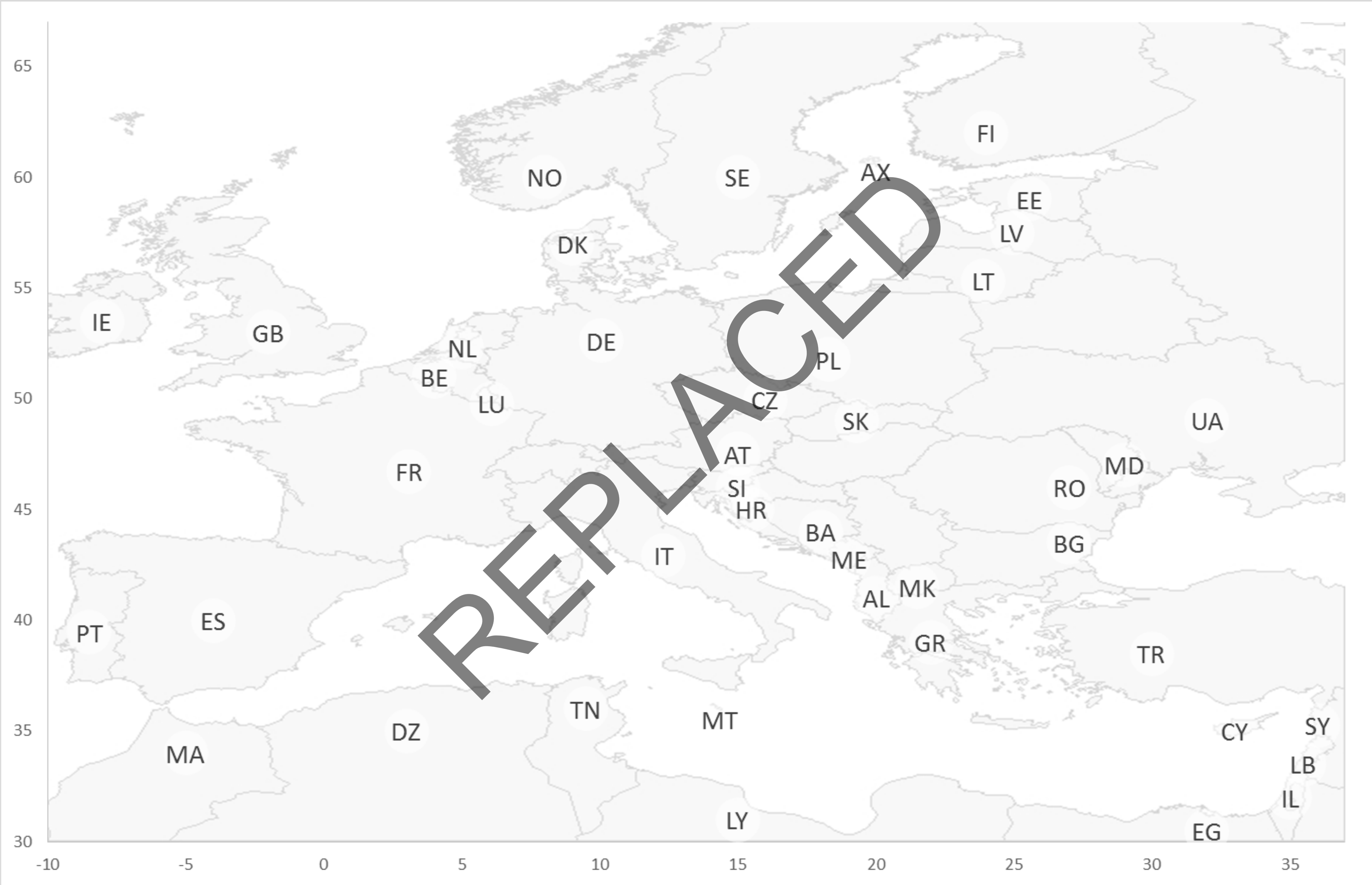
## Stock Annex for the European Eel

Stock-specific documentation of the assessment procedures used by the International Council for Exploration of the Sea (ICES) for European Eel (*Anguilla anguilla*).

| | |
|---|---|
| Stock | European Eel |
| Working group | Joint EIFAAC/ICES/GFCM Working Group on Eel (WGEEL) |
| Last updated | October 2015 |
| Revised by | WGEEL by correspondence: No Stock Annex |
| Timeline of revisions | Development updates: 2016, 2017: 1st Revision 2020 |
| Main modifications | This is the 1st Version of a Stock Annex for Eel |

## Countries involved

| Code | Country | EU/non EU |
|---|---|---|
| NO | Norway | non-EU |
| SE | Sweden | EU |
| AX | Åland | non-EU |
| FI | Finland | EU |
| EE | Estonia | EU |
| LV | Latvia | EU |
| LT | Lithuania | EU |
| RU | Russia | non-EU |
| PL | Poland | EU |
| DE | Germany | EU |
| DK | Denmark | EU |
| NL | Netherlands | EU |
| BE | Belgium | EU |
| IE | Ireland | EU |
| GB | Great Britain | EU |
| FR | France | EU |
| ES | Spain | EU |
| PT | Portugal | EU |
| IT | Italy | EU |
| MT | Malta | EU |
| SI | Slovenia | EU |
| HR | Croatia | EU |
| BA | Bosnia-Herzegovina | non-EU |
| ME | Montenegro | non-EU |
| AL | Albania | non-EU |
| GR | Greece | EU |
| BG | Bulgaria | EU |
| RO | Romania | EU |
| MD | Moldavia | non-EU |
| UA | Ukraine | non-EU |
| GE | Georgia | non-EU |
| TR | Turkey | non-EU |
| CY | Cyprus | EU |
| SY | Syria | non-EU |
| LB | Lebanon | non-EU |
| IL | Israel | non-EU |
| EG | Egypt | non-EU |
| LY | Libya | non-EU |
| TN | Tunisia | non-EU |
| DZ | Algeria | non-EU |
| MA | Morocco | non-EU |
| AT | Austria | EU |
| CZ | Czech Republic | EU |
| SK | Slovakia | EU |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# A. General

## A.1 Introduction

The reports of the joint EIFAAC/ICES/GFCM Working Group on Eel document the ongoing process of describing the stock of the European eel, and associated fisheries and other anthropogenic impacts, and developing a methodology for giving scientific advice on management to effect a recovery in the international, panmictic European eel stock.

The Memorandum of Understanding (MoU) between the EU and ICES requires an assessment of the status of the eel stock every year. As recruitment and landings data are reported to the working group every year, these form the basis of the annual assessment. New national biomass and anthropogenic mortality stock indicators are scheduled to be available in 2015, 2018 and every six years thereafter. These have not, however, been benchmark assessed and are not therefore incorporated yet into the advice.

The Stock Annex for Eel describes the eel stock, the development of eel advice, the management frameworks for eel and the analysis of the recruitment for provision of advice. Chapter A is intended to give an overview of the main features of the eel biology and mortality and is not intended to be exhaustive. Additional source material should be consulted for the detail.

Once the Stock Annex is fully developed (ca. 2017), it is intended that the Annex would be updated on a triennial cycle, with annual descriptions of data inputs, outputs and any deviations from the described protocol being documented within the main WGEEL reports.



## A.2 Advisory and Management Bodies

### ICES

The International Council for the Exploration of the Sea (ICES) is an intergovernmental organization that develops science and advice to support the sustainable use of the oceans. This is advanced through the coordination of oceanic and coastal monitoring and research, and advises international commissions and governments on marine policy and management issues.The ICES area of competence extends into the Arctic, the Mediterranean Sea, the Black Sea, and the North Pacific Ocean with 20 Member Countries (http://www.ices.dk/explore-us/who-we-are/Pages/Member-Countries.aspx).

The content of ICES scientific advice is solely the Advisory Committees (ACOM) responsibility not subject to modification by any other ICES entity. ACOM has one member from each member country, under the direction of an independent chair appointed by the Council, and works on the basis of scientific analysis prepared in the ICES expert groups and the advisory process includes peer review of the analysis before it can be used as basis for the advice. In the case of eel, the relevant expert group is the joint EIFAAC/ICES/GFCM Working Group on Eel.

### EIFAAC

The stated role of the European Inland Fisheries and Aquaculture Advisory Commission, EIFAAC, is to promote the long-term sustainable development, utilization, conservation, restoration and responsible management of European inland fisheries and aquaculture. This should be based on the best available scientific advice, the application of an ecosystem approach, the precautionary approach and the need to safeguard biodiversity. EIFAAC seeks to support sustainable economic, social and recreational activities towards these goals through providing advice, information and coordination, encouraging enhanced stakeholder participation and communication, and the delivery of effective research. The area of competence covers all of Europe, with the exception of parts of the Balkans, together with Turkey and Israel, and has membership from most of the countries including the EU. (See http://www.fao.org/fishery/rfb/eifaac/en#Org-GeoCoverage)

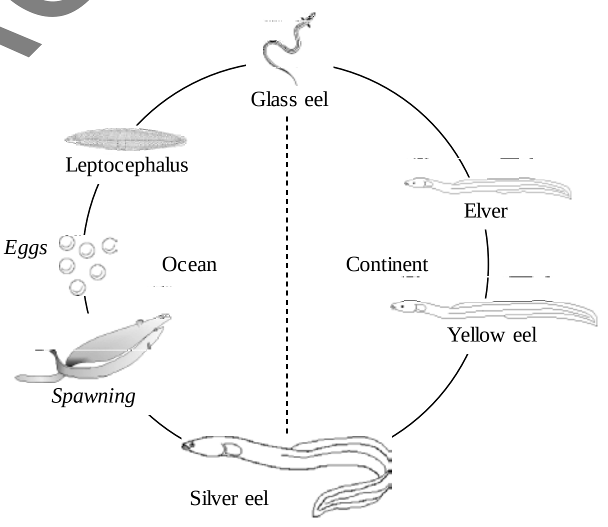
#### GFCM

The General Fisheries Commission for the Mediterranean (GFCM) is a regional fisheries management organization (RFMO) established under the provisions of Article XIV of the FAO Constitution. The GFCM initially started its activities as a Council in 1952, when the Agreement for its establishment came into force, and became a Commission in 1997. The main objective of the GFCM is to promote the development, conservation, rational management and best utilization of living marine resources as well as the sustainable development of aquaculture in the Mediterranean, the Black Sea and connecting waters. Membership is 23 countries and the EU (see http://www.fao.org/gfcm/background/area-of-application/en/ ).



### A.3 Life cycle

European eel life history is complex and atypical among aquatic species, being a long-lived semelparous and widely dispersed stock. The shared single stock is panmictic (Palm *et al.*, 2009) and data indicate the spawning area is in the southwestern part of the Sargasso Sea and therefore outside Community Waters (McCleave *et al.*, 1987; Tesch and Wegner, 1990). The newly hatched *leptocephalus* larvae drift with the ocean currents to the continental shelf of Europe and North Africa where they metamorphose into glass eels and enter continental waters. The growth stage, known as yellow eel, may take place in marine, brackish (transitional), or freshwaters. This stage may last typically from two to 25 years (and could exceed 50 years) prior to metamorphosis to the silver eel stage and maturation. Age-at-maturity varies according to temperature (latitude and longitude), ecosystem characteristics, and density-dependent processes. The European eel life cycle is shorter for populations in the southern part of their range compared to the north. Silver eels then migrate to the Sargasso Sea where they spawn and die after spawning, an act not yet witnessed in the wild. (ICES, 2014b).




**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 and are therefore only tentatively included.** (Diagram: Willem Dekker).

### A.4 Range

The European eel (*Anguilla anguilla*) is distributed across the majority of coastal countries in Europe and North Africa, with its southern limit in Mauritania (30°N) and its northern limit situated in the Barents Sea (72°N) and spanning all of the Mediterranean basin (ICES, 2014b; Figure A-1). The spawning area in Sargasso Sea is thought to be situated quite narrowly between latitudes 23° and to 29.5°N but on a wider longitudinal range from 48° to 78°W (McCleave *et al.*, 1987; Tesch and Wegner, 1990). At the continental scale, eels have a wide and scattered distribution and are found in virtually all types of water bodies from rivers and lakes to estuaries and coastal waters. Its distribution area is estimated to be at ca. 90 000km$^2$ (Moriarty and Dekker, 1997; Dekker, 2009).

It is not known what areas contribute to successful spawning or to what degree and, therefore, it is not possible to determine the number of age groups that contribute successfully to the spawning effort. It seems likely that a considerable number of year classes contribute each year.

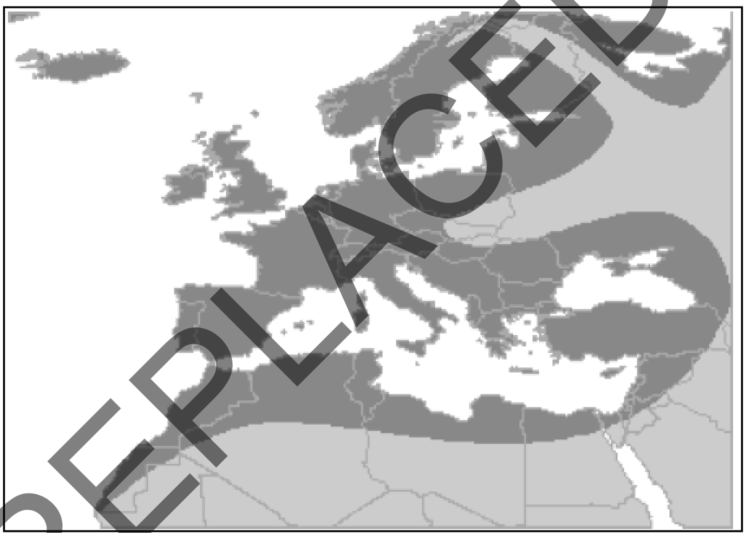




**Figure A-1. The distribution area of European eel (Moriarty and Dekker, 1997).**

### A.5 Size and age

Eels are a long-lived species with the yellow eel stage lasting 2–20 years for males or 5–50 years for females (Dekker, 2002). According to Vøllestad (1992), mean length and age at the silvering differs significantly between males (405.6 mm; 5.99 years respectively) and females (623.2 mm; 8.73 years). However, when compared to other fish, growth is slower, usually 3–4 cm a year (Dekker, 2002). Annual growth be as low as 1 cm a year or less in the northern areas (e.g. Poole *et al.*, 1992; 1996a,b; J. D. Godfrey, personal communication) and up to 15 cm a year in the more southern areas. (Dekker, 2002). Mean length of the female silver eel increases with latitude while the same relationship for males is absent (Figure A-2, left) and there is also an increase in age with latitude (Figure A-2, right; ICES, 2010b).

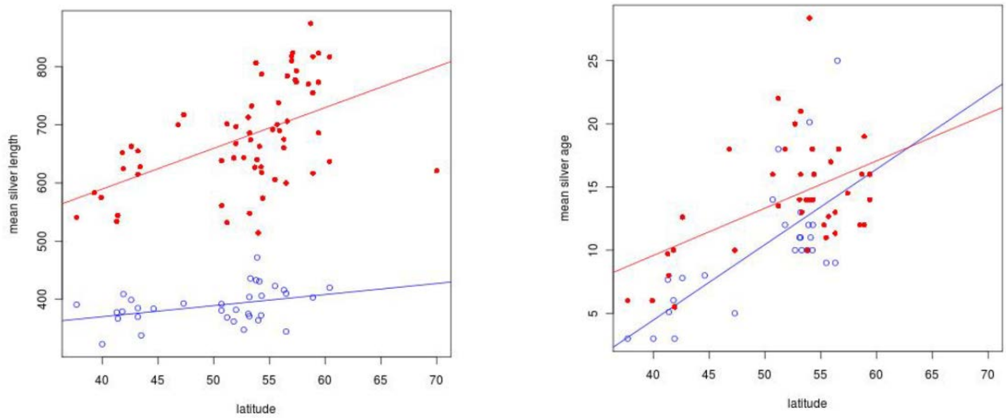



**Figure A-2. Left Graph: Mean silver eel length according to latitude from twelve different countries (66 different locations), blue: male; red: female) (ICES 2010b): Right Graph: Mean silver eel age according to latitude from twelve different countries, blue: male; red: female (ICES 2010b).**

## A.6 Natural mortality

There are hardly any empirical data on natural eel mortality available. A value of M=0.1386 $yr^{-1}$ is frequently applied, giving Dekker (2000) as a reference, even if Dekker only assumed that value to be an empirically sound level of mortality rate.

Recently, Bevacqua *et al*. (2011) calibrated a general model for natural mortality for the post-settlement yellow eel stage, considering the effects of body mass, temperature, stock density and gender. Results showed eel mortality values appreciably lower than those of most fish, most likely due to the exceptionally low energy consuming metabolism of eel. These findings have been recently confirmed by Dekker (2012) who found that natural mortality on Swedish restocked eels has been much lower than the usual estimates (M=0.10 $yr^{-1}$) (ICES, 2012b).

## A.7 Fisheries

Fisheries have taken place over the whole geographic range, and most often occur as scattered small-scale rural enterprises (Dekker, 2004). Eel are traded both locally and internationally. Total landings and effort data are incomplete. There is a great heterogeneity among the time-series of landings because of inconsistencies in reporting by, and between, countries, as well as incomplete reporting. Changes in management practices have also affected the reporting of non-commercial and recreational fisheries. Figure A-3 presents the total landings for all life stages as reported by countries to the WG.

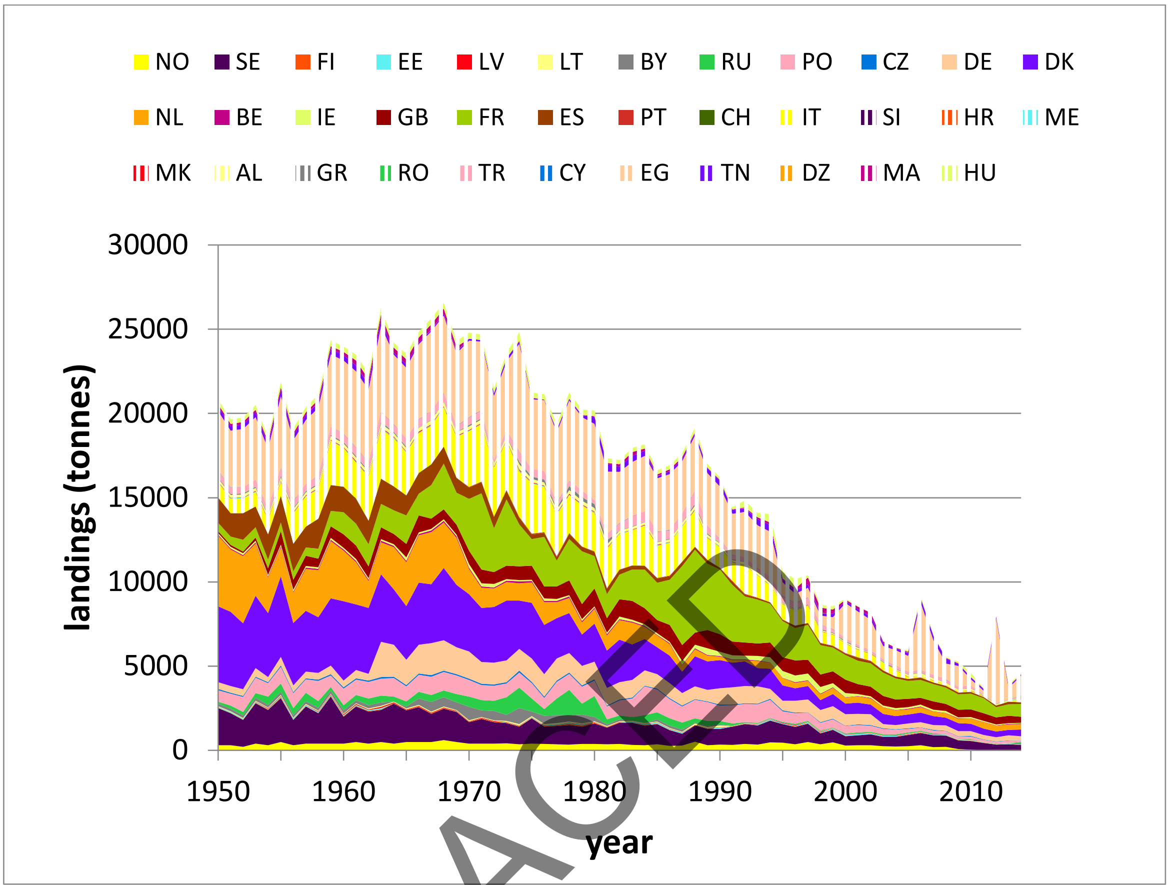





**Figure A-3. Total landings (all life stages) from 2013 Country Reports (not all countries reported); the corrected trend has missing data filled by GLM (ICES 2013b).**

### A.7.1 Glass eel fisheries

The glass eel fisheries are mainly concentrated around SW England, the Bay of Biscay area (Dekker, 2003) and along the Mediterranean coasts of Spain and Italy (ICES, 2012b). Being executed in the estuaries and river mouths, these fisheries capitalize on the natural concentration of glass eels in the area (Dekker, 2003). The exploitation of glass eels takes place in winter and early spring when they arrive on the European coast. The glass eel fishing gear consists of both active and passive gears. The active gear includes different hand-held or ship-borne nets while passive gear is composed of traps and fykenets kept fixed in a stream (Dekker, 2002). The glass eels caught are used for stocking, aquaculture or local consumption (ICES, 2013b). The EU Regulation (Article 7.1) states that 60% of the eels less than 12 cm in length caught annually should be reserved for stocking.

### A.7.2 Yellow eel / Silver eel fisheries

Yellow and silver eel fisheries have been located all over the distribution area of the species, from the Mediterranean basin to northern Scandinavia (Dekker, 2003), with some countries having reduced or closed their fisheries in response to the EU Regulation. Historically the biggest landings have been reported from the northern part of the distribution area with an exception of Spain and Italy in the Mediterranean. Various types of gear are used in the yellow and/or silver eel fisheries, including different nets, traps, hooks, etc. in both salt- and freshwater (Dekker, 2003). The eel fisheries, located in the coastal and rural areas all over Europe are rather small-scaled making up less than 5% of the total European catch (Dekker, 2002). According to Moriarty and Dekker (1997) these fisheries employed thousands of people across Europe in the 1990s but the number is declining since. In many of the European countries yellow and silver eels are not distinguished in the reported catch (ICES, 2014b). Directed fisheries for silver eel in coastal waters are specific to the Baltic/Kattegat, where poundnets are used (Dekker, 2003). As the eel densities are low in the northern areas (25 eels/km$^2$ of land surface), the fishery is concentrated on the emigration period in the late summer and autumn when most of the silver eel is exploited. In contrast, yellow eel fisheries are established in Middle Europe where eel densities per km$^2$ of land surface are much higher (400 eels/km$^2$; Dekker, 2003). Yellow and silver eel caught are mainly sold for consumption, either locally or after export to neighbouring countries, in mostly within the EU (ICES, 2015).

#### A.7.3 Recreational fisheries

In many EU countries, recreational fishery contributes significantly to the total catch. The gear might consist of rod-and-line as well as longlines and nets or traps. Usually a licence or permit is required to be able to fish recreationally, however there are countries where the access to the fishery is free or based on private ownership (Dekker, 2005). Data on recreational fisheries are collected but the inconsistencies in reporting make assessment unreliable (ICES, 2014b).



### A.8 Other anthropogenic mortality

In addition to fisheries, other forms of anthropogenic mortality exert considerable pressure on the eel stock. These anthropogenic mortalities can be quantified and applied in the reporting of silver eel production, escapement and mortality under the requirements of the EU Regulation (see Section C-3). Obstacles to migration in river systems are one of several factors that cause considerable mortality and are likely to have contributed to the dramatic decline in the eel population.  All continental life-history stages of eel can be impacted by different types of barriers and obstacles. Juvenile eels may be obstructed in their upstream migrations, increasing density-dependence in the downstream areas. Silver eels, and large yellow eels in some locations, can be delayed in downstream migration due to river discharge regulation, often leading to changed behaviour and increased predation, and are likely to experience significant mortality rates associated with passage downstream through power generation facilities.  Pumping stations associated with water level control and cooling water intakes are also often associated with yellow and silver eel mortality.

Fish passes are often used as an engineered mitigation measure for reducing impacts on fish, although many studies show that fish passes are not available, not effective or not working at all.

#### A.8.1 Hydropower installations

Hydropower has been recognized as one of several factors contributing to the decline in the eel population (ICES, 2002), and eels tend to have considerably greater mortality rates from downstream passage at hydropower stations than other fish species (Hadderingh and Bakker, 1998). Mortality and injury due to hydropower stations can occur at inadequate deflection screens, in turbines and in the tail races. The rate of injury depends on the position of the turbine in the river bed (eels migrate in the main current), the working regime (switching off the turbine during the main migration period reduces the damages), the efficacy of the protection screen, the turbine type, the water flow rate, the head height, characteristics of the turbine and the presence and location of spillways.

Mortality rates when passing a hydropower station also depend on 1) the proportion of eel moving into the power station intake, 2) the mortality rate of those moving into the power station (turbine mortality, impingement on the trash rack, etc.), and 3) the mortality rate of those using alternative routes (bypass channels, old river bed, etc.). Mortality estimates of downstream migrating eels from hydropower are given in Table A-1. The table summarizes field studies from several eel species (*A. anguilla*, *A. rostrata*, *A. dieffenbachii* and *A. australis*). It should be noted that in many rivers there are multiple hydropower installations and consequently there are cumulative mortalities summing up to considerable mortality rates in such rivers.

The most comprehensive estimation comes from a study (Gomes and Larinier, 2008) that developed mortality predictive equations based on body length of eels, turbine diameter, nominal discharge and blade velocity for Kaplan turbines. According to this model based on 71 field studies, damage rate increases with fish length and is generally higher on small turbines with high rotation speeds than on slow, large diameter turbines. Damage is also lower at full opening compared to reduced opening (Gomes and Larinier, 2008).



**Table A-1. Mortality estimates of eel at hydropower generating plants according to type of turbine and presence of a mitigation system (bypass, fish- friendly turbine). The number of studies used to calculate the average mortality rates is given in brackets (from ICES, 2011). Note, there is no direct correspondence between the two columns.**

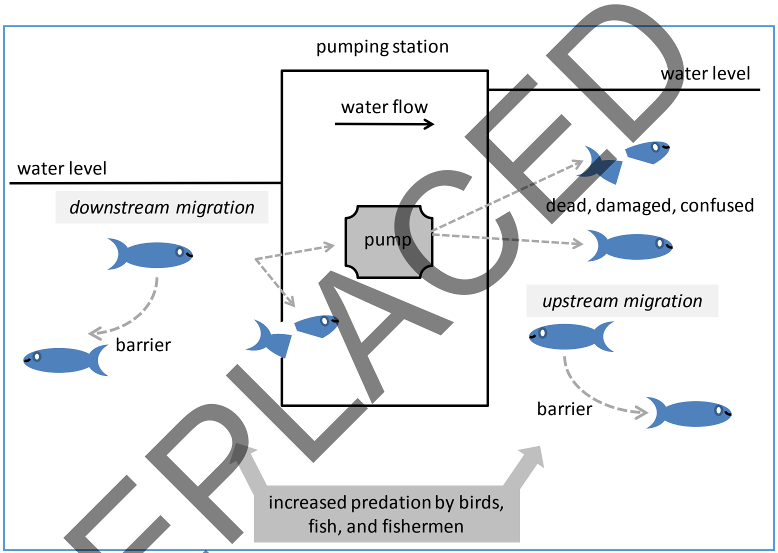
| | Turbine mortality % | Total mortality % |
|---|---|---|
| Average (all turbines) | 28 (29) | 36 (10) |
| Average francis | 32 (7) | 52 (3) |
| Average kaplan | 38 (9) | 28 (6) |
| Average other turbines (mix, propeller, unknown) | 21 (11) | 40 (1) |
| Average no bypass or unknown | 32 (24) | 44 (6) |
| Average with bypass | 9 (5) | 26 (4) |

### A.8.2 Pumping stations

Pumping stations can negatively influence fish and fish migration as illustrated in Figure A-4 In the first place pumping stations can cause damage and direct or delayed mortality in fish when passing through a pump. Secondly, a pumping station functions as a barrier for migration of diadromous fish like eel, both during upstream and downstream migration. Thirdly, pumping stations will increase the predation risk to fish. Damaged and confused fish will be easier to prey on by piscivorous fish or birds. The risk of being captured by commercial or recreational fishermen is higher in the vicinity of pumping stations when migratory fish aggregate while searching for an opportunity to pass. Various factors, such as pump and propeller type, head of water, capacity and timing of operation are all known to influence the level of impact on eel (ICES 2011) and some impact estimates are summarised in Table A-2. Buysse *et al*. (2014) demonstrated that propeller pump and Archimedes screw pumps cause eel mortality in lowland canal situations and therefore may significantly threaten escapement targets set in Eel Management Plans. Buysse *et al*. (2015) assessed maximum mortality rates ranging from 19 ± 4% for the large de Wit Archimedes screw pump, to 14 ± 8% for the small de Wit Archimedes screw pump, based on the condition of the fish and injuries sustained over a 12-month period (2012–2013).

**TableA-2. Mortality estimates of eel passing through pumping stations of various types. The number of studies used to calculate the average mortality rates is given in brackets (summarised from ICES, 2011). Some additional mortality consequent on undetected internal injury may have occurred in a few studies. Note, there is no direct correspondence between the two columns.**

| | Damaged % | Mortality % |
|---|---|---|
| Average (all pumps) | 30 (18) | 26 (27) |
| Average Water wheel | 0 (1) | 0 (1) |
| Average Archimedes | 12 (4) | 5 (7) |
| Average Centrifugal | 1 (3) | 13 (4) |
| Average Turbine-Archinmedes | 0 (1) | 0 (1) |
| Average Propeller-Centrifugal | - | 11 (2) |
| Average Propeller | 60 (8) | 60 (9) |
| Average Propeller (closed) | - | 35 (2) |
| Average Hidrostalpump | <3 (1) | 0 (1) |




**FigureA-4. Impacts of pumping stations on fish and fish migration (redrawn from STOWA, 2010).**



### A.8.3 (Cooling) water intakes

Intakes used for water supply represent another anthropogenic threat to aquatic ecosystems and fish stocks. When water is abstracted from surface water bodies, there is a risk that fish and other organisms will be drawn in. This may prevent fish from migrating effectively and lead to death or injury to fish at screens, turbines and pump mechanisms (Environment Agency UK, 2011). Eels can get caught up in intake flows and screens at any stage of their life. However, they are most at risk during their upstream and downstream migrations within freshwaters (Environment Agency UK, 2011). The degree of risk or damage is highly site-specific and depends largely on the actual conditions at each location (e.g. type of power plant or technical facility in general, capacity of water intake, configuration and design of mitigation measures including screens and behavioural deterrent systems, biological characteristics of the potentially impacted species). It should also be noted that outfall sources can also divert and delay eel migrations leading to additional mortality.

*Intakes*

Adult silver eels are particularly vulnerable when they actively follow currents downstream ('positive rheotaxis').

Glass eel and elvers are also at risk when they have to pass areas with intakes, which sometimes have enormous capacities for water intake.

*Outfalls*

Juveniles (glass eels, elvers or smaller yellow eels) are more at risk during active migration upstream ('negative rheotaxis').

### A.8.4 Mitigation measures

To reduce the negative effects of hydropower turbines, pumping stations, water intakes and other technical constructions, several approaches for mitigation measures exist:

- Bypass & deflection
- Mechanical barriers (e. g. trash racks, leader nets)
- Electrical barriers (usually small scale)
- Light screens
- Bubble screens
- Sound and Infrasound
- Turbine management
- Trap & transport of silver eels

A comprehensive description of problems and possible solutions has been given by the Environment Agency (EA, 2011, "The Eel Manual"). Also, several reports of the Working Group on Eels provide more detailed information on the issue (e.g. ICES 2003, 2007, 2011).



## A.9 Stocking

In several European countries, stocking of eels has long been practised in eel fishery management. Stocking has involved different sizes of eels: glass eels, ongrown eels (approximately 2–10 g) or young yellow eels (wild-caught small juveniles). Until recently, stocking has been used primarily as a tool to enhance fisheries, with little focus on successful spawner escapement. Given the present low and declining status of potential spawning stock, on a Europe-wide scale, the enhancement of spawning stocks is a more pressing requirement than supporting fisheries. WGEEL reports (2006, 2007, 2008 and 2009) have commented extensively on stocking theory and practical approaches to stocking based on manuals and reports (Williams and Aprahamian, 2004; Symonds, 2006; Williams and Threader, 2007). Stocking is listed as one management option in the Regulation (EC) 1100/2007 ("Eel Regulation") and is a management measure in many EMPs.

Several essential preconditions have been mentioned, first that demonstrable surplus should exist in some local (donor) glass eel stocks and that anthropogenic mortality in the recipient areas is minimized. The potential risks involved have been discussed (ICES, 2011). Some of the issues were:

- The risk of altering genetic aspects of eel stocks.

- The risk of spreading of disease and parasites.
- Potential effects on sex ratio in recipient waters.
- Potential problems in homing ability of eels translocated to distant water bodies (Westin, 2003; ICES, 2006; Westerberg *et al*., 2014).

There is now evidence that translocated and stocked eel will produce eel which grow to yellow and silver, and will attempt to migrate. An extensive review of this subject was carried out by Wickström *et al*. (2010).

When stocking to increase silver eel escapement and thus aid stock recovery, an estimation of the prospective net benefit should be made prior to any stocking activity. ICES (2011) examined the potential net benefit of translocating glass eels using the TRANSLOCEEL model. Four scenarios were calculated, and the only situation which resulted in an increase numbers of glass eel produced in the long term, was when the glass eel are left *in situ*, and the corresponding mortality is reduced. All other situations lead, at best, to a stabilization of the population. It was concluded that, in reality, a net benefit of restocking for the whole stock will be difficult to achieve.



Giving priority to the recovery of the European stock, the objective of any stocking exercise should be to maximize net benefit to the stock as a whole until clear signs of recovery. However, stocking with an element of fishery support, combined with maintaining some spawner escapement, is not excluded in the EU Regulation. Given the current assessment of the overall stock, stocking, where it occurs, should be in conjunction with reductions in fisheries (yellow and silver) mortality and other direct mortalities (e.g. turbine, pumping stations) affecting the stocked eels. Stocking should not be seen as a substitute for reducing mortality, but as an additional measure.

Data on the amount of stocked glass eel and young yellow eel are provided and updated annually in the WGEEL reports. Note that various countries use different size and weight classes of young yellow eels for stocking purposes. Figures A-5 and A-6 provide an overview of quantities stocked.

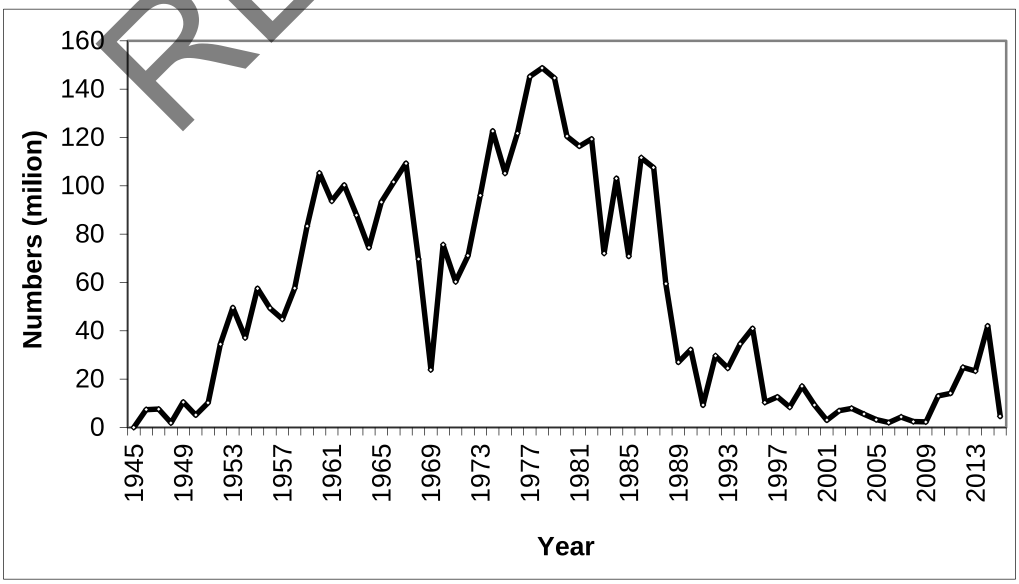



**Figure A-5. Reported stocking of glass eel in Europe (Sweden, Finland, Estonia, Latvia, Lithuania, Poland, Germany, the Netherlands, Belgium, Northern Ireland, Spain, Greece, France (no data before 2010)) in millions stocked (1945–2014).**

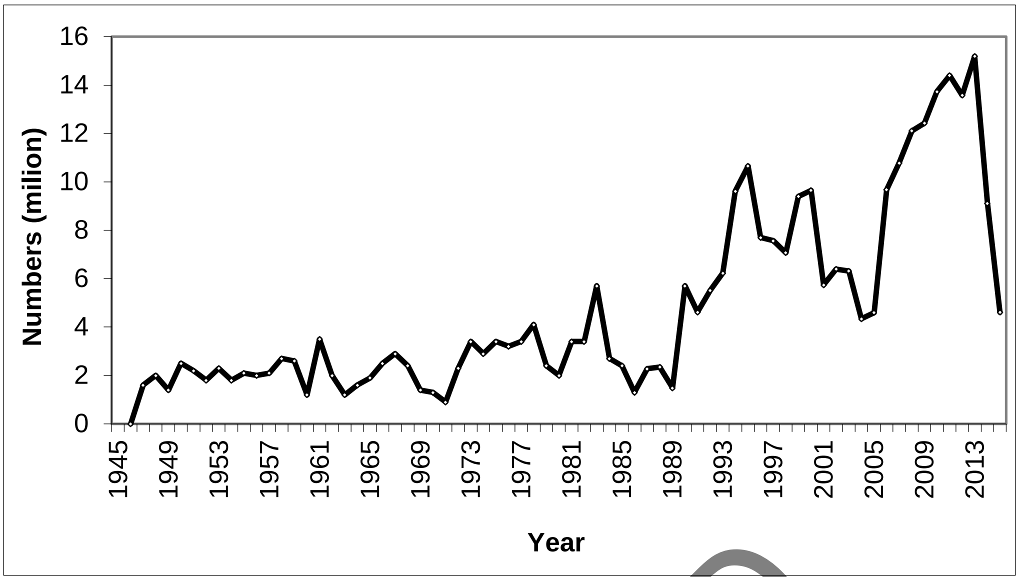



**Figure A-6. Reported stocking of young yellow eel in Europe (Sweden, Finland, Estonia, Latvia, Lithuania, Poland, Germany, Denmark, the Netherlands, Belgium, and Spain), in millions stocked (1945–2014).**



## A.10 Production/escapement

Eels are semelparous and undergo a final seaward spawning migration (Section A-3). The silver eel 'run' is composed of multiple year classes and variable sex ratios that differ between locations. The mechanism behind the silvering process from yellow eel to seaward migrating silver eel is poorly understood and production (numbers or biomass) of silver eel is likely to be related to a combination of stock density and location growing conditions. During their migration silver eels are affected by inland and coastal fisheries, and by a variety of anthropogenic factors such as hydropower turbines, pumps etc. (See Section A-8) leaving a final escapement to the ocean. It is this escapement ($B_{current}$) relative to pristine production ($B_o$) that is required to be quantified under the EU Regulation (Section C-3).

## A.11 Eel quality

Recently there has been a growing awareness that spawner quality might be an essential element in the decline of the species and may also hinder a recovery. 'Quality' is considered as the 'quality of spawners' describing the capacity of silver eels to reach spawning areas and to produce viable offspring (ICES, 2006). Getting a comprehensive overview of the quality (including contamination levels, biomarker responses, lipid content and condition) of the silver eel population all over Europe seems to be an essential and urgent objective for the management of European eel. However, the challenge on incorporating eel quality into the assessments remains. The WKPGMEQ (ICES, 2015) defined a number of eel quality indicators and advised on harmonised methods to measure eel quality.

### A.11.1 Diseases, parasites and contaminants

Infestation of the introduced swimbladder nematode *Anguillicola crassus* (Kuwahara, Niimi and Itagaki 1974), now widespread across Europe, may affect the capacity of European eels to complete their spawning migration (Palstra *et al.*, 2007). Various diseases are known to affect eel, but the most important are probably the viruses, Anguiilia herpesvirus 1 (AngHV-1), Eel Virus European (EVE) and other aquabirna viruses (IPNV) and Eel Virus European X (EVEX) (ICES, 2015).

A variety of contaminants have been found to affect the eel and impacts were reported on several levels of biological organization from subcellular, organ, individual up to even population level. The toxic effects can occur at different moments in eel's life cycle: during growing, silvering, migration, the development of reproductive cells, and larval stage (Geeraerts and Belpaire, 2010). Contamination (e.g. by PCBs) might impair fertility (Palstra *et al*., 2006) and affect lipid metabolism resulting in insufficient energy reserves to power successful migration and reproduction (Belpaire *et al*., 2009). Sühring *et al*. (2015) found evidence that persistent organic pollutants such as PBDEs, as well as their brominated and chlorinated substitutes are redistributed from muscle tissue to gonads and eggs. Freese *et al*. (2015) found habitat-dependent and life-history stage-related accumulation of several PCB's, leading to the conclusion that that the contamination status of water systems is fundamental for the life cycle of eels and needs to be considered in stock management and restocking programmes.

Brinkmann *et al*. (2015) developed a physiologically based toxicokinetic model to predict the uptake and distribution of water-borne organic chemicals in the whole fish and in different tissues at any time during exposure. The authors conclude that this model has the potential to help identify suitable habitats for restocking under eel management plans.

Most reports deal with the yellow eel stage and a wide range of effects have been demonstrated. However, in the yellow eel phase, the effects are apparently less harmful, because contaminants are stored in lipid tissue while growing. It is assumed that most toxic effects start to harm during the silvering phase, when morphological and physiological changes take place initiated by hormonal changes. Meanwhile, fat is being metabolized, resulting in a remobilization of the live-long accumulated contaminants. Eels are more vulnerable to pollution than many other fish as they accumulate contaminants to a much higher degree (Belpaire and Goemans, 2008). However, many gaps in our knowledge remain, especially concerning the impacts (dose-effect relationships) of contaminants and diseases on migration and reproduction success of the European eel.



#### A.11.2 Condition/energy

There are indications that poor condition of silver eels migrating to the oceanic spawning grounds might be another factor in explaining the stock decline. Large amounts of work have examined the lipid levels needed for eels to successfully migrate to the Sargasso Sea and varying thresholds (% total body lipid content) have been proposed; that at least 13% lipid is necessary for swimming (Belpaire *et al*., 2009) and additional reserves are required to complete maturation. As such, it's proposed that minimal fat levels of 20% are required to support migration and reproduction (van den Thillart *et al*., 2007).

#### A.11.3 Eel quality database

An international Eel Quality Database, EQD, has been initiated by ICES WGEEL (Belpaire *et al*., 2011) and further developed at Instituut voor Natuur- en Bosonderzoek by Belgium (INBO). It allows the compilation of contaminant and disease data in anguillids over the world, combined with relevant habitat parameters. The database integrates data of contaminants (PCBs, pesticides, heavy metals, brominated flame retardants, dioxins, PFOS), diseases and parasites (such as *A. crassus*, bacteria, and viruses such as EVEX and other lesions) and condition (i.e. fat content). However, the long-term management of the EQD needs a structural basis and is currently hampered by insufficient resources. ICES (2009a) suggested that the EQD should be managed at an international level (e.g. by ICES DataCentre) or some European agency, with long-term funding options and database management expertise.

### A.12 Oceanic effects

Besides anthropogenic factors acting during the continental life stages of eel, climatic and oceanic factors are also known to influence population development.

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 steep decline in recruitment between 1980 and 1983 and the failure for this to recover in the following years cannot be easily explained by oceanic factors alone and is out of phase with the NAO. The causal link between climate and recruitment strength is unknown, as is 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 are 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.

Continual climate and ocean warming in the last decades has probably overridden the effect of the NAO (WGEEL, 2008; Table A-2). However, the potential importance of oceanic factors was examined by Hanel *et al*. (2014). Their recent study in the Sargasso Sea revealed that the relative abundances of European eel and American eel, *Anguilla rostrata*, leptocephali were much lower in 2011 than in 1983 and 1985 when compared to catches of other common leptocephali. The overall leptocephalus community was rather similar to previous studies. This indicates that decreased recruitment originates within the spawning area and likely is due to not just the processes during the migration to the continents.

**Table A-4. Oceanic parameters and their putative effects on eels, (source Report WG Eel 2008 updated for 2010).**

| 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 progressive northerly position of the Gulf Stream. Impacts larval migration. | Dekker, 2004; Durif *et al.*, 2010 |
| Sargasso Sea Sea Surface Temperatures (SS-SST), average 0-100 m deep | Marine production increases with sea surface temperature in the cooler waters from the North Atlantic but decreases in warmer waters. This effect is due to a reduced vertical mixing. Impacts larval feeding. | Bonhommeau *et al.*, 2008; Durif *et al.*, 2010 |
| 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. Impacts larval migration. | Friedland *et al.*, 2007 |
| Mean Temperature of the northern hemisphere (NHT) | Would reflect climate change and extrapolate primary production. Impacts larval feeding. | Knights and Bonhommeau, unpublished |
| Gulf Stream Index (GSI) | Latitude of the Gulf Stream, from monthly charts of the north wall. Impacts larval migration | 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. Impacts larval migration | Bonhommeau, 2008 |
| PP (Bermuda biological station, North of spawning area) | Primary production. Considered as a good proxy for leptocephali food. Impacts larval feeding. | Bonhommeau, 2008; Riemann *et al.*, 2010 |
| Sea surface temperatures anomalies (SSTA) | Food availability expected to be reduced during warm high SSTA periods due to reduced spring mixing, nutrient recirculation and productivity. Impacts larval feeding | 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. Impacts larval migration. | Friedland *et al.*, 2007; Munk *et al.*, 2010 |

# B Development of Eel Advice

## B.1 History of the Working Group

The Working Group on Eel has been to the forefront of many research and development activities on eel since the 1960s, with main publications produced under various fora including the FAO Occasional Papers and Reports. Noting the decline in landings and stock, and the alarming deterioration in recruitment, from the mid-1990s the Working Group played a leading role in raising awareness of the seriousness of the situation, in developing the framework on which the Regulation was built, in providing encouragement and support at the international level and in support and development for the monitoring, assessment and reporting for the recovery of the eel stock.

The following provides a chronology of the WGEEL activities. In 1968, EIFAC held a plenary session in Rome following considerable international interest in eels, with a decline in the landings noted and stocking being proposed as a mitigation measure. In 1970, EIFAC organized a first meeting, on the development of eel fishing gear (Hamburg); in 1974 a second EIFAC meeting in Dublin; In 1976, a joint ICES/EIFAC working group was convened and a symposium, which led to working group meetings to examine available data such as landings and recruitment.

By 1981, it was realized that the data were inconsistent and incomplete and the Working Groups lost impetus. EIFAC continued the interest in eel by undertaking biennial working parties which included some collation of annual data, such as recruitment time-series. These continued until 1996, when EIFAC and ICES joined their forces on eel again. During this time (1985) it was noted that there was a widespread decline in recruitment since 1980 and by 1993 that the recruitment decline had lasted for a generation, and thus was affecting spawner production. This prompted renewed concerns and following the establishment of the joint ICES/EIFAC WG in 1994 ICES issued advice that the eel stock needed protection and that fishing pressure should be reduced.

A further Working Group meeting in 1999 initiated renewed data collection and examined the trends in recruitment, landings, stocking, etc. Causes for the decline could not be identified although fisheries, habitat loss, hydropower and ocean change were likely involved. The contents for a possible recovery plan were proposed.

Since 2001, the joint EIFAC/ICES Working Group has met annually with advice provided within the EU ICES MoU framework which was amended to specifically include eel. The collation of data was improved with the introduction of Country Reporting following the 2002 WG meeting. Intense activity during the period 2003 to 2007 supported the EU in the establishment of the EU Regulation for Stock Recovery with the EU issuing the first plan in 2003 and the Official version in 2006, ratified in 2007 (Annex, SA3).

From 2006 the WG has focused on: continuing the collation of time-series data, providing support for local stock assessments and the determination of the local stock indicators (Biomass, mortality), on developing an international framework for post-evaluation of the Regulation and on developing an international stock assessment for the development of Biological Reference Indicators in support of provision of stock and mortality advice.

In 2014 in response to the need for a stock-wide recovery and to fill non-EU gaps in the data for the international stock assessment, the General Fisheries Commission for the

Mediterranean (GFCM) entered into a joint MoU with EIFAAC and ICES for a joint EIFAAC/ICES/GFCM Working Group on Eel.

### B.2 Development of the ICES Advice

Since 1998 (ICES, 1999 through to ICES, 2010), ICES has given advice[1] that the stock has shown a long-term decline; that fishing and other anthropogenic impacts should

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[1] ICES, 1999 (advice) advised "The eel stock is outside safe biological limits and the current fishery is not sustainable. (…) Actions that would lead to a recovery of the recruitment are needed. The possible actions are 1) restricting the fishery and/or 2) stocking of glass eel."

ICES (2000) (advice) recommended "that a recovery plan should be implemented for the eel stock and that the fishing mortality be reduced to the lowest possible level until such a plan is agreed upon and implemented."
ICES (2001) (advice) recommended "that an international rebuilding plan is developed for the whole stock. Such a rebuilding plan should include measures to reduce exploitation of all life stages and restore habitats. Until such a plan is agreed upon and implemented, ICES recommends that exploitation be reduced to the lowest possible level."
ICES (2002) (advice) recommended "that an international recovery plan be developed for the whole stock on an urgent basis and that exploitation and other anthropogenic mortalities be reduced to as close to zero as possible, until such a plan is agreed upon and implemented. […] Exploitation, which provides 30% of the virgin (F=0) spawning stock biomass is generally considered […] a reasonable provisional reference target. However, for eel a preliminary value could be 50%."
ICES (2006) (advice) advice read: "An important element of such a recovery plan should be a ban on all exploitation (including eel harvesting for aquaculture) until clear signs of recovery can be established. Other anthropogenic impacts should be reduced to a level as close to zero as possible."
ICES (2008a) (advice) concluded "There is no change in the perception of the status of the stock. The advice remains that urgent actions are needed to avoid further depletion of the eel stock and to bring about a recovery."
ICES (2009) (advice) reiterated its previous advice that "all anthropogenic impacts on production and escapement of eels should be reduced to as close to zero as possible until stock recovery is achieved".

ICES (2010c) (advice) reiterated its previous advice that "all anthropogenic mortality (e.g. recreational and commercial fishing, barriers to passage, habitat alteration, pollution, etc.) affecting production and escapement of eels should be reduced to as close to zero as possible until there is clear evidence that the stock is increasing."

ICES (2011 advice) and ICES (2012 advice) reiterated its previous advice that "all anthropogenic mortality (e.g. recreational and commercial fishing, hydropower, pollution) affecting production and escapement of eels should be reduced to as close to zero as possible until there is clear evidence that both recruitment and the adult stock are increasing. "ICES (2013 advice) once more advised "that all anthropogenic mortality (e.g. recreational and commercial fishing, hydropower, pollution) affecting production and escapement of silver eels should be reduced to as close to zero as possible, until there is clear evidence of sustained increase in both recruitment and the adult stock."

be reduced; that a recovery plan should be compiled and implemented; that preliminary reductions in mortality to as close to zero as possible are required until such a plan is implemented, until stock recovery has been achieved, until there is clear evidence that the stock is increasing, that both the recruitment and adult stock are increasing, and of sustained increase in both recruitment and the adult stock.

ICES (2002) discussed a potential reference value for spawning–stock biomass: "a precautionary reference point for eel must be stricter than universal provisional reference targets. Exploitation, which provides 30% of the virgin (F = 0) spawning–stock biomass is generally considered to be such a reasonable provisional reference target. However, for eel a preliminary value could be 50%." That is: ICES advised to set a spawning-stock biomass limit above the universal value of 30%, at a value of 50% of $B_0$. ICES (2007) added: "an intermediate rebuilding target could be the pre-1970s average SSB level which has generated normal recruitments in the past."

ICES has not advised on specific values for mortality-based reference points, but the wordings "the lowest possible level" and "as close to zero as possible" imply that the mortality limit should be set close to zero. Over the years, the implied time frame for this advice has changed from "until a plan is agreed upon and implemented", to "until stock recovery is achieved" and "until there is clear evidence that the stock is increasing". The first and third phrases are more interim precautionary mortality advice than clear reference points.

# C. Management frameworks for Eel

## C.1 EU Regulation 1100/2007

The EC Regulation (Council Regulation 1100/2007) for the recovery of the eel stock required Member States to establish eel management plans for implementation in 2009 (see Annex 3). Under the EC Regulation, MSs should monitor the eel stock, evaluate current silver eel escapement and post-evaluate implemented management actions aimed at reducing eel mortality and increasing silver eel escapement. Under the Regulation, each Member State shall report to the Commission initially every third year until 2018 and subsequently every six years. The first report was due by 30th June 2012.



## C.2 ICES Advice on Reference Limits

The objective of each eel management plan shall be to 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. That is: a limit is set at an escapement ($B_{current}$) of 40% of $B_o$, in-between the universal level and the more precautious level advised. It is noted that neither an explicit time frame nor a short-term mortality limit were set in the Regulation.

Because current recruitment is generally far below the historical level, a return to the limit level is not to be expected within a short range of years, even if all anthropogenic impacts are removed (Åström and Dekker, 2007). The Eel Regulation indeed expects to

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ICES (2014 and 2015 advice) advised "that all anthropogenic mortality (e.g. recreational and commercial fishing, hydropower, pollution) affecting production and escapement of silver eels should be reduced to, or kept as close to, zero as possible.

achieve its objective “in the long term”, but it does not specify an order of magnitude for that duration. Noting the general objective to protect and recover the European eel stock, we conclude that a further deterioration of the status of the stock should be avoided, which implicitly sets an upper limit on anthropogenic mortality (in the order of magnitude of $\Sigma A = 0.92$, see below).

The 40% biomass limit of the Eel Regulation applies to all management units, without differentiation between the units. Whether or not that implies that the corresponding mortality limit ($\Sigma A = 0.92$) also applies to all units or not, is unclear. However, since it is unknown whether or not all areas contribute to successful spawning, a uniform mortality limit for all areas will constitute a risk-averse approach (Dekker, 2010).

### C.3 Eel Reporting/Stock Indicators

The Regulation sets reporting requirements (Article 9) such that Member States must report on the monitoring, effectiveness and outcomes of EMPs, including the proportion of silver eel biomass that escapes to the sea to spawn, or leaves the national territory, relative to the target level of escapement; the level of fishing effort that catches eel each year; the level of mortality factors outside the fishery; and the amount of eel less than 12 cm in length caught and the proportions utilized for different purposes.

These reporting requirements were further developed by the Commission in 2011/2012 and published as guidance for the production of the 2012 reports. This guidance added the requirement to report fishing catches (as well as effort), and provides explanations of the various biomass, mortality rates and stocking metrics required for international assessment and post-evaluation, as follows:

- Silver eel production (biomass)

  $B_0$ The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock;

  $B_{current}$ The amount of silver eel biomass that currently escapes to the sea to spawn;

  $B_{best}$ The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock, included re-stocking practices, hence only natural mortality operating on stock.

- Anthropogenic mortality (impacts)

  $\Sigma F$ The fishing mortality rate, summed over the age-groups in the stock,;

  $\Sigma H$ The anthropogenic mortality rate outside the fishery, summed over the age-groups in the stock,;

  $\Sigma A$ The sum of anthropogenic mortalities, i.e. $\Sigma A = \Sigma F + \Sigma H$. It refers to mortalities summed over the age-groups in the stock.

- Stocking requirements

  R(s) The amount of eel (<20 cm) stocked into national waters annually. The source of these eel should also be reported, at least to originating Member State, to ensure full accounting of catch vs. stocked (i.e. avoid ‘double banking’). Note that R(s) for stocking is a new symbol devised by the Workshop to differentiate from “R” which is usually considered to represent Recruitment of eel to continental waters.

In July 2012, Member States first reported on the actions taken, the reduction in anthropogenic mortalities achieved, and the state of their stock relative to their targets. In May 2013, ICES evaluated these progress reports in terms of the technical implementation of actions (ICES 2013a). In October 2014, the EU Commission reported to the European Parliament and the Council with a statistical and scientific evaluation of the outcome of the implementation of the Eel Management Plans.

In June 2015 Member States reported again on progress with implementing their EMPs, and will report a third time in 2018 (deadline 30th June 2018).

## C.4 Non-EU Countries

The Eel Regulation 1100/2007 only applies to EC Member States but the eel distribution extends much further than this. The whole-stock (international) assessment requires data and information from both EU and non-EU countries producing eels. Some non-EU countries provide such data to the WGEEL and more countries are being supported to achieve this through efforts of the General Fisheries Commission of the Mediterranean (GFCM). The GFCM has recently been integrated into the WGEEL with the goal of facilitating knowledge transfer and a full international stock assessment. The GFCM is currently undertaking a series of case studies to develop regional multi-annual management plans for shared stocks. Coordinated measures however, must necessarily be simple and adaptable to data poor situations given the wide variation in data availability across countries. In the GFCM region, eel is included as one of the priority fisheries shared by all countries.

## C.5 Other Legislative Structures

### C.5.1 CITES

The European eel was listed in Appendix II of the Convention on International Trade in Endangered Species (CITES) in 2007, although this did not come into force until March 2009. Since then, any international trade in this species needs to be accompanied by a permit. All trade into and out of the EU is currently banned as it was not possible to provide a non-detriment finding, but trade from non-EU Range States to non-EU countries is still permitted provided those States have demonstrated non-detriment findings.

Article IV.2 of the CITES Convention requires that, amongst other things: *The export of any specimen of a species included in Appendix II shall require the prior grant and presentation of an export permit. An export permit shall only be granted when the following condition has been met: a Scientific Authority of the State of export has advised that such export will not be detrimental to the survival of that species.*

Accordingly, there can be no resumption of export/import of eel from/to the EU, or between non-EU countries, before a non-detriment finding has been ratified that the export of specimens will not be detrimental to the conservation status of the species in the wild.

In 2015, ICES was requested to provide advice on criteria for defining a non-detriment finding (ICES, 2015 and Advice).

### C.5.2 IUCN & CMS

The International Union for the Conservation of Nature (IUCN) has assessed the European eel as 'critically endangered' on its Red List, in 2009 and again in 2014 although recognising that "if the recently observed increase in recruitment continues, management actions relating to anthropogenic threats prove effective, and/or there are positive effects of natural influences on the various life stages of this species, a listing of Endangered would be achievable" and therefore "strongly recommend an update of the status in five years".

Most recently, the European eel has been added to Appendix II of the Convention on Migratory Species (CMS), whereby Parties (covering almost the entire distribution of European eel) to the Convention call for cooperative conservation actions to be developed among Range States.

# D. Recruitment Assessment

Recruitment time-series have been collated by the WG since the early 1980s and these, along with the much less complete fisheries landings, have formed the basis for the provision of advice on the status of the eel stock since that time. The trend in recruitment for the European eel is derived from long-term time-series collected in estuaries scattered over all of Europe. These recruitment-series are the best indicator of the status of the stock, as there is no pan-European evaluation of the silver eel stock output. In addition, the evaluation of eel management actions taken by the different countries will have to take into account the trend in recruitment, as this recruitment will affect the expected output after a delay determined by the local growth rate of eel.

This chapter provides the background and methods used in the analysis of the recruitment data and has been updated to use the 2015 data and results as a demonstration of the process. The report of recruitment analysis (Annex 8 of WGEEL Report 2015) was provided for the ADGEEL in October 2015.



### D.1.1 Introduction

The recruitment time-series data are derived from fishery-dependent sources (i.e. catch records) and also from fishery-independent surveys (i.e. boats, handnet, fykenet or trapping ladders) across much of the geographic range of European eel (Figure D.1). The stages are categorized as glass eel, young small eel and larger yellow eel recruiting to continental habitats. The glass eel recruitment series used in the recruitment analysis are either comprised of only glass eel or of a mixture of glass eel and young yellow eel.

The WGEEL is currently also building up data from yellow eel series, but these are related to standing stock. The yellow eel series used in the recruitment analysis all come from trapping ladders. Yellow eel series used in the recruitment analysis are predominantly comprised of young yellow eel, or of yellow eel that might be several years old (such as in the Baltic).


**Figure D-1. Location of all the recruitment monitoring sites in Europe listed in Table D-1, white circle = glass eel, blue circle = glass eel and young yellow eels, yellow square=yellow eel series.**

### D.1.2 Site data

The WGEEL has collated information on recruitment from 51 time-series. The series code, name, comments about the data collection method, the international region, whether they are part of the North Sea or Elsewhere series, the country, river, location, sampling type, data units, life stages sampled, first and last year of data, whether they are active in the year of assessment, and whether or not there are missing data in the series, are all fully described in Table D.1 and the raw data for each location are given in Annex 5. Some of the time-series date back to the beginning of 20th century (yellow eel, Gőta Älv, Sweden) or 1920 (glass eel, Loire, France).

**Table D-1. Collated metadata descriptions for the recruitment series.**

| CODE | NAME | RIVER/SITE | COUNTRY | NORTH SEA/ EUROPE ELSEWHERE | STAGE (GLASS OR YELLOW) | DATA RANGE | METHOD | DATA UNITS |
|---|---|---|---|---|---|---|---|---|
| Imsa | Imsa Sandnes trapping all | Imsa | NO | NS | G | 1975–present | Freshwater elver trap | Number |
| Dala | Dalälven trapping all | Dalä | SE | EE | Y | 1951–present | Trapping all | Kg |
| Morr | Mőrrumsån trapping all | Mőrrumsån | SE | EE | Y | 1960–present | Trapping all | Kg |
| Mota | Motala Strőm trapping all | Motala | SE | EE | Y | 1942–present | Trapping all | Kg |
| Ring[1] | Ringhals scientific survey | Ringhals | SE | NS | G | 1981–present | Scientific estimate modified midwater trawl at power plant water intake | Index |
| YFS2 | IYFS2 scientific estimate | Skagerrak-Kattegat | SE | NS | G | 1991–present | Scientific estimate midwater trawl | Index |
| Kavl | K¨avlingeân trapping all | Kävlingeån | SE | EE | Y | 1992–present | Trapping all | Kg |
| Laga | Lagan trapping all | Lagan | SE | NS | Y | 1925–present | Trapping all | Kg |
| Ronn | Rőnne ålv trapping all | Rőnne | SE | NS | Y | 1946–present | Trapping all | Kg |
| Gota[2] | Gőta ålv trapping all | Gőta älv | SE | NS | Y | 1900–2015 | Trapping all | Kg |
| Visk | Viskan Sluices trapping all | Viskan | SE | NS | G+Y | 1972–present | Trapping at overflow dam | Kg |
| YFS1 | IYFS scientific estimate | Skagerrak-Kattegat | SE | NS | G | 1975–1989 | Scientific estimate | Index |
| Ems | Ems Herbrum commercial catch | Ems | DE | NS | G | 1946–2001 | Commercial catch | Kg |
| Sle | Slette A | Slette Å | DK | NS | G+Y | 2008–present | Electrofishing | Eels/m$^2$ |
| Klit | Klitmoeller A | Klitmoeller Å | DK | NS | G+Y | 2008–present | Electrofishing | Eels/m$^2$ |
| Nors | Nors A | Nors Å | DK | NS | G+Y | 2008–present | Electrofishing | Eels/m$^2$ |

| CODE | NAME | RIVER/SITE | COUNTRY | NORTH SEA/ EUROPE ELSEWHERE | STAGE (GLASS OR YELLOW) | DATA RANGE | METHOD | DATA UNITS |
|---|---|---|---|---|---|---|---|---|
| Hart[3] | Harte trapping all | Harte | DK | EE | Y | 1967–present | Trapping at HPS | Kg |
| Gude | Guden À Tange trapping all | Guden Å | DK | NS | Y | 1980–present | Trapping all | Kg |
| Vida | Vidaa Højer sluice commercial catch | Vidaa | DK | NS | G | 1971–1990 | Commercial catch | Kgg |
| RhDO | Rhine DenOever scientific estimate | Rhine | NL | NS | G | 1938–present | Scientific estimate, net | Index |
| RhIj | Rhine IJmuiden scientific estimate | Rhine | NL | NS | G | 1969–present | Scientific estimate, net | Index |
| Katw | Katwijk scientific estimate | Katwijk | NL | NS | G | 1977–present | Scientific estimate | Index |
| Lauw | Lauwersoog scientific estimate | Lauwersoog | NL | NS | G | 1976–present | Scientific estimate, net | No/h |
| Stel | Stellendam scientific estimate | Stellendam | NL | NS | G | 1971–present | Scientific estimate | Index |
| Yser[4] | Ijzer Nieuwpoort scientific estimate | Ijzer | BE | NS | G | 1964–present | Scientific estimate dipnets | Kg |
| Meus[5] | Meuse Lixhe dam trapping partial | Meuse | BE | NS | Y | 1992–present | Partial trapping | Kg |
| ShaA | Shannon Ardnacrusha trapping all | Shannon | IE | EE | G+Y | 1977–present | Trapping all | Kg |
| Feal[6] | River Feale | Feale | IE | EE | G+Y | 1985–present | Trapping all | Kg |
| ShaP[7] | Shannon Parteen trapping partial | Shannon | IE | EE | Y | 1985–present | Trapping partial | Kg |
| Maig[8] | River Maigue | Maigue | IE | EE | G | 1994–present | Trapping all | Kg |
| Inag[9] | River Inagh | Inagh | IE | EE | G+Y | 1996–present | Trapping all | Kg |
| Erne[10] | Erne Ballyshannon trapping all | Erne | IE | EE | G+Y | 1959–present | Trapping all from 1980 | Kg |
| SeHM[11] | Severn HMRC, commercial catch | Severn | GB | EE | G | 1979–present | Commerical catch | T |
| Bann | Bann Coleraine trapping partial | Bann | GB | EE | G+Y | 1960–present | Partial trapping | Kg |

| CODE | NAME | RIVER/SITE | COUNTRY | NORTH SEA/ EUROPE ELSEWHERE | STAGE (GLASS OR YELLOW) | DATA RANGE | METHOD | DATA UNITS |
|---|---|---|---|---|---|---|---|---|
| Vil | Vilaine Arzal trapping all | Vilaine | FR | EE | G | 1971–present | Trapping all: fishery corrected data | t |
| Fre | Frémur | Frémur | FR | NS | Y | 1997–present | Trapping all | number |
| AdCP | Adour Estuary (cpue) commercial cpue | Adour | FR | EE | G | 1928–2008 | Commercial CPUR | cpue |
| AdTC | Adour Estuary (catch) commercial catch | Adour | FR | EE | G | 1986–2008 | Commercial catch | t |
| GiCP | Gironde Estuary commercial (cpue) | Gironde | FR | EE | G | 1961–2008 | Commerical cpue | cpue |
| GiTC | Gironde Estuary (catch) commercial catch | Gironde | FR | EE | G | 1923–2008 | Commerical catch | t |
| GiSC | Gironde scientific estimate | Gironde | FR | EE |  | 1992–present | Scientific estimate | Index |
| Loi | Loire Estuary commercial catch | Loire | FR | EE | G | 1924–2008 | Commercial catch | KG |
| SevN | Sèvres Niortaise Estuary commercial cpue | Sèvres | FR | EE | G | 1962–2008 | Commerical cpue | cpue |
| Bres[12] | Bresle | Bresle | FR | EE | G+Y | 1994–present | Trapping all | number |
| Nalo[13] | Nalon Estuary commercial catch | Nalon | ES | EE | G | 1953–present | Commericial catch: San Juan de la Arena fishmarket sales | Kg |
| Ebro | Ebro delta lagoons | Ebro | ES | EE | G | 1966–2015 | Commercial catch: fishmarket | Kg |
| Albu[14] | Albufera de Valencia commercial catch | Albufera | ES | EE | G | 1949–2014 | Commercial catch | Kg |
| AlCP[15] | Albufera de Valencia commercial cpue | Albufera | ES | EE | G | 1982–2014 | Commercial cpue | cpue |
| MiSp | Minho Spanish part, commercial | Miño | ES | EE | G | 1975–2015 | Commercial catch | Kg |
| MiPo | Minho Portugese part, commercial catch | Miño | PT | EE | G | 1975–2015 | Commercial catch | Kg |

| CODE | NAME | RIVER/SITE | COUNTRY | NORTH SEA/ EUROPE ELSEWHERE | STAGE (GLASS OR YELLOW) | DATA RANGE | METHOD | DATA UNITS |
|---|---|---|---|---|---|---|---|---|
| Tibe | Tiber Fiumara Grande commercial catch | Tiber | IT | EE | G | 1975–2006 | Commercial catch | t |

**Changes in data collection regimes and major data anomalies are described below:**

**[1]Ring. Sampling dependent on cooling water intake, and sometimes it is necessary to use an alternative intake nearby. There is some calibration between these two intakes.**

**[2]Gota. Fish pass rebuilt 2010/2011.**

**[3]Hart. Affecting data from 1991 onwards, a bypass allowing eels to avoid the facility was completed in 1990 and the number of eel traps was reduced from two to one. From spring 2008 to present, there has been a 60% reduction in water flow at power station, directly affecting catch. Both changes likely lead to decrease in catch.**

**[4]Yser. Variable fished effort noted, low in 2006, high in 2012 and 2013: accompanying effort data available from 2002 onwards.**

**[5]Meus. New Fish pass built in 2008, perhaps affecting catch from 2008 onwards.**

**[6]Feal. Operation of fish trap switched from commercial fisherman to scientific staff (IFI) in 2009.**

**[7]ShaP. Trap improved prior to the run in 2015.**

**[8]Maig. Operation of fish trap switched from commercial fisherman to scientific staff (IFI) in 2009. Trap improved prior to the run in 2011. 2014 catch is certainly an underestimate, as it was derived from partial trapping effort only.**

**[9]Inag. Operation of fish trap switched from commercial fisherman to scientific staff (IFI) in 2009. Trap improved prior to the run in 2011. Significant flood in 2012 leading to underestimate (floods not recorded prior to 2009).**

**[10]Erne. The trap was significantly upgraded prior to the 2015 season.**

**[11]SeHM. The related series SeEA was dropped in 2015 recruitment assessment as it contains the same in formation as this series, but with greater inconsistencies.**

**[12]Bres. Change in trapping ladder affecting catch (increase) in 2003. Second change in trapping ladder affecting catch from 2013 onwards.**

**[13]Nalo. In the 1970s (no more specific date available) fishermen started to use boats to catch eels in addition to the land-based methods used previously. Effort data collected from 2006 allowing for potential for calibration.**

**[14]Albu. In 2001 there was a change in data compilation methods, but the series integrity has been preserved.**

**[15]AlCP. In 2001 there was a change in data compilation methods, but the series integrity has been preserved.**

### D.1.3 Time-series description

- 36 time-series were updated to 2015 (26 for glass eel and ten for yellow eel Table D-1 Annex 5).
- Five time-series (three for glass eel and two for yellow eel) were updated to 2014 only (Table 1.4 Annex 5).

Among the time-series based on trap indices, some have reported preliminary data for 2015 as the season is not yet finished (Lagan (SE), Kävlingeån (SE), Gőta Älv (SE), Motala Strőm (SE), Parteen (IE), Bann (GB), Frémur (FR), Bresle (FR)), while others have not yet reported (Guden Ǻ (DK), Harte (DK)). Therefore, the indices given for 2015 must be considered as provisional especially those for the yellow eel.

Ten time-series have been stopped (ten for glass eel and none for yellow eel, Table D-1 Annex 5). They stopped reporting either because of a lack of recruits in the case of the fishery-based surveys (Ems in Germany, stopped in 2001; Vidaa in Denmark, stopped in 1990), a lack of financial support (the Tiber in Italy, 2006) or the introduction of quota from 2008 to 2011 that has disrupted the five fishery-based French time-series. Note the French Vilaine time-series could be used again in 2015 because the glass eel fishery never achieved its quota.

The number of glass eel and glass eel + young yellow eel time-series available has declined from a peak of 33 in 2008. The maximum number of older yellow eel time-series has increased to 12 in 2014 (Figure D.2). Before 1960, the number of glass eel or glass eel + yellow eel series, which will be used to build the WGEEL recruitment index for glass eel, is quite small, with six series before 1959 (Figure D.2). Those are Den Oever (scientific survey), the Loire (total catch), the Ems (mixture of catch and trap and transport), the Gironde (total catch), the Albufera de Valencia in the Mediterranean, and the Adour, which dates as far back as 1928, and is based on cpue. For the latter however, only the years 1928 to 1931 are available and the series only resumes in 1966.

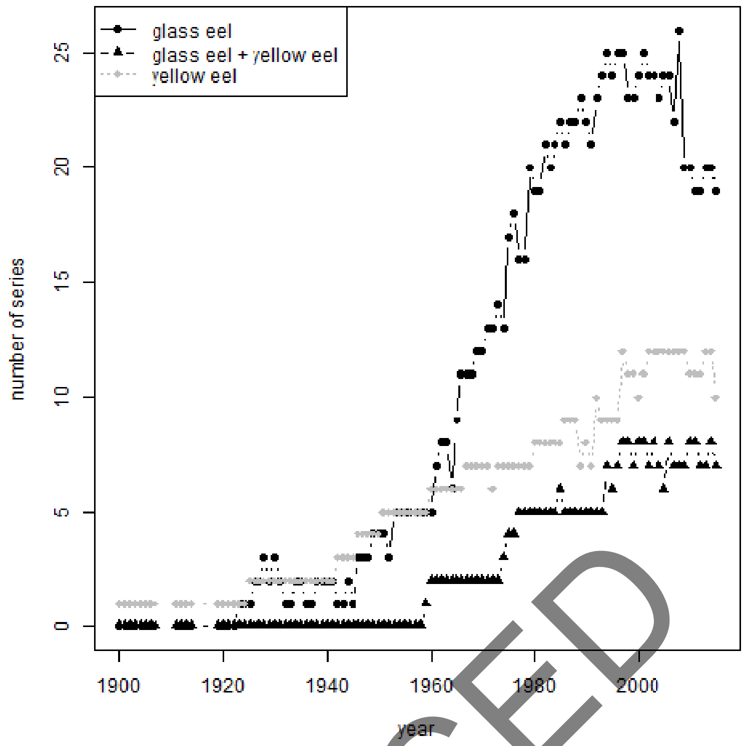



**Figure D-2. Trends in the number of time-series for glass (black circle), glass+young yellow eel (grey triangle) and older yellow eel (black triangle) giving a report in any specific year.**



## D.2 Analysis

For the development of the Stock Annex, we have used the analysis outputs by the WGEEL 2015 and as presented in the Eel Advice for 2015 in order to demonstrate the assessment methodology.

### D.2.1 Setting Reference Periods

The original analysis of trends in recruitment data (Dekker, 2000; 2002) used a scaling to a period which encapsulated the most dataseries, 1979–1994. WGEEL kept the "historical analysis" to give consistent advice from year to year. In 2006 (ICES, 2006) first separated the recruitment into glass eel and young yellow eel.

Young yellow eel are by their nature older than 0+ glass eel recruits. This age differential varies with location and the young yellow eel could include up to ten or more year classes. The age structure of the different series which include Baltic series and some other places in Europe are currently not known. The scaling for yellow eel was done on the same period as the glass eel series, though it could have spanned a longer period as more than four reliable series were available after 1946. WGEEL chose to be consistent between the two time-trends. The yellow eel series mix up data where the age is expected to be different and they also probably integrate more bias due to local factors affecting the survival of young eels. Those would be local factors in the rivers (e.g. Meuse, Frémur, Shannon) or at the coast (Baltic series) and they may vary between years and between sites.

For the GLM reconstructed WGEEL 'Recruitment Index', the reference period was set to pre-1980. There are twelve yellow eel and 39 glass eel series and all are included in the analysis. 1960 was set as the start of the reference period (1960–1979) in order to exclude data from four series where a significant change in effort had occurred in three of them because they were based on total catch of commercial glass eel which were known to have been affected by changes in fishing practices, and the progressive shift from hand nets to push net fisheries from 1940 to 1960 (Briand *et al.*, 2008: see paragraph 24.1.1).

#### D.2.2 Simple Geometric Means of Raw Data

The calculation of the geometric mean of all series shows that recruitment was increasing from a minimum in 2009 until 2014 but was lower in 2015 (Figures D.3 and D.4). Figure D.3, although consistent with the trend provided by WGEEL since 2002, might be biased by the loss of most Bay of Biscay series from 2008 to 2012. The scaling was performed on the 1979–1994 average of each series, and seven series without data during that period were excluded from the analysis[2]. This scaling is simply to standardise the series so that they can all be presented on the same y-axis, and this period of years is not presented as a reference time period.

When looking at the separate trends for both glass eel and yellow eel series, as introduced by the WGEEL in 2006 (ICES, 2006), there was an increasing trend from 2011 visible for both series. Both series dropped again in 2015, which is curious given the difference in age of the eels in each series mentioned previously. Note that no lag was added to the yellow eel series but that the age of yellow eels might range from one to several years old (Figure D.4).



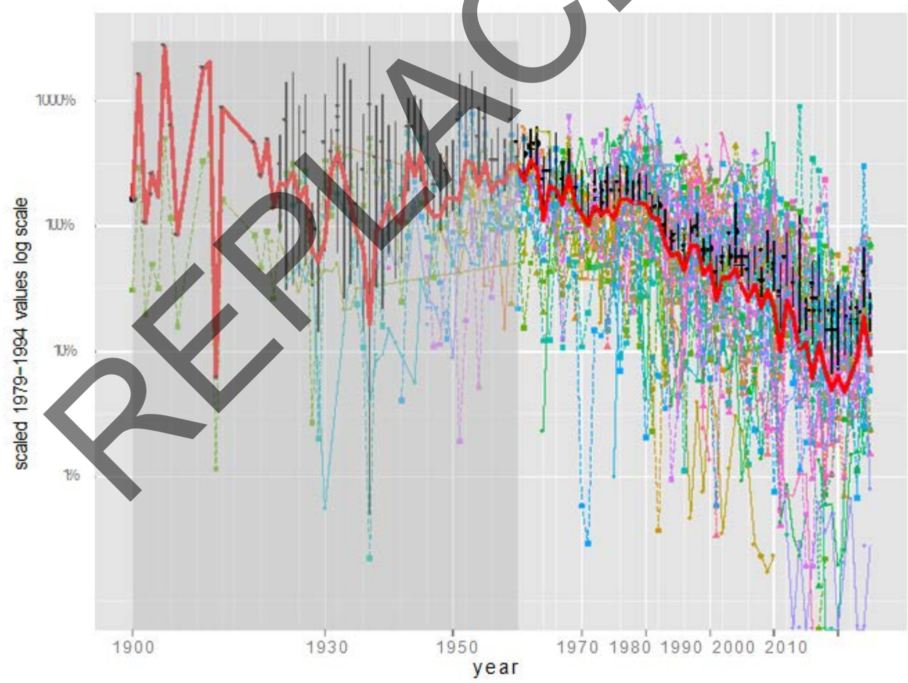



**Figure D-3. Time-series of glass eel and yellow eel recruitment in European rivers with time-series having data for the 1979–1994 period (44 sites) up to 2015. Each time-series has been scaled to its 1979–1994 average. Note the logarithmic scale on the y-axis. The mean values and their bootstrap confidence interval (95%) are represented as black dots and bars. Geometric means are presented in red.**

[2] [1]the series left out are : Bres, Fre, Inag, Klit, Maig, Nors, Sle.

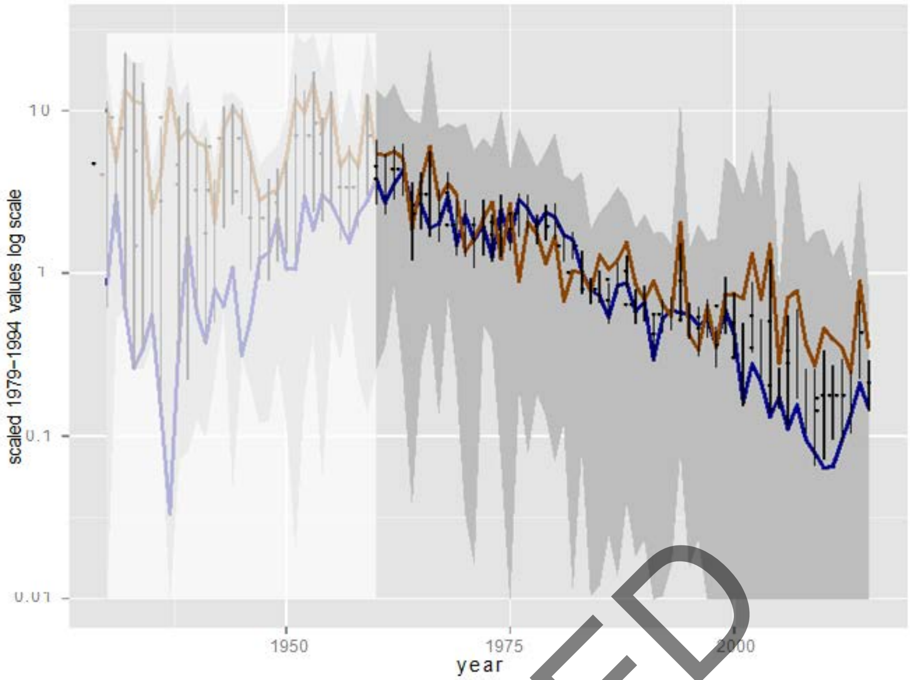



**Figure D-4. Time-series of glass eel and yellow eel recruitment in Europe with 44 time-series out of the 51 available to the working group up to 2015. Each time-series has been scaled to its 1979–1994 average. The mean values of combined yellow and glass eel time-series and their bootstrap confidence interval (95%) are represented as black dots and bars. The brown line represents the mean value for yellow eel; the blue line represents the mean value for glass eel time-series. The range of these time-series is indicated by a grey shade. Note that individual time-series from Figure D.3 were removed to make the mean value more clear. Note also the logarithmic scale on the y-axis.**



### D.2.3 GLM based trend

The 'WGEEL recruitment index' (ICES, 2008) is a statistical prediction using a simple GLM. A difference in spatial pattern of recruitment was observed at most stations in the North Sea, where the decline was sharper than elsewhere (ICES, 2010). There is currently no explanation for that observation.

The GLM (Generalised Linear Model): *glass eel ~ year: area + site*, where:

glass eel is individual glass eel series,

site is the site monitored for recruitment and,

area is either the North Sea or Elsewhere Europe.

The GLM uses a gamma distribution and a log link. The dataseries comprising only glass eel, or a mixture of glass eel and what is mostly young of the year eel, are grouped and later labelled glass eel series.

In the case of yellow eel series, only one estimate is provided: *yellow eel ~ year + site*.

```
For Glass Eel
model_ge_area=glm(data_std~year_f:area+nam,data=glass_eel_yoy,family=Gamma(link=log),
   ⇨              subset=glass_eel_yoy$data>0 & glass_eel_yoy$year>1959 ,maxit=300)

   and this for Yellow Eel
model_older=glm(data_std~year_f+as.factor(nam),data=older,family=Gamma(link=log),subset=older$data>0 & older$year>1949 ,maxit=300)
```

The trend is reconstructed using the predictions from 1960 for 40 glass eel series and for 12 yellow eel series. This analysis rebuilds all the series by extrapolating the missing values. Note that rebuilding annual values for the geometric means of predicted values is not different from looking at the coefficients for year in the model. The series are then averaged. Some zero values have been excluded from the GLM analysis: 12 for the glass eel model and one for the yellow eel model (see Table D-2, D-3).

The reference period for pre-1980 recruitment level is 1960–1979 and the data from 1950 to 1960 for four series were excluded (see Section D.2.1). After 1960, the number of available series increases rapidly (Figure D.2). Although no such biases are known for the yellow series recruitment series, the same reference period has been chosen to provide consistent results.

Following the high levels in the late 1970s, there has been a rapid decrease in the glass eel recruitment trends (Figures D-5 and D-6).

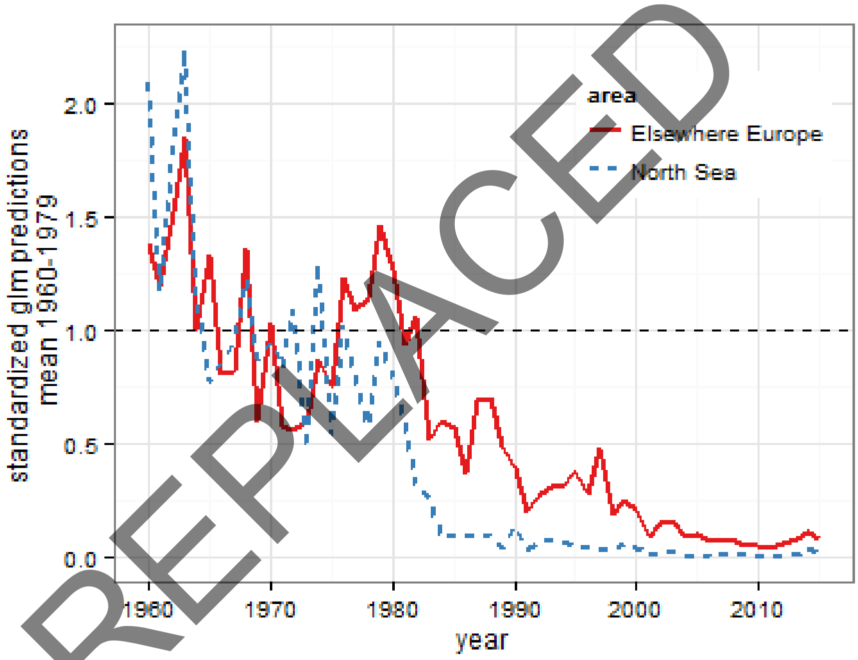





**Figure D-5. WGEEL recruitment index: mean of estimated (GLM) glass eel recruitment for the continental North Sea and elsewhere in Europe updated to 2014. The GLM (recruit = area: year + site) was fitted on 40 series comprising either pure glass eel or a mixture of glass eels and yellow eels and scaled to the 1960–1979 average. No series are available for glass eel in the Baltic area.**

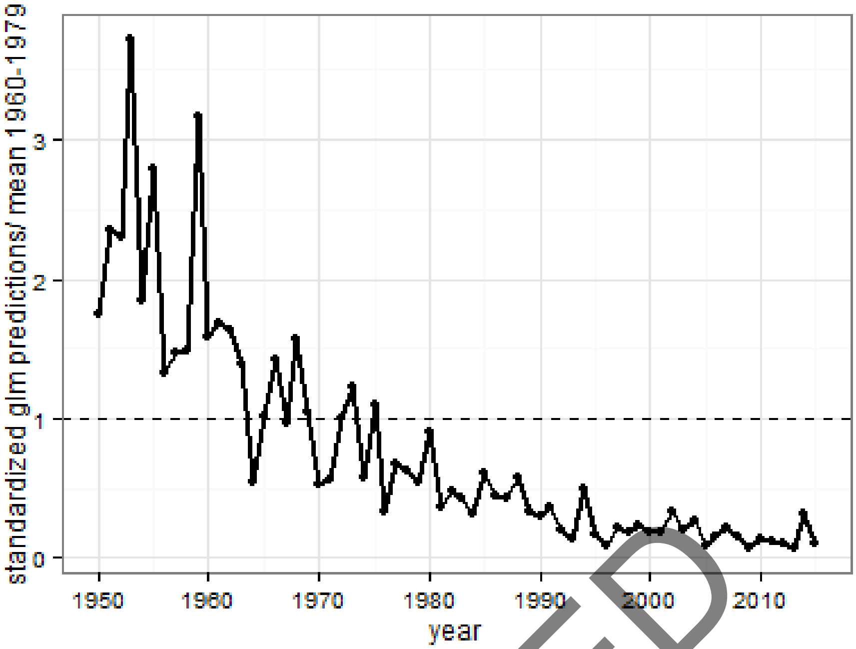



**Figure D-6. Mean of estimated (GLM) yellow eel recruitment and smoothed trends for Europe updated to 2014. The GLM (*recruit ~ year + site*) was fitted to 12 yellow eel series and scaled to the 1960–1979 average.**

**Table D-2. GLM glass eel ~ year: area + site geometric means of predicted values for 39 glass eel series, values given in percentage of the 1960–1979 period.**

| | 1960 | | 1970 | | 1980 | | 1990 | | 2000 | | 2010 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | EE | NS | EE | NS | EE | NS | EE | NS | EE | NS | EE | NS |
| 0 | 138 | 209 | 103 | 95 | 127 | 79 | 40 | 14 | 21.4 | 4.7 | 4.9 | 0.5 |
| 1 | 119 | 117 | 58 | 84 | 95 | 59 | 20 | 3 | 9.7 | 0.9 | 4.3 | 0.5 |
| 2 | 152 | 178 | 57 | 109 | 106 | 32 | 27 | 8 | 15.0 | 2.6 | 6.3 | 0.5 |
| 3 | 185 | 224 | 60 | 48 | 53 | 26 | 31 | 7 | 15.5 | 2.1 | 8.6 | 1.1 |
| 4 | 100 | 117 | 87 | 129 | 60 | 10 | 31 | 7 | 8.9 | 0.6 | 11.2 | 4.3 |
| 5 | 133 | 77 | 75 | 54 | 57 | 9 | 38 | 5 | 10.1 | 1.3 | 8.4 | 1.2 |
| 6 | 81 | 86 | 123 | 102 | 37 | 9 | 28 | 5 | 7.2 | 0.4 | | |
| 7 | 83 | 95 | 109 | 80 | 69 | 10 | 48 | 4 | 7.9 | 1.3 | | |
| 8 | 136 | 122 | 114 | 58 | 70 | 10 | 19 | 3 | 7.1 | 0.8 | | |
| 9 | 60 | 87 | 146 | 95 | 49 | 4 | 25 | 6 | 5.0 | 0.9 | | |

**Table D-3. GLM yellow eel ~ year + site geometric means of predicted values for 12 yellow eel series, values given in percentage of the 1960–1979 period.**

| | 1950 | 1960 | 1970 | 1980 | 1990 | 2000 | 2010 |
|---|---|---|---|---|---|---|---|
| 0 | 175 | 158 | 52 | 90 | 30 | 18 | 13 |
| 1 | 236 | 168 | 56 | 37 | 37 | 18 | 12 |
| 2 | 230 | 164 | 100 | 47 | 21 | 34 | 11 |
| 3 | 372 | 139 | 123 | 43 | 14 | 20 | 7 |
| 4 | 184 | 55 | 58 | 32 | 50 | 26 | 31 |
| 5 | 278 | 102 | 109 | 62 | 16 | 9 | 11 |
| 6 | 132 | 142 | 34 | 45 | 9 | 15 | |
| 7 | 146 | 97 | 68 | 44 | 21 | 22 | |
| 8 | 148 | 156 | 62 | 58 | 18 | 15 | |
| 9 | 316 | 104 | 54 | 33 | 23 | 8 | |



#### D.2.4 Determining a change in trend

In the context of a rebuilding stock, an increasing recruitment is expected as a sign of recovery. SGIPEE (ICES, 2010) and WGEEL (ICES, 2014) has elaborated and refined methods to test signals of recovery of recruitment. Most recently (ICES, 2014a), a Bayesian Eel Recruitment Trend (BERT) model was proposed that takes into account the autocorrelation that exists in recruitment series to give confidence in identifying a trend shift. The criterion can thus be defined on the basis of this test. If the test gives a high credibility (95% for example) to a trend shift in the positive direction (i.e. an increase in recruitment), this can be considered as a good sign that the stock is at least moving towards recovery. A positive trend can be determined at a very low recruitment, however, and so this criterion is not sufficient on its own to define a recovering trend in the eel stock.

## E. Others (e.g. age terminology)

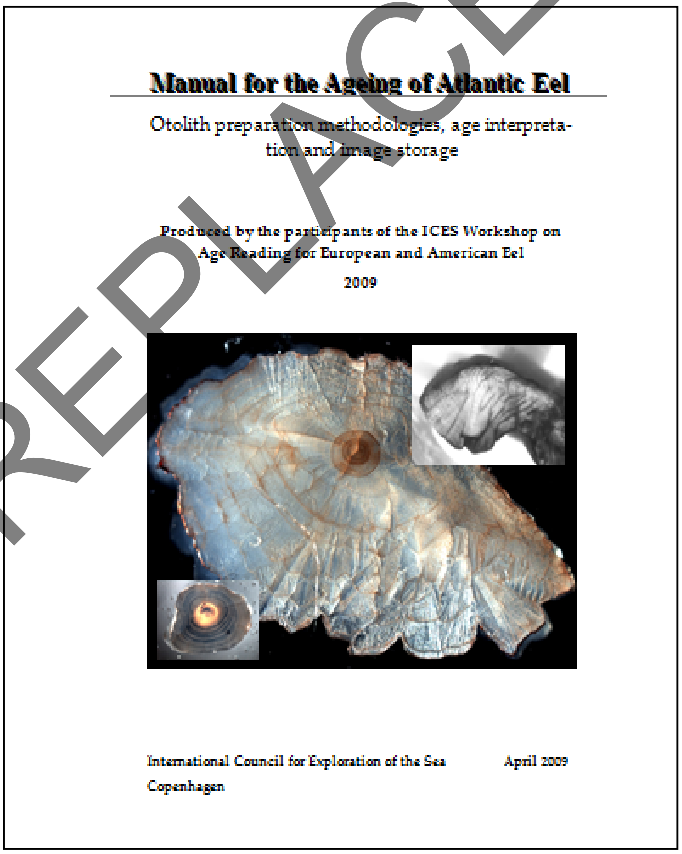
### E.1 Age

#### E.1.1 Introduction

Eel age determination for Atlantic eel has long been problematic with much debate on both the techniques and the interpretation with relatively few validation studies. Validation is difficult given the terminal nature of ageing with otoliths and also the relatively slow growth and long life cycle often involving different habitats. Ageing using sagittal otoliths, rather than other structures such as scales and opercular bones, appears to be the only viable option for eel and the extraction of eel otoliths was described by Moriarty (1973).

The results obtained using different preparation methods may vary considerably (Moriarty and Steinmetz, 1979; Moriarty, 1983; Berg, 1985; Vøllestad, 1985; Vøllestad and Næsje, 1988; Fontenelle, 1991; Poole *et al*., 1996b) but few have been validated. The ageing of slow growing eels and the occurrence of supernumerary zones has caused much confusion (Dahl, 1967; Moriarty, 1972; 1983; Deelder, 1981; Poole *et al*., 1992) although subsequently, the 'burning and cracking' method was validated in some situations (Moriarty and Steinmetz, 1979; Moriarty, 1983; Vøllestad and Næsje, 1988; Poole *et al*., 1996a).

Burning and cracking was recommended by an EIFAC eel age workshop in 1987 as the best option for ageing eels (Vøllestad, Lecomte-Finiger and Steinmetz, 1988), particularly for the slow growing and older specimens (e.g. Vøllestad and Næsje, 1988). There have been many developments since 1988, both in improved otolith preparation techniques, imaging and validations along with the use of eels of known age and chemical marking of otoliths.


**Manual for the Ageing of Atlantic Eel**

Otolith preparation methodologies, age interpretation and image storage

Produced by the participants of the ICES Workshop on Age Reading for European and American Eel

2009

International Council for Exploration of the Sea Copenhagen

April 2009



Two ICES Workshops, WKAREA and WKAREAII, produced protocols and a Manual for the extraction, preparation and reading of otoliths (ICES, 2009; 2011). The workshops also carried out intercalibration between methods and between readers. It was recommended that the User Manual developed by the Workshop should be followed for eel age determination. It is also recommended that periodic updating of the manual should take place and reader verification and intercalibration should be routinely organised.

### E.1.2 Age reading

The two main otolith preparation protocols for the Atlantic species of eel, *Anguilla anguilla* and *A. rostrata*, currently in use are, with slight variations between institutes, the burning and cracking (or better now the cutting and burning), and the grinding and polishing (and in most cases staining) protocols. Clearing whole otoliths "in toto" has limited use for small eels of young age. A preparation with a transverse section of the otolith should be used for slow growth, or old eels, with burning and cracking.

The estimation of growth is based on the count of winter annuli, excluding the oceanic and glass eel phase. The identification of the zero band may be confirmed by the use of the measurement of the nucleus size, or the average measurement of the radius from the centre of the nucleus to the zero band (170µm) which is quite consistent for *A. Anguilla* and *A. rostrata*, irrespective of the otolith preparation technique used.

The date of reference for age is set as the 1st of January, meaning that a cautious approach is recommended for eels sampled in winter and spring before the period for which the winter annuli is not obvious on the otolith margin. Age estimation should be obtained using both the otolith annuli count and additional data such as location and date of capture, eel life stage (i.e. yellow or silver), length, sex, and previous history if known (e.g. stocked from wild, stocked from aquaculture) as this supports a more accurate interpretation of the growth pattern and helps to discriminate winter annuli from false checks. "Blind reader" tests may be appropriate in some circumstances but for routine age determination, possession of the full information reduces unnecessary misinterpretation and variability.

Reference should be made to the Eel Age Manuals (ICES, 2009; 2011) for methods, terminology, reference collections and images of ototliths and intercalibrated readings.

## E.2 Maturity/silver determination

The eel is semelparous (Section A-3) and undergoes a period of maturation, known as silvering, before and during its migration from its continental habitat to the ocean. Determining the silvering stage is important in quantifying the proportion of eels likely to finally silver and migrate as potential spawners.

Methods used for determination of silvering stage were reviewed by the WGEEL (ICES, 2010) and compared to assess their practicality and efficiency as tools to evaluate the number of potential spawners in a sample. Methods using external objective criteria (such as body measurements) are more accurate than observations based on skin colour or the visibility of the lateral line. The silvering index (Durif *et al.*, 2005; 2009), based on eye diameters, pectoral fin length, body length and body weight, was preferred for an accurate description of the sample (ICES, 2010; Table E-1). Practical guidelines are specified to measure body parameters. Because silvering occurs over summer, the appropriate period for such a survey would be September, just before migratory movements.

The pectoral fin length is measured from the insertion to the tip of the fin and corresponds to the greatest possible length (Figure E-1). The mean eye diameter is calculated using vertical (Dv) and horizontal (Dh) eye diameters, measured along the visible part of the cornea.


**Figure E-1. Details of the body measurements (A. body length B. pectoral fin length; C. Horizontal eye diameter). Durif *et al.*, 2009.**



**Table E-1. Classification functions for stage determination (I to FV and MII) of eels. Values correspond to the weights to be assigned to each variable. c: Constant, BL (body length in mm), W (body weight in g), MD (mean eye diameter in mm), FL (fin length in mm).**

| | Yellow eels | | Pre-silver females | Silver females | | Silver males |
|---|---|---|---|---|---|---|
| | I | FII | FIII | FIV | FV | MII |
| c | -61.276 | -87.995 | -109.014 | -113.556 | -128.204 | -84.672 |
| BL | 0.242 | 0.286 | 0.280 | 0.218 | 0.242 | 0.176 |
| W | -0.108 | -0.125 | -0.127 | -0.103 | -0.136 | -0.116 |
| MD | 5.546 | 6.627 | 9.108 | 12.187 | 12.504 | 12.218 |
| FL | 0.614 | 0.838 | 1.182 | 1.230 | 1.821 | 1.295 |

Classification scores for each case are computed for each stage according to the formula:

$$S_i = c_i + w_{i1}*x_1 + w_{i2}*x_2 + \ldots + w_{in}*x_n$$

Where I denotes the respective stage, n denotes the n variables, c is a constant (Table 2), $w_{in}$ is the weight for the $n^{th}$ variable in the computation of the classification score for the $i^{th}$ group, and $x_n$ is the observed value for the respective case for the $n^{th}$ variable. $S_i$ is the resultant classification score. An eel was assigned to the stage for which it had the highest $S_i$. The efficiency of the analysis was evaluated through a classification matrix, which indicated the number of eels that were correctly classified and those that were misclassified.

## F Next steps for developing the Eel Stock Annex

The content of the Stock Annex will be reviewed by the WG annually, and data tables updated every three years.

The further development of this stock annex will depend largely on the development of the stock assessment procedures in support of the ICES stock advice. At such time as the 3Bs and sigmaA stock indicators and/or stock recruitment reference points become approved, the data and analyses will be described in new sections of this Annex. These sections will likely include the following content and structure:

- Describe how each Country derives its 3Bs and sigmaA stock indicators for progress reporting
  - Data inputs (Local assessments)
  - Surveys
  - Analysis/Model
  - Reporting
- Describe peer-review/benchmark of local assessments/reported stock indicators
- Describe Proposed/accepted International Stock Assessment framework
  - Data inputs (EMU Stock Indicators) and other supporting data
  - Analysis/Model
  - Biological Reference Points/Mortality limits
- Describe a standardized pan-European stock assessment that can be used as a calibration/verification of the national data indicators



# G Data

## G.1 Commercial catch

### G.1.1 Landings data

Landings data are incomplete.

There is a great heterogeneity among the time-series of landings because of inconsistencies in reporting by, and between, countries, as well as incomplete reporting. Changes in management practices have also affected the reporting of non-commercial and recreational fisheries.

### G.1.2 Discards estimates

No data.

May have relevance in future in relation to catch & release in recreational fisheries.

### G.1.4 Recreational catches

Recreational landings and total recreational catches incomplete.

## G.2 Biological sampling

Collected at the national level.

### G.2.1 Maturity

None. Natural mortality.

None. Length and age composition of landed and discarded fish in commercial fisheries.

None.

### G.3 Surveys

Organised at the national level.

#### G.3.1 Survey design and analysis

#### G.3.2 Survey data used

### G.4 Commercial cpue

Data incomplete.

### G.5 Other relevant data

See Chapter E.

## H Assessment methods and settings

### H.1 Choice of stock assess model

None.

### H.2 Model used of basis for advice

None.

See Chapter D for the analysis of recruitment trends which provide the basis for the advice.

### H.3 Assessment model configuration

Not applicable.

| Type | Name | Year range | Age range | Variable from year to year Yes/No |
|---|---|---|---|---|
| Caton | Catch in tonnes | | | |
| Canum | Catch-at-age in numbers | | | |
| Weca | Weight-at-age in the commercial catch | | | |
| West | Weight-at-age of the spawning–stock at spawning time. | | | |
| Mprop | Proportion of natural mortality before spawning | | | |
| Fprop | Proportion of fishing mortality before spawning | | | |
| Matprop | Proportion mature at age | | | |
| Natmor | Natural mortality | | | |

## I Short-term prediction

Model used: **None**

Software used:

Initial stock size:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Procedures used for splitting projected catches:

## J Medium-term prediction

Model used: **None**

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Uncertainty models used:

1) Initial stock size:
2) Natural mortality:
3) Maturity:
4) F and M before spawning:
5) Weight-at-age in the stock:
6) Weight-at-age in the catch:
7) Exploitation pattern:
8) Intermediate year assumptions:
9) Stock–recruitment model used:

## K Long-term prediction

Model used: **None**

Software used*:*

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:

## L Biological reference points

The EC Regulation sets an escapement limit for each EMU 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.

Recruitment at the 1960–1979 level is regarded as an un-impaired recruitment level.

The management biomass reference limit of 40% of $B_0$ for eel, a Category 3 species in the Data-Limited Species approach, is in line with the 40% maximum spawning potential (at F=0) reference point (a common proxy for MSY) advised for category 3 and 4 species by ICES (2015a: WKLIFE V). Given the EU $B_{lim}$ of 40% builds in a precautionary boundary above the standard 30% and is equivalent to the 40% maximum spawning potential, see above, the EU 40%, and its equivalent mortality limit may be used as the limit reference point for eel in the provision of advice with respect to management of the eel stock. There are no biological reference points agreed for eel.

| | Type | Value | Technical basis |
|---|---|---|---|
| MSY | MSY $B_{trigger}$ | xxx t | Explain |
| Approach | $F_{MSY}$ | Xxx | Explain |
| | $B_{lim}$ | xxx t | Explain |
| Precautionary | $B_{pa}$ | xxx t | Explain |
| Approach | $F_{lim}$ | Xxx | Explain |
| | $F_{pa}$ | Xxx | Explain |

ICES has advised the EC CITES Scientific Review Group on reference points for the eel stock that could be used in developing, and reviewing, an application for a non-detriment finding (NDF), under circumstances of any future improvement of the stock (ICES, 2015a). These reference points were developed specifically using CITES guiding principles for NDF.

## M References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# Annex SA1: Acronyms



| Acronyms | Definition |
|---|---|
| ACE | Advisory Committee on the Environment |
| ACFM (ICES) | Advisory Committee on Fisheries Managment |
| ACOM (ICES) | Advisory Committee on Management |
| AFN | National Forestry Authority |
| AIC | *Akaike Information Criterion* |
| ANCOVA | Analysis of Covariance |
| ANOVA | Analysis of Variance |
| BERT | Bayesian Eel Recruitment Trend model |
| BIC | *Bayesian Information Criterion* |
| BIOR | Institute of Food Safety, Animal Health and Environment “BIOR”, Latvia |
| CCM | Catchment Characterisation and Modelling |
| CITES | Convention on International Trade in Endangered Species |
| CNTS | Centre National de Traitement Statistiques, France (ex CRTS) |
| COMM | EU Commission |
| CPUE | Catch per unit of effort |
| CR | Country Report |
| CUSUM | Cumulative Sum Control Chart |
| DBEEL | Database on Eel (EU POSE project) |
| DCAL | Department of Culture, Arts & Leisure, N. Ireland |
| DCF | Data Collection Framework |
| DFO | Department of Fisheries and Oceans |
| DG-MARE | Directorate-General for Maritime Affairs and Fisheries, EU Commission |
| DGPA | General Directorate of Fisheries and Aquaculture, Portugal |
| DLS | Data-Limited Stocks |
| DPMA | Direction des Pêches Maritimes et de l’Aquaculture, France |
| EIFAAC | European Inland Fisheries & Aquaculture Advisory Commission |
| EMP | Eel Managment Plan |
| EMU | Eel Management Unit |
| EFF | European Fisheries Fund |
| FAO | Food and Agriculture Organisation |
| FEAP | The Federation of European Aquaculture Producers |
| FGFRI | Finnish Game and Fisheries Research Institute |
| GAM | Generalised Additive Model |
| GEM | German Eel Model |
| GFCM | General Fisheries Commission of the Mediterranean |
| GIS | Geographic Information Systems |
| GLM | Generalised Linear Model |
| GlobAng | French Model of Eel Population Dynamics |
| HPS | Hydropower Station |
| ICES | International Council for the Exploration of the Sea |
| LHT | Life History Trait |
| L50 | L50 = the length (L) at which half (50%) of a fish species may be able to spawn |
| LVPA | Length-based Virtual Population Assessment |
| MIWA | Marine and Inland Waters Administration |
| MS | Member State |
| MSY | Maximum Sustainable Yield |
| NAO | North Atlantic Oscillation |
| ONEMA | Office National de l'Eau et des Milieux Aquatiques, France (ex-CSP) |
| POSE | Pilot projects to estimate potential and actual escapement of silver eel |
| RBD | River Basin District |

| Acronyms | Definition |
|---|---|
| RGEEL | Review Group on Eel (ICES) |
| SGIPEE | Study Group on International Post-Evaluation on Eels |
| SLIME | Restoration the European Eel population; pilot studies for a scientific framework in support of sustainable management |
| SMEPII | Scenario-based Model for Eel Populations, vII |
| SNPE | Suivi national de la pêche aux engins et aux filets |
| SPR | Estimate of spawner production per recruiting individual. |
| SQL | Special purpose programming language for managing data |
| SSB | Spawning–Stock Biomass |
| STECF | Scientific, Technical and Economic Committee for Fisheries, EU Commission |
| SWAM | Swedish Analytical Models |
| ToR | Terms of Reference |
| VPA | Virtual Population Analysis |
| WG | Working Group |
| WGEEL | Joint EIFAAC/ICES/GFCM Working Group on Eel |
| WKEPEMP | The Workshop on Evaluating Progress with Eel Management Plans |
| WKESDCF | Workshop on Eels and Salmon in the Data Collection Framework |
| WFD | Water Framework Directive |
| WKLIFE | Workshop on the Development of Assessments based on LIFE-history traits and Exploitation Characteristics |
| WKPGMEQ | Workshop of a Planning Group on the Monitoring of Eel Quality under the subject “Development of standardized and harmonized protocols for the estimation of eel quality” |
| WGRFS | Working Group on Recreational Fisheries Surveys |
| YFS1 | Young Fish Survey: North Sea Survey location |

## Annex SA2: Glossary

| **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.** |
|---|---|
| Eel River Basin or Eel Management Unit | "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]." EC No. 1100/2007. |
| Elver | Young eel, in its first year following recruitment from the ocean. The elver stage is sometimes considered to exclude the glass eel stage, but not by everyone. To avoid confusion, pigmented 0+cohort age eel are included in the glass eel term. |
| Glass eel | Young, unpigmented eel, recruiting from the sea into continental waters. WGEEL consider the glass eel term to include all recruits of the 0+ cohort age. In some cases, however, also includes the early pigmented stages. |
| 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. The term is used in relation to the EU Water Framework Directive. |
| Silver eel | Migratory phase following the yellow eel phase. Eel in this phase are characterized by darkened back, silvery belly with a clearly contrasting black lateral line, enlarged eyes. Silver eel undertake downstream migration towards the sea, and subsequently westwards. This phase mainly occurs in the second half of calendar years, although some are observed throughout winter and following spring. |
| Stocking | Stocking (formerly called restocking) 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. |
| To silver (silvering) | Silvering is a requirement for downstream migration and reproduction. It marks the end of the growth phase and the onset of sexual maturation. This true metamorphosis involves a number of different physiological functions (osmoregulatory, reproductive), which prepare the eel for the long return trip to the Sargasso Sea. Unlike smoltification in salmonids, silvering of eels is largely unpredictable. It occurs at various ages (females: 4–20 years; males 2–15 years) and sizes (body length of females: 50–100 cm; males: 35–46 cm) (Tesch, 2003). |
| 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 and therefore includes young pigmented eels ('elvers' and bootlace). |

| Eel reference points/population dynamics | |
|---|---|
| Curent escapement biomass ($B_{current}$) | The amount of silver eel biomass that currently escapes to the sea to spawn, corressponding to the assessment year. |
| Best achievable biomass ($B_{best}$) | Spawning biomass corresponding to recent natural recruitment that would have survived if there was only natural mortality and no stocking, corressponding to the assessment year. |
| Pristine biomass ($B_0$) | Spawner escapement biomass in absence of any anthropogenic impacts. |
| $B_{MSY-trigger}$ | Value of spawning–stock biomass (SSB) which triggers a specific management action, in particular: triggering a lower limit for mortality to achieve recovery of the stock. |
| $B_{stop}$ | Biomass of the spawning stock, at which recruitment is severely impaired, and the next generation is (on average) expected to produce an equally low spawning-stock biomass as the current. |
| $B_{stoppa}$ | Biomass of the spawning stock at which recruitment is severely impaired, and the next generation has a 5% chance to produce an equally low spawning-stock biomass as the current. |
| Limit anthropogenic mortality ($A_{lim}$) | Anthropogenic mortality, above which the capacity of self-renewal of the stock is considered to be endangered and conservation measures are requested (Cadima, 2003). |
| Limit spawner escapement biomass ($B_{lim}$) | Spawner escapement biomass, below which the capacity of self-renewal of the stock is considered to be endangered and conservation measures are requested (Cadima, 2003). |
| Precautionary anthropogenic mortality ($A_{pa}$) | Anthropogenic mortality, above which the capacity of self-renewal of the stock is considered to be endangered, taking into consideration the uncertainty in the estimate of the current stock status. |
| Precautionary spawner escapement biomass ($B_{pa}$) | The spawner escapement biomass, below which the capacity of self-renewal of the stock is considered to be endangered, taking into consideration the uncertainty in the estimate of the current stock status. |
| $R_{target}$ | The Geometric Mean of observed recruitment between 1960 and 1979, periods in which the stock was considered healthy. |
| Spawner per recruitment (SPR) | Estimate of spawner production per recruiting individual. |
| %SPR | Ratio of SPR as currently observed to SPR of the pristine stock, expressed in percentage. %SPR is also known as Spawner Potential Ratio. |
| ΣF | The fishing mortality rate, summed over the age-groups in the stock. |
| ΣH | The anthropogenic mortality rate outside the fishery, summed over the age-groups in the stock. |
| ΣA | The sum of anthropogenic mortalities, i.e. ΣA = ΣF + ΣH. |
| "3Bs & A" | Refers to the 3 biomass indicators ($B_0$, $B_{best}$ and $B_{current}$) and anthropogenic mortality rate (ΣA). |



Definition: 40% EU Target: "The objective of each Eel Management Plan shall be to 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". The WGEEL takes the EU target to be equivalent to a reference limit, rather than a target.

## Annex SA3: EU Council Regulation (EC) No. 1100/2007

# COUNCIL REGULATION (EC) No 1100/2007

## of 18 September 2007

## establishing measures for the recovery of the stock of European eel

THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 37 thereof,

Having regard to the proposal from the Commission,

Having regard to the opinion of the European Parliament [1],

Whereas:

(1) On 19 July 2004 the Council adopted conclusions concerning the Commission's Communication to the Council and the European Parliament of 1 October 2003 on the development of a Community Action Plan for the Management of European Eel, which included a request to the Commission to come forward with proposals for long-term management of eels in Europe.

(2) On 15 November 2005 the European Parliament adopted a resolution calling on the Commission to immediately submit a proposal for a regulation for the recovery of European eel stocks.

(3) The latest scientific advice from the International Council for the Exploration of the Sea (ICES) concerning European eel is that the stock is outside safe biological limits and that current fisheries are not sustainable. ICES recommends that a recovery plan be developed for the whole stock of European eel as a matter of urgency and that exploitation and other human activities affecting the fishery or the stock be reduced as much as possible.

(4) There are diverse conditions and needs in the Community which require different specific solutions. That diversity should be taken into account in the planning and execution of measures to ensure protection and sustainable use of the population of European eel. Decisions should be taken as close as possible to the locations where eel are exploited. Priority should be given to action by Member States through the drawing up of Eel Management Plans adjusted to regional and local conditions.

(5) Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora [2] and Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy [3] are intended, *inter alia*, to protect, conserve and enhance the aquatic environment where eels spend part of their life cycle and it is necessary to ensure that there is coordination and consistency between measures taken under this Regulation and those taken under the aforementioned Directives. In particular, Eel Management Plans should cover river basins defined in accordance with Directive 2000/60/EC.

(6) The success of measures for the recovery of the European eel stock depends on close cooperation and coherent action at Community, Member State and local and regional level as well as on information, consultation and involvement of the public sectors involved. To this end support from the European Fisheries Fund may contribute to the effective implementation of Eel Management Plans.

(7) If river basins lying within the national territory of a Member State cannot be identified and defined as constituting natural habitats for the European eel, it should be possible for that Member State to be exempted from the obligation to prepare an Eel Management Plan.

(8) In order to ensure that eel recovery measures are effective and equitable, it is necessary that Member States identify the measures they intend to take and the areas to be covered, that this information be communicated widely, and that the effectiveness of the measures be evaluated.

(9) Eel Management Plans should be approved by the Commission on the basis of a technical and scientific evaluation by the Scientific, Technical and Economic Committee for Fisheries (STEFC).



(1) Opinion of 16 May 2006 (not yet published in the Official Journal).

(2) OJ L 206, 22.7.1992, p. 7. Directive as last amended by Directive 2006/105/EC (OJ L 363, 20.12.2006, p. 368).

(3) OJ L 327, 22.12.2000, p. 1. Directive as amended by Decision No 2455/2001/EC of the European Parliament and of the Council (OJ L 331, 15.12.2001, p. 1).

(10) Within a river basin where fisheries and other human activities affecting eels may have transboundary effects, all programmes and measures should be coordinated for the whole of the relevant river basin. However, coordination must not take place at the expense of the rapid introduction of the national parts of Eel Management Plans. For river basins extending beyond the boundaries of the Community, the Community should endeavour to ensure appropriate coordination with the third countries concerned.

(11) In the context of transboundary coordination, both within and outside the Community, special attention should be devoted to the Baltic Sea and European coastal waters falling outside the scope of Directive 2000/60/EC. However, the need for such coordination should not prevent urgent action being taken by Member States.

(12) Special measures to increase the numbers of eels less than 12 cm in length released into European waters as well as for the transfer of eel less than 20 cm in length for the purpose of restocking should therefore be implemented as part of an Eel Management Plan.

(13) By 31 July 2013, 60 % of eels less than 12 cm in length caught annually should be reserved for restocking. The evolution of market prices for eel less than 12 cm in length should be monitored annually. In the event of a significant decline in average market prices for eels less than 12 cm in length used for restocking in eel river basins as defined by Member States, compared to the price of eels less than 12 cm in length used for other purposes, the Commission should be authorised to take appropriate measures which may include a temporary reduction in the percentage of eels less than 12 cm in length to be reserved for restocking.

(14) Catches of eels in Community waters seaward of the boundary of eel river basins defined by Member States as constituting natural eel habitats should be reduced gradually by reducing fishing effort or catches by at least 50 % based on the average fishing effort or catches in the years 2004 to 2006.

(15) Based on information to be provided by Member States, the Commission should produce a report on the outcome of the implementation of the Eel Management Plans and if necessary propose any appropriate measures to achieve with high probability the recovery of European eel.

(16) A control and monitoring system should be established by Member States adapted to the circumstances and to the legal framework already applicable to inland fisheries in consistency with Council Regulation (EEC) No 2847/93 of 12 October 1993 establishing a control system applicable to the common fisheries policy [1]. In this context Member States should establish certain information and estimates concerning commercial and recreational fishing activities to support if necessary the reporting and evaluation of Eel Management Plans as well as control and enforcement measures. Member States should furthermore take measures to ensure control and enforcement of imports and exports of eel,

HAS ADOPTED THIS REGULATION:

*Article 1*

**Subject-matter**

1. This Regulation establishes a framework for the protection and sustainable use of the stock of European eel of the species *Anguilla anguilla* in Community waters, in coastal lagoons, in estuaries, and in rivers and communicating inland waters of Member States that flow into the seas in ICES areas III, IV, VI, VII, VIII, IX or into the Mediterranean Sea.

2. As regards the Black Sea and the river systems connected to it, the Commission shall take a Decision in accordance with the procedure referred to in Article 30(2) of Council Regulation (EC) No 2371/2002 of 20 December 2002 on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy [2], after consultation of the Scientific Technical and Economic Committee for Fisheries by 31 December 2007 on whether these waters constitute natural habitats for the European eel in accordance with Article 3 of this Regulation.

3. Measures under this Regulation shall be adopted and implemented without prejudice to the relevant provisions of Directives 92/43/EEC and 2000/60/EC.

*Article 2*

**Establishment of Eel Management Plans**

1. 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.



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(1) OJ L 261, 20.10.1993, p. 1. Regulation as last amended by Regulation (EC) No 1967/2006 (OJ L 409, 30.12.2006, p. 11), corrected by OJ L 36, 8.2.2007, p. 6.
(2) OJ L 358, 31.12.2002, p. 59.

2. 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.

3. For each eel river basin defined under paragraph 1, Member States shall prepare an Eel Management Plan.

4. The objective of each Eel Management Plan shall be to 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. The Eel Management Plan shall be prepared with the purpose of achieving this objective in the long term.

5. 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.

6. Each Eel Management Plan shall contain a description and an analysis of the present situation of the eel population in the eel river basin and relate it to the target level of escapement laid down in paragraph 4.

7. Each Eel Management Plan shall include measures to attain, monitor and verify the objective set out in paragraph 4. The Member States may define the means depending on local and regional conditions.

8. An Eel Management Plan may contain, but is not limited to, the following measures:

— reducing commercial fishing activity,

— restricting recreational fishing,

— restocking measures,

— structural measures to make rivers passable and improve river habitats, together with other environmental measures,

— transportation of silver eel from inland waters to waters from which they can escape freely to the Sargasso Sea,

— combating predators,

— temporary switching-off of hydro-electric power turbines,

— measures related to aquaculture.

9. Each Eel Management Plan shall contain a time schedule for the attainment of the target level of escapement laid down in paragraph 4, following a gradual approach and depending on an expected recruitment level; it shall include measures that will be applied as of the first year of application of the Eel Management Plan.

10. In the Eel Management Plan, each Member State shall implement appropriate measures as soon as possible to reduce the eel mortality caused by factors outside the fishery, including hydroelectric turbines, pumps or predators, unless this is not necessary to attain the objective of the plan.

11. Each Eel Management Plan shall include a description of the control and enforcement measures which will apply in waters other than Community waters in accordance with Article 10.

12. An Eel Management Plan shall constitute a management plan adopted at national level within the framework of a Community conservation measure as referred to in Article 24(1)(v) of Council Regulation (EC) No 1198/2006 of 27 July 2006 on the European Fisheries Fund (1).

(1) OJ L 223, 15.8.2006, p. 1.

*Article 3*

**Exemption from the obligation to prepare an Eel Management Plan**

1. A Member State may be exempt from the obligation to prepare an Eel Management Plan if appropriate justification is provided that river basins or maritime waters lying within its territory do not constitute natural habitats for the European eel.

2. Member States shall communicate to the Commission not later than 1 January 2008 a request for exemption prepared in accordance with paragraph 1.

3. On the basis of a technical and scientific evaluation by the Scientific Technical and Economic Committee for Fisheries or by other appropriate scientific bodies, the request for exemption shall be approved by the Commission in accordance with the procedure referred to in Article 30(2) of Regulation (EC) No 2371/2002.

4. Where the Commission approves a request for exemption, Article 4 shall not apply to the Member State concerned.

*Article 4*

**Communication of Eel Management Plans**

1. Member States shall communicate to the Commission not later than 31 December 2008 Eel Management Plans prepared in accordance with Article 2.

2. A Member State which has not submitted an Eel Management Plan to the Commission for approval by 31 December 2008 shall either reduce fishing effort by at least 50 % relative to the average effort deployed from 2004 to 2006 or reduce fishing effort to ensure a reduction in eel catches by at least 50 % relative to the average catch from 2004 to 2006, either by shortening the fishing season for eel or by other means. This reduction shall be implemented from 1 January 2009.

3. The reduction in catches set out in paragraph 2 may be substituted in whole or in part by immediate measures concerning other anthropogenic mortality factors, which will allow a number of migrating silver eels equivalent to that which the reduction of catches would allow to escape to the sea to spawn.

*Article 5*

**Approval and implementation of Eel Management Plans**

1. On the basis of a technical and scientific evaluation by the Scientific Technical and Economic Committee for Fisheries or by other appropriate scientific bodies, the Eel Management Plans shall be approved by the Commission in accordance with the procedure referred to in Article 30(2) of Regulation (EC) No 2371/2002.

2. Member States shall implement the Eel Management Plans approved by the Commission in accordance with paragraph 1 from 1 July 2009, or from the earliest possible time before that date.

3. From 1 July 2009, or from the date of implementation of an Eel Management Plan before that date, fishing for eel of the species *Anguilla anguilla* shall be permitted the whole year round provided that the fisheries conform to the specifications and restrictions set out in an Eel Management Plan approved by the Commission in accordance with paragraph 1.

4. A Member State which has submitted an Eel Management Plan to the Commission for approval not later than 31 December 2008, which cannot be approved by the Commission in accordance with paragraph 1, shall either reduce fishing effort by at least 50 % relative to the average effort deployed from 2004 to 2006 or reduce fishing effort to ensure a reduction in eel catches by at least 50 % relative to the average catch from 2004 to 2006, either by shortening the fishing season for eel or by other means. This reduction shall be implemented within three months of the decision not to approve the plan.

5. The reduction in catches set out in paragraph 4 may be replaced in whole or in part by immediate measures concerning other anthropogenic mortality factors, which will allow a number of migrating silver eels equivalent to that which the reduction of catches would allow to escape to the sea to spawn.

6. In the event that the Commission cannot approve an Eel Management Plan, the Member State may submit a revised plan within three months of the decision not to approve the plan.

The revised Eel Management Plan shall be approved in accordance with the procedure established in paragraph 1. The implementation of the reduction in catches set out in paragraph 4 shall not apply if a revised plan is approved by the Commission.

*Article 6*

**Transboundary Eel Management Plans**

1. For eel river basins extending to the territory of more than one Member State, the Member States involved shall jointly prepare an Eel Management Plan.

If coordination is in danger of resulting in such a delay that it will become impossible to submit the Eel Management Plan on time, Member States may submit Eel Management Plans for their national part of the river basin.

2. Where an eel river basin extends beyond the territory of the Community, the Member States involved shall endeavour to develop an Eel Management Plan in coordination with the relevant third countries, and the competence of any relevant regional fisheries organisation shall be respected. If the relevant third countries do not participate in the joint preparation of an Eel Management Plan, the Member States concerned may submit Eel Management Plans for the part of the eel river basin situated within their territory, with the objective of achieving the target level of escapement laid down in Article 2(4).

3. Articles 2, 4 and 5 shall apply *mutatis mutandis* to the transboundary plans referred to in paragraphs 1 and 2 of this Article.

*Article 7*

**Measures concerning restocking**

1. If a Member State permits fishing for eels less than 12 cm in length, either as part of an Eel Management Plan established in accordance with Article 2, or as part of a reduction in fishing effort in accordance with Article 4(2) or Article 5(4), it shall reserve at least 60 % of the eels less than 12 cm in length caught by the fisheries in that Member State during each year to be marketed for use in restocking in eel river basins as defined by Member States according to Article 2(1) for the purpose of increasing the escapement levels of silver eels.

2. The 60 % for restocking is to be set out in an Eel Management Plan established in accordance with Article 2. It shall start at least at 35 % in the first year of application of an Eel Management Plan and it shall increase by steps of at least 5 % per year. The level of 60 % shall be achieved by 31 July 2013.

3. In order to ensure that the respective percentages set out in paragraph 2, of eels less than 12 cm in length caught are used in a restocking programme, Members States must establish an appropriate reporting system.

4. The transfer of eels for restocking shall be part of an Eel Management Plan as defined in Article 2. Eel Management Plans shall specify the quantity of eels of less than 20 cm in length needed for restocking for the purpose of increasing escapement levels of silver eels.

5. The Commission shall annually report to the Council on the evolution of market prices for eels of less than 12 cm in length. For this purpose the Member States concerned shall establish an appropriate system to monitor prices and shall report annually to the Commission on these prices.

6. In the event of a significant decline of average market prices for eels used for restocking, as compared to those of eels used for other purposes, the Member State concerned shall inform the Commission. The Commission, in accordance with the procedure referred to in Article 30(2) of Regulation (EC) No 2371/2002, shall take appropriate measures to address the situation, which may include a temporary reduction of the percentages referred to in paragraph 2.

7. The Commission shall, not later than 1 July 2011, report to the Council and evaluate the measures concerning restocking including the evolution of market prices. In the light of this evaluation, the Council shall decide by qualified majority, on a proposal from the Commission, on appropriate measures to balance the measures concerning restocking while achieving the percentages referred to in paragraph 2.

8. Restocking shall be deemed to be a conservation measure for the purposes of Article 38(2) of Regulation (EC) No 1198/2006, provided that:

— it is part of an Eel Management Plan established in accordance with Article 2,

— it concerns eels less than 20 cm in length, and

— it contributes to the achievement of the 40 % target level of escapement as referred to in Article 2(4).

*Article 8*

**Measures concerning Community waters**

1. Where a Member State operates a fishery in Community waters that catches eel, the Member State shall either reduce fishing effort by at least 50 % relative to the average effort deployed from 2004 to 2006 or reduce fishing effort to ensure a reduction of eel catches by at least 50 % relative to the average catch from 2004 to 2006. This reduction is to be achieved gradually, initially by steps of 15 % per year in the first two years over a 5-year period, from 1 July 2009.

2. For the purposes of paragraph 1, Community waters are those waters seaward of the boundary of those eel river basins which constitute natural eel habitats as defined by Member States according to Article 2(1).

*Article 9*

**Reporting and Evaluation**

1. Each Member State shall report to the Commission, initially every third year, with the first report to be presented by 30 June 2012. The frequency of reporting shall decrease to once every sixth year, after the first three tri-annual reports have been submitted. Reports shall outline monitoring, effectiveness and outcome, and in particular shall provide the best available estimates of:

(a) for each Member State, the proportion of the silver eel biomass that escapes to the sea to spawn, or the proportion of the silver eel biomass leaving the territory of that Member State as part of a seaward migration to spawn, relative to the target level of escapement set out in Article 2(4);

(b) the level of fishing effort that catches eel each year, and the reduction effected in accordance with Articles 4(2) and 5(4);

(c) the level of mortality factors outside the fishery, and the reduction effected in accordance with Article 2(10);

(d) the amount of eel less than 12 cm in length caught and the proportions of this utilised for different purposes.

2. The Commission shall, not later than 31 December 2013, present a report to the European Parliament and the Council with a statistical and scientific evaluation of the outcome of the implementation of the Eel Management Plans, accompanied by the opinion of the Scientific, Technical and Economic Committee for Fisheries.

3. The Commission shall, in the light of the report referred to in paragraph 2, propose any appropriate measures to achieve with high probability the recovery of the stock of European eel and the Council shall decide by qualified majority on alternative measures to achieve the target level of escapement set out in Article 2(4) or a reduction of fishing effort in accordance with Articles 4(2) and 5(4).

*Article 10*

**Control and enforcement in waters other than Community waters**

1. Member States shall establish a control and catch monitoring system adapted to the circumstances and to the legal framework already applicable to their inland fisheries, which shall be consistent with the relevant provisions set out in Regulation (EEC) No 2847/93.

2. The control and catch monitoring system shall contain a thorough description of all systems of allocation of fishing rights in eel river basins which constitute natural eel habitats as defined by Member States according to Article 2(1), including privately owned waters.

*Article 11*

**Information concerning fishing activities**

1. By 1 January 2009, each Member State shall establish the following information concerning commercial fishing activities:

— a list of all fishing vessels flying its flag authorised to fish for eel in Community waters in accordance with Article 8, notwithstanding the overall length of the vessel,

— a list of all fishing vessels, commercial entities or fishermen, authorised to fish for eel in eel river basins which constitute natural eel habitats as defined by Member States according to Article 2(1),

— a list of all auction centres or other bodies or persons authorised by Member States to undertake the first marketing of eel.

2. Member States shall establish on a regular basis an estimate of the number of recreational fishermen and their catches of eels.

3. On a request from the Commission, Member States shall provide the information referred to in paragraphs 1 and 2.

*Article 12*

**Control and enforcement concerning imports and exports of eel**

No later than 1 July 2009, Member States shall:

— take the measures necessary to identify the origin and ensure the traceability of all live eels imported or exported from their territory,

— determine whether the eel harvested in the Community area and exported from their territory was caught in a manner consistent with Community conservation measures,

— take measures to determine whether the eel harvested in the waters of any relevant regional fisheries organisation and imported into their territory was caught in a manner consistent with the rules agreed in the regional fisheries organisation in question.

*Article 13*

**Entry into force**

This Regulation shall enter into force on the third day following that of its publication in the *Official Journal of the European Union*.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at Brussels, 18 September 2007.

*For the Council*

*The President*

R. PEREIRA

## Annex SA4: Recommendations of the ICES Workshop on Eels and Salmon in the Data Collection Framework WKESDCF

Changes to the EU Data Collection Framework (DCF) in 2007 introduced requirements to collect data on eel and salmon, but the specific data requested for these species did not meet the needs of national and international assessments. The proposed development of the new Data Collection - Multi-Annual Programme (DC-MAP) in 2013 provided the opportunity to coordinate and improve the collection of data used in assessments for these species. ICES convened at workshop to address the following tasks:

- determine the data required to support international obligations for the assessment of eel and salmon;
- describe the national monitoring and survey programmes required to meet these data requirements; and
- consider options for integrating salmon and eel surveys and monitoring.

For each species/area, the workshop considered: the national/international management objectives; the assessments undertaken to support these objectives; the data required to undertake the assessments; and the proposed changes to the DC-MAP to provide these data.

Eel and salmon differ markedly from marine species in their biology, the nature and distribution of their fisheries, and the methods used to assess stock status and provide management advice. As a result, the data collection requirements do not fit well into the 'standard' approaches used for marine species. In particular, much of the assessment of both species is conducted at a local and national level even when the results contribute to international assessments. These approaches may differ depending upon a range of factors including the practicalities of collecting particular data.

The Workshop made detailed recommendations for several tiers of data collection. There are some data (e.g. catches) that are required for all stock components; these data are of little value if they are not collected in a consistent way for all fisheries. The collection of other data may depend on local requirements and constraints.



### General recommendations

- The revised DCF Regulation should cover the collection of data on all recreational and commercial eel and salmon fisheries regardless of how they are undertaken; however it should be noted that the distinction between recreational and commercial fisheries is not always clear, and it may be difficult to define precise métier because of the varied and specialised methods used to exploit these species (Section 2.2.2);
- Economic data should be collected for both salmon and eel fisheries (however the Workshop did not address this topic in any detail) (Section 2.2.2);
- For clarity, eel and salmon should be dealt with in separate subsections to marine species in the new DC-MAP (Section 2.3), the data elements for Baltic and Atlantic salmon should also be separately specified under the new DC-MAP, and these requirements for eel and salmon should be integrated with those relating to the WFD, MSFD and HD (Section 4.1.3);

- There will need to be some flexibility in the requirements for data collection on eel and salmon, but ICES should be given the role of confirming that proposed data are appropriate and/or required [see other recommendations] (Section 2.3);
- Sampling of diadromous species within national programmes should endeavour to meet the standards of precision required for marine species, and where this is impractical it should be addressed within the usual derogation procedures or pilot studies (Section 5);
- An international pilot study (appropriate under 93/2010, Ch. II Sec B, Para. 1) would be a fruitful way forward: to establish minimum standards for data collection on the basis of current expert judgement; to analyse achieved precision levels where adequate databases exist; and to stimulate further analysis when and where more data become available within the framework of the DC-MAP. Separate pilot studies might be required for eels and salmon, but a joint study should be considered (Section 5);
- Habitat data collection should be included under the new DC-MAP, and this should be harmonised with the requirements to collect data on habitat under Article 17 of the Habitats Directive (Section 6);
- Member States should seek opportunities to harmonise data collection programmes for eels and salmon, particularly in relation to electrofishing surveys, trapping facilities, automatic counters and habitat surveys (Section 6).

## Recommendations concerning data collection for eel

- The future DC-MAP should make delivery of EMP assessment results for eel (biomass, mortality rates, restocking amounts) to ICES an obligation for Member States (Section 3.4.1);
- A coordinated programme of work should be undertaken to address the assessment of densities or standing stock of eels in large open water bodies, such as lakes, deep rivers, transitional and coastal waters; this is a suitable topic for an international "Pilot Study" under the DC-MAP (Section 3.4.2);
- The requirement to collect fecundity data on European eel should be removed from the DC-MAP (Section 3.5);
- The following data should be collected annually for all fisheries exploiting European eel:
- fishing capacity and effort;
- number and weight of all eel caught, separated by:
- commercial and recreational fisheries;
- location of fishery (freshwater, transitional and coastal);
- stage (eel<12 cm length, yellow, silver);
- number and weight of glass eel/elver used for restocking (Section 3.6).
- The following data should be collected at least once in every EMP reporting period for fisheries exploiting European eel, subject to minimum catch thresholds:
- Information on the abundance and distribution of exploited eels necessary to estimate mortality rates in those EMUs supporting fisheries where the

catch is estimated at or exceeding 25 t of silver eel equivalents per year (or as approved by ICES) (Section 3.6).

- The following data should be collected annually for stocks in at least on 'Eel index river' per EMU, as agreed by ICES:
- information on abundance of recruits (glass eel and/or elvers);
- information on abundance of standing stock (yellow eel);
- counts or estimates of the number, weight and sex ratio of emigrating silver eel;
- information on anthropogenic impacts in these systems, on all life stages (Section 3.6).
- Eel recruitment time-series identified by ICES as contributing to the annual international stock assessment process should be included in the new DC-MAP (Section 3.6);
- The new DC-MAP should include surveys for standing stock of eel as employed for assessing stock compliance with EMP limits, and should integrate the DC-MAP surveys with WFD and MFSD surveys (Section 3.6);
- The following data collection should be included in the new DC-MAP, estimated at EMU level and at appropriate temporal frequencies:
- growth rates of eel, determined at yellow and silver stages;
- sex ratio of standing stock and silver eel;
- infection intensity and abundance of *Anguillicoloides crassus*, and other parasites and diseases as recognised by ICES as having a potential impact on effective spawner stock biomass;
- tissue concentrations of contaminants as recognised by ICES as having a potential impact on effective spawner–stock biomass (Section 3.6).
- The new DC-MAP should support the need for international surveys at sea of eel in the spawning area in the Sargasso Sea (Section 3.6);
- The new DC-MAP should include support for the collection of data necessary to establish the mortality caused by non-fisheries anthropogenic factors (Section 3.6).

## Annex SA5: Recruitment dataseries

**Link to Table M-1: Raw recruitment data**