Departments of Environment Protection Agencies and Fisheries Department under Ministry of Agriculture, but in some cases for Ministry of Environment if this institution issues licence. Both landings and gears are indicated in the reports of the Curonian Lagoon fishers, however only landings indicate inland and coastal fishers. However, fishing gears must always be indicated in fishers' logbooks. Reliability of the official reports and even records of caught fish in the logbooks could be underestimated. Hence, these data should be treated as questionable, however, should demonstrate general landing tendencies in long term.

Commercial size limit is 45 cm; bycatch of 35–44 cm length eels cannot exceed 10% of total eel catch. All eels under 35 cm length must be released. The limitation is not applicable for longlining and catching migrating silver eels from inland lakes.

LT.D.1 Curonian Lagoon

Most landings in the Curonian Lagoon are obtained using so called "Lagoon fykenets". Ministry of Environment confirms quota for this gear yearly and it's stable during the last five years: 390 fykenets are allowed to use in the Curonian Lagoon fishery. Fykenets are allowed in the Curonian Lagoon from April 1 until October 31.

Longlines are not limited, however companies should have license to use it. It is not allowed to use earthworms for longlining to avoid bycatch of small eels, which are under commercial size limit (<45 cm); this is the only limitation for longlining. Longlining is time consuming fishing method, eel landings are often very small and as the result the gear is not popular in the Curonian Lagoon nowadays. Only 4–5 companies use such gear during May–September.

LT.D.2 Baltic Sea

Longlines are the only gear used to catch eels in the coastal waters of the Baltic Sea. However, four companies in 2008 started operate using fykenets in the coastal waters; the gear targets herring, smelt, other species, however should catch some eels as well. About 10 enterprises seasonally (May–September) used longlines to fish eel in the Lithuania coastal waters of the Baltic Sea during the last decade. However, during the last few years longlining for eels in coastal waters nearly does not occur.

LT.D.3 Inland waters

Most landings at the inland water sites are obtained using trapnets, which fully block small rivers flowing out of lakes. Eel fishery using trapnets is allowed from April 1 to June 15 and from September 1 to October 31. Few companies in the inland lakes (three–four lakes) catch yellow eels.

Table LT.7. Gear quotas and eels landings in the Curonian Lagoon and inland water bodies.

	2004	2005	2006	2007	2008
Fykenets in Curonian Lagoon	390	390	390	390	390
Catches in Curonian Lagoon, t	9,7	12,4	10,9	7,6	
Catch per fykenet (yellow and silver), t	0.025	0.032	0.028	0.020	
Trapnets in rivers	69	77	72	48	44
Catches in rivers, t	3,1	6,3	2,2	4,0	
Catch per trapnet (silver), t	0.045	0.082	0.031	0.083	
Fishing companies in lakes	3	4	5	4	
Catches in lakes (yellow), t	3,2	3,5	2,6	3,4	
Total catches, t	16,0	22,2	15,8	14,9	

LT.E Catches and landings

LT.E.1 Glass eel fishery

There are no glass eel fisheries in Lithuania as a consequence of absence of eels at glass eel stage.

LT.E.2 Restocking

The first eel restocking in Lithuania occurred during 1928–1939 when 3.2 million elvers were released in the lakes of Eastern Lithuania (Vilnius region). The most intensive restocking has been carried out in Lithuania since the 1960s to supplement eel populations in the inland water bodies. Since the mid 1960s, Lithuanian lakes have been stocked with about 50 million elvers or young yellow eels at an average stocking rate of 1.1 million eels yearly (Ložys, 2002; Ložys, 2004). Since 1983 about 99% of restocked eels were released to the Nemunas RBD and the Curonian Lagoon. Almost 10 million glass- or on-grown in aquaculture eels were released during the period. However, most eels were restocked during 1983–1986 (almost 8 million); while during the last decade only 0.6 million were restocked.

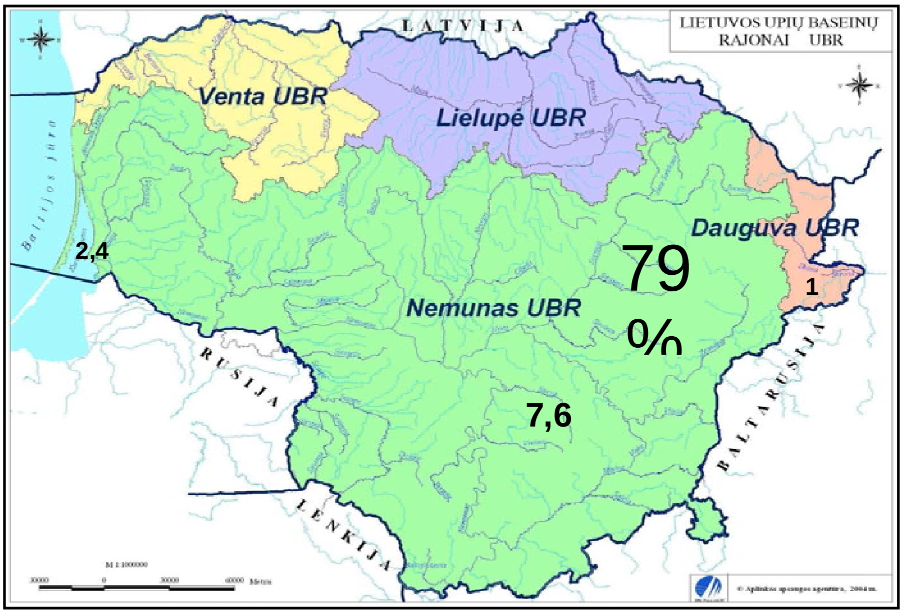

Figure LT.3. Main restocking areas in Lithuania since 1983.

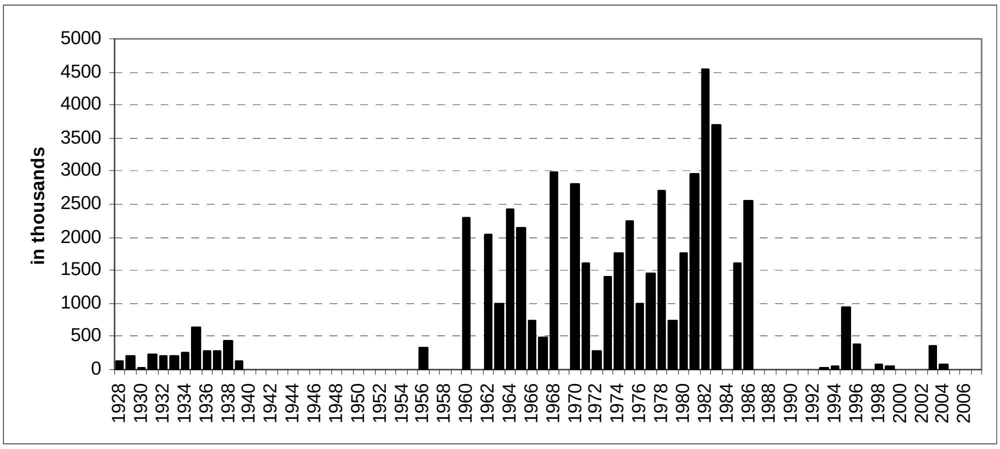

Figure LT.4. Eel restocking in Lithuania during 1928–2007.

LT.E.1 Curonian Lagoon

In the Curonian Lagoon most eels caught by commercial fishers are at yellow eel stage; however some silver eels migrating downstream from inland lakes must be caught in fykenets in the Lagoon as well. There are no special studies implemented on the eel stage in the Curonian Lagoon fishery landings. However, some scientific observations allow to state that most eels in landings are at yellow eel stage.

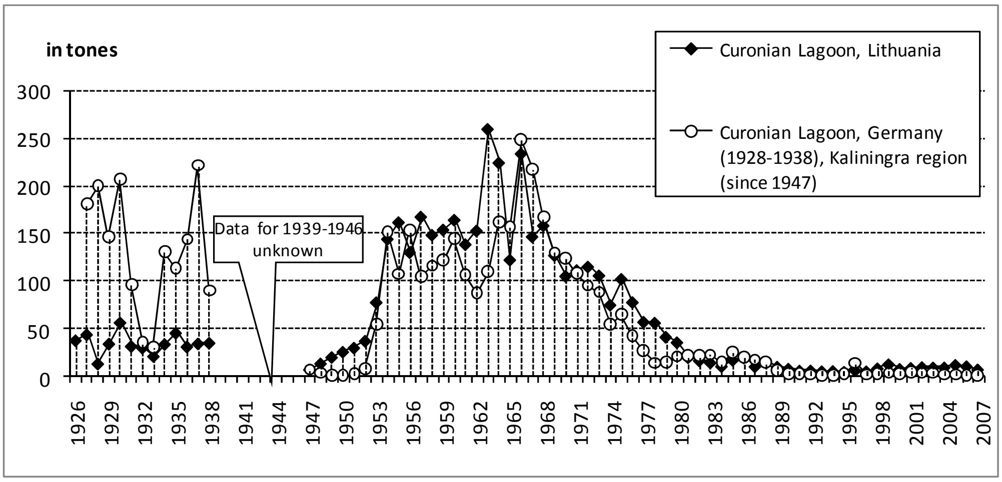

Figure LT.5. Total landings in the Curonian Lagoon during 1927–2007 (Lithuania, Germany (1928–1938) and Kaliningrad region (Russia, since 1947).

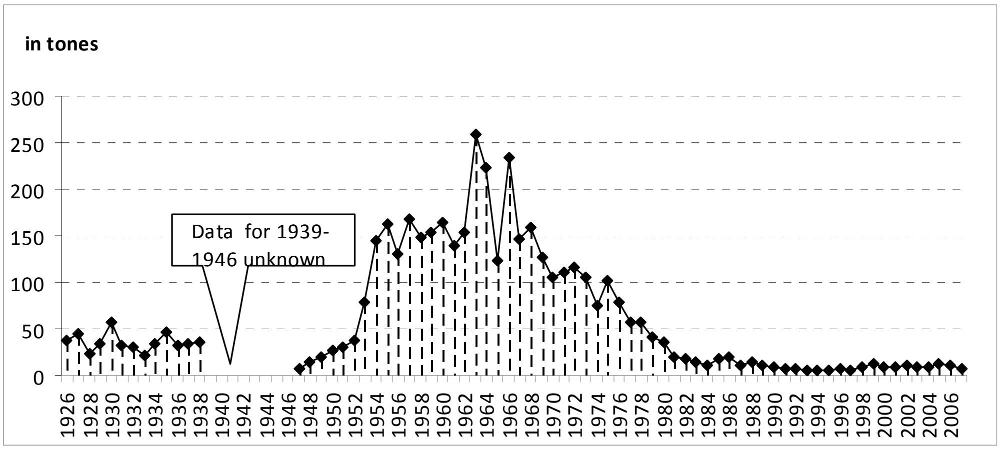

Figure LT.6. Eel landings in the Northern part of the Curonian Lagoon (Lithuania) during 1926–2007.

LT.E.4 Baltic Sea

According to scientific surveys and some observations of the commercial landings it could be presumed that practically all eels in the landings at the coastal waters are at yellow eel stage.

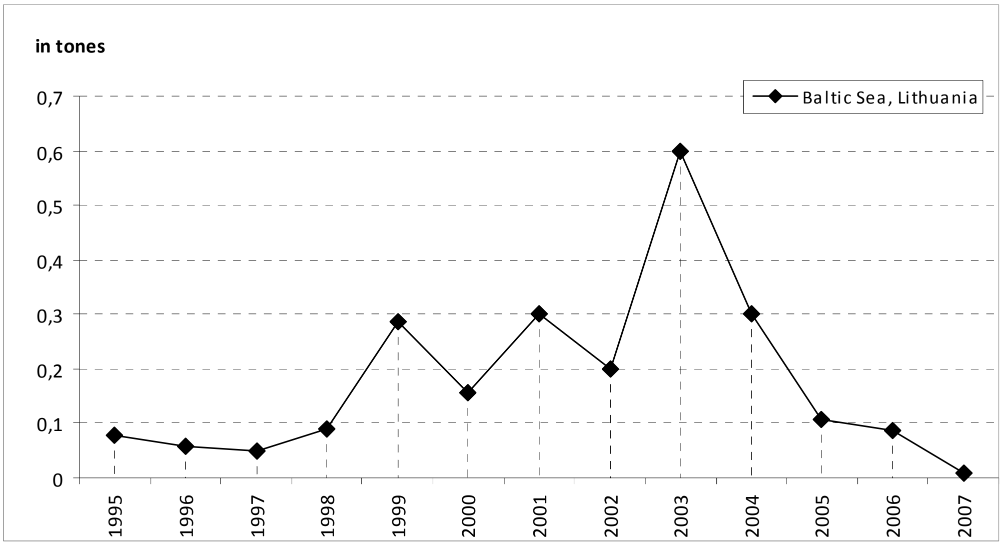

Figure LT.7. Eel landings in the coastal waters of the Baltic Sea during 1995–2007.

LT.E.5 Inland waters

According to some observations of commercial landings it could be presumed that most eels in the landings at the inland waters are at silver eel stage. Some could be obtained by longlining or using fykenets and they are at yellow eel stage, however these eels are only a minor part of total landing at the inland water sites.

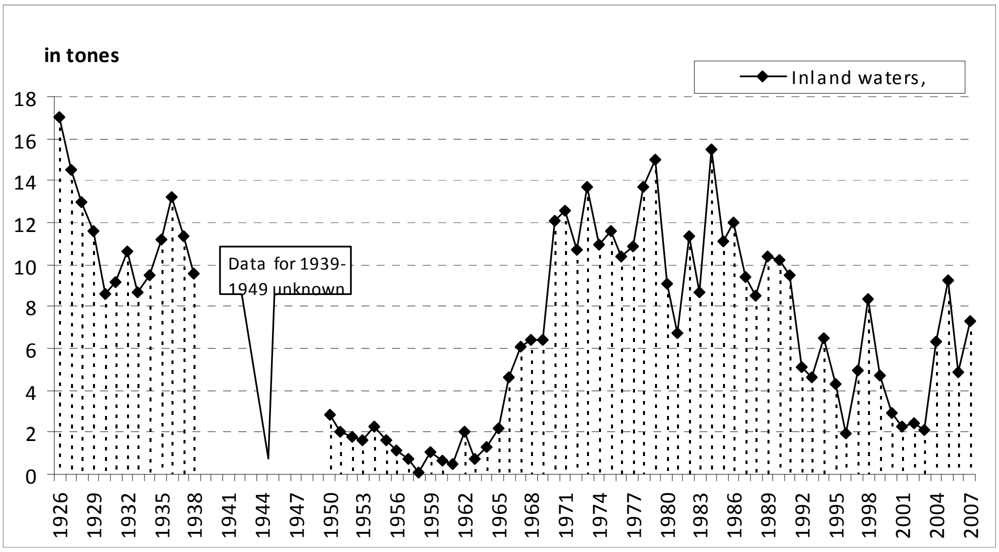

Figure LT.8. Eel landings in the inland waters, Lithuania, during 1950–2007.

LT.F. Catch per unit of effort

No detailed evaluation on catch per unit of effort (cpue) in commercial landings is done in Lithuania. Evaluation of cpue using data on official landings could be not reliable, since landings can be underestimated. The evaluation of detailed cpue could be implemented analysing landings of small but reliable subset of companies in the inland waters, Curonian Lagoon and coastal waters of the Baltic Sea.

LT.G. Scientific surveys of the stock

LT.G.1 Recruitment surveys, glass eel

Glass eel recruitment surveys are not possible in South-Eastern Baltic countries. According to the last studies eels recruit to Lithuanian fresh water at yellow eel stage. There were no special recruitment surveys implemented in Lithuania, however recent study allowed distinguishing naturally recruited and restocked eels in coastal waters of the Baltic Sea, the Curonian Lagoon and inland lake (Shiao *et al*., 2006).

LT.G.2 Stock surveys, yellow eel

Yellow eel sampling was started in 2003 and still continues on irregular basis using longlines at the coastal waters and longlines or eel boxes at the Curonian Lagoon. The Ministry of Environment, Republic of Lithuania and the Lithuanian Fisheries Produces' Association supported the studies. The samplings continue using other funds (i.e. Mutual Lithuania-Latvia-Taiwan fund and funding provided by Ministry of Education) and are performed with a purpose to study:

- migrations between fresh and brackish water sites and to evaluate natural recruitment sing eel otoliths and method of microchemical analysis;
- eels growth and age;
- population differences using DNA analysis;
- eel feeding;
- eel parasites.

Neither scientific surveys, neither sampling from commercial landings on regular basis to assess stock was implemented in Lithuania.

LT.G.3 Silver eel

In 2006–2007 a study was implemented trying to estimate seasonality of silver eel migrations in Lithuanian. Results of the study indicates that 61% of migrating silver eels start their migrations during spring, 10% during summer and 29% during autumn.

LT.H. Catch composition by age and length

In 2003 only catch composition by age and length was observed in 60 eels from Baltic Sea, 100 from Curonian Lagoon and 10 from fresh-water lake.

Table LT.8. Biological characteristics (means ± SD) of the European eels collected from Lithuanian sites.

Sampling location	Sampling period	Stage	Sample size	Mean (±SD) and range		
				Total length (cm)	Body weight (g)	Age (year)
Baltic coasts	June-September	Yellow eel	48	63.0 ± 7.3 (47.5 - 81.0)	582.4 ± 274.6 (180.0 - 1400.0)	11.0 ± 1.8 (8 - 16)
Curonian Lagoon	June-August	Yellow eel (except one silver eel)	50	66.3 ± 10.4 (49.0 - 92.0)	691.4 ± 441.7 (201.0 - 2126.0)	10.8 ± 1.7 (6 - 15)
Lake Baluošai	April	Silver eel	10	64.7 ± 11.0 (43.3 - 80.0)	519.9 ± 266.2 (127.0 - 930.0)	19.0 ± 3.0 (15 - 24)

LT.I. Other biological sampling

All sampled eels are measured, weighted, measured eye diameter, fin length and width, sex and eel development stage determined. Otoliths for growth, age determination as well as for microchemical analysis (which allows determining recruitment to the fresh-water time, distinguishing natural recruits and restocked eels) are collected; samples are collected additionally for parasitological analysis. However, all this sampling is done on irregular basis.

LT.J. Other sampling

Institute of Ecology and few other institutions implement routine state environmental monitoring funded by Ministry of Environment. The monitoring includes water quality measurements in preselected sites trough-out Lithuania, fish communities' assessment, toxic and risky materials are measured in fish tissues. Institute of Ecology is responsible for collecting these samples, while some are measured by laboratory under Ministry of Environment. The obtained data could reflect dynamics in eel habitat quality (e.g. changes in habitat pollution).

During 1993–2004 water quality according State Monitoring Programme was estimated in 13 lakes and Kaunas water reservoir. In 2005–2006 water quality was observed in more than 20 lakes. Water quality in rivers is under observation at 51 monitoring sites. According to the monitoring result, concentrations of the contaminants such as heavy metals (Zn, Cu, Cr, Pb, Ni, Cd, Hg, V, As, Sn), fenols, pesticides, chlororganic compounds did not exceed permissible exposure limits in all monitoring sites from 1997, heavy metals concentrations are decreasing. Water quality in rivers substantially improved during the period, however, monitoring data in lakes indicates higher eutrofication lavel.

LT.K. Stock assessment and its use for management advice

There is no routine assessment of the eel stock in Lithuania as well as there are no evaluations of the impact of exploitation on eel stock. There is only some advice given for management by experts for eel stock management related to issues of population structure (restocked/naturally recruited), natural eel recruitment, eel stocking success, swimbladder parasite *Anquillicola crassus* infection, eel growth and age.

LT.L. Sampling intensity and precision

Only a few hundred specimens for specific scientific research purposes were or will be sampled during scientific surveys within the projects funded by The Ministry of Environment, Republic of Lithuania; the Lithuanian Fisheries Produces' Association; Mutual Lithuania-Latvia-Taiwan fund and funding provided by Ministry of Education. There is no sampling from commercial landings implemented in Lithuania.

LT.M. Standardisation and harmonization of methodology

Methodology principles of collected samples analysis is as follows:

- The total length (TL) and weight (W) of each eel was measured to the nearest 1.0 mm and 1.0 g.;
- Sexes were determined macroscopically from the gross morphology of the gonads, where eels with thin, regularly lobed organs (Syrski's organ) were considered males, while individuals with more broad and folded curtain-like gonads were females (Tesch, 2003).
- The eels were classified as yellow and silver eels, by their external color, fin shape and eye size.
- The largest pair of eel otoliths (sagittae) are removed, dried in air, embedded in Epofix resin, ground and polished until the core was exposed. For electron probe microanalysis, the polished otoliths are coated with carbon under a high-vacuum evaporator. Sr and Ca concentrations in the otolith were measured from the otolith core to the edge at 10 μm intervals. Quantitative analyses were conducted using beam conditions of 15 kV for the acceleration voltage, 3 nA for the current, and a 5 × 4 μm rectangular scanning beam using an electron probe microanalyser (JEOL JXA-8900R).
- After microchemical analysis, the otolith are polished to remove the carbon layer, then etched with 5% EDTA for 1 to 2 minutes to reveal the annual rings for age determination.

LT.N. Overview, conclusions and recommendations

Despite some eel importance for Lithuania fisheries little is done to improve eel stock management during the last decades. Only recently the Ministry of Environment, Republic of Lithuania (in 2004) and the Lithuanian Fisheries Produces' Association (during 2003–2004) supported initiative of Institute of Ecology by providing grants for eel studies. As an outcome at least some knowledge of Lithuania eel stock is obtained (Shiao *et al*., 2006; Lin *et al*., 2007). The institution, which is mostly responsible for fisheries management in Lithuania, i.e. Fisheries Department under Ministry of Agriculture, should improve eel research in Lithuania and to improve eel stock management. There are following minimum gaps which should be done in Lithuania:

- Restocking (that is: import of young eels from France, for release in inland waters) has been practised for decades, mostly in inland waters. Recent restockings are in the order of 300 kg of glass eels per year for the whole country. Available data on restocking and fishing yield seem not to match, so the positive effect of restocking is unclear. Past research on the microchemistry of eel otoliths gives insight in the origin of eels (natural recruits vs. restockings), but the information available is just not adequate to address the effectiveness of restocking (no silver eel was sampled). It is therefore recommended to continue the existing restocking programmes (if affordable), to complete the micro-chemistry analyses, and to reconsider the restockings after.

- The obligation to monitor the eel stock overlaps with monitoring obligations under the Water Framework Directive WFD. WFD monitoring is known to be less informative for eel, but the excessive costs of additional monitoring provide a strong argument to prioritize the optimization of WFD monitoring for eel.
- Monitoring of fisheries requires registration of catch and effort (see above), and sampling of catches. Currently, there is no information on catch compositions. It is recommended to establish a pilot project on catch sampling, which will identify the spatial and temporal variation in catch compositions, and thereby provide a basis for subsequent development of a cost-effective catch-sampling programme.
- Assessment of the impact of fishing and other anthropogenic impacts.
    - For the yellow eel (growing) phase, mortality as a consequence of fishing may be assessed by statistical analysis of catch compositions (length frequencies). In combination with landings statistics (above), this will provide an estimate of the impact of fishing. Mortality by hydropower generation will additionally require the quantification of the amount of eels affected, that is: a quantification of trash rack and turbine mortality. A one-time analysis of hydropower related mortality is required.
    - For the silver eel (return to the ocean) phase, tagging or telemetry studies will be required to estimate the impact of fishing and hydropower generation. Tagging and telemetry studies being rather expensive, initial results can be used to assess the need for subsequent continuation.

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