Nomination

Anguilla anguilla (Linnaeus 1758), European eel

Geographical extent

OSPAR Regions: I, II, III, IV, V
Biogeographic zones: 5,6,8,9,10,11,12,13,14,15,16,17,19,23
Region & Biogeographic zones specified for decline and/or threat: as above

Eel can occur in all ICES fishing areas in the north-east Atlantic except for the areas directly east of Greenland and the Spitsbergen area north of continental Norway (Figure 2). Within its distribution area it cannot be confused with any other species of fish (except possibly with *Conger conger*) with its elongated snake-liked body and smooth slimy skin.[1] Before reaching sexual maturity the eel can reach a length of well over 1 m and a weight of several kilos. It can also attain a very high age, well over 50 years (CITES 2007a).

The European eel has an unusual distribution pattern with its spawning grounds somewhere in the warm offshore waters of the Sargasso Sea, an extended larval phase migration using the Gulf Stream to reach European coasts, and an adult distribution in freshwater habitats and adjacent brackish and coastal marine waters of Iceland and Europe from Norway southward, Northwest Africa, and the Mediterranean and Black Sea watersheds of Turkey and the Middle East (Figure 3 a, b). Adults migrate back to the West Atlantic, probably spawn only in one season and die afterwards (Dekker 2003; Froese & Pauly 2006; Fricke 2007).

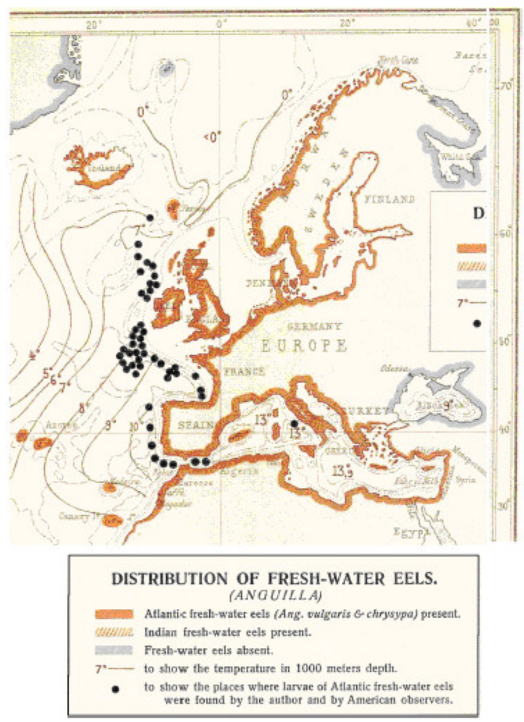

Figure 2: Distribution of *Anguilla anguilla* in European coastal waters. Map reproduced and adapted from Schmidt (1909); source: Dekker 2003. The Black Sea as part of the natural distribution area of the European eel is currently debated.

[1] However, it should be noted that Iceland is unique in that it can harbour European eel (*Anguilla anguilla*) *and* American eel (*Anguilla rostrata*) hybrids. Historically, the numbers of either species in Iceland have been low.

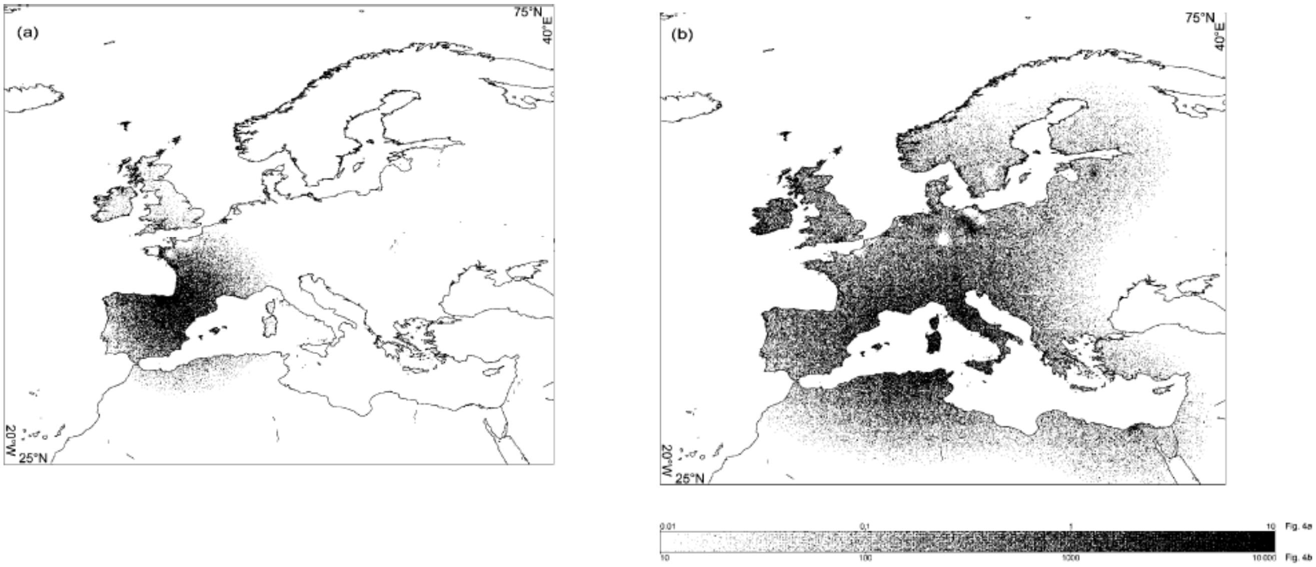

Figure 3 (from Dekker 2003): Model prediction (Kriging technique) of geographic spread of eel fishing yield per surface area. Spatially predicted values are scaled between minimum and maximum observed values, represented by dithered gray scales: the higher the density of pixels, the higher the yield. Note the logarithmic transformation of the yield. (*a*) Yield of glass eel per river drainage area. (*b*) Yield of yellow/silver eel per water surface area. Legend for Figs. 3*a* and 3*b*: units in kg·km–2; the scale is logarithmic.

Application of the Texel-Faial criteria

Global/regional importance

Global importance. As a conservative estimate, at least 80% (possibly 100%) of the larvae of European eel pass through the OSPAR Maritime area, and at least 50% of the adult eels live in river systems flowing into the area. Therefore, OSPAR Maritime Area is of global importance for *Anguilla Anguilla.*

Decline

Severely declined. The population of the European eel (*Anguilla anguilla*) is in decline and current fisheries are considered outside sustainable limits (WGEEL 1999, 2000, 2001, 2002, 2005, 2006). For European eel, a massive decline of *glass eel* arriving at European coasts was observed during the last 25 years (Figure 4, 5). It has been estimated that 1-5% of the former numbers of recruit arrive in Europe today (Dekker 2004; WGEEL 2006; CITES 2007a). There are no signs of improved recruitment since the worst year of 2001; thus it is likely that the stock will continue to decrease (Figure 4). Due to the long time lag between recruitment (glass eel) and maturity (silver eels), the severity of the situation of European eel is often not realized by fishermen, fishery managers and even scientists (H. Wickström, Swedish Board of Fisheries, Institute of Freshwater Research, Drottningholm, personal communication, 11 Feb. 2005).

Sensitivity

The European eel *Anguilla anguilla* has an unusual life history, making its sensitivity difficult to assess. Eels are long-lived and spawn only once in their lifetime (Figure 6). An analysis of the stock dynamics under different management regimes indicates that the recovery time for eel could be at least 20 years, depending on the implemented fisheries restrictions and the model assumptions (Åström & Dekker 2006).

Anguilla anguilla shows a complex and not yet fully understood migration pattern with a large proportion of the stock showing catadromous spawning migrations after a freshwater life history stage. After semelparous spawning of adult eel in the western Atlantic Sargasso Sea. European eel leptocephalus larvae follow the Gulf Stream and arrive in Europe as "glass" eels. The migration towards Europe takes seven months to three years. Arriving in western European continental waters, glass eels are regularly harvested for direct human consumption or collected for aquaculture and restocking purposes. European eel is relatively long-lived; the generation time is 12 years in the North Sea drainages and continental Europe, but 17-20 years in Scandinavia and around most of the Baltic Sea (Dekker 2003, 2004; H. Wickström, Swedish Board of Fisheries, Institute of Freshwater Research, Drottningholm, Sweden, personal communication, 11 Feb. 2005). Maximum total length 50 cm (male), 133 cm (female); maximum total weight 2.85 kg; maximum individual age 85 years, usually up to 15-20 years (Fricke 2007, Vollestad 1992).

As stated above, it is generally believed that most eels are catadromous. However, yellow eels can also be found in estuarine and coastal habitats throughout the area where glass eels and elvers occur naturally, and some may actually remain in marine habitat their entire life-cycle (Tsukamoto et al 1998, Daverat et al 2006). For the Baltic Sea is emerging that around 80% of the eel could remain in this marine habitat for all their life (Wickström & Westerberg 2006).

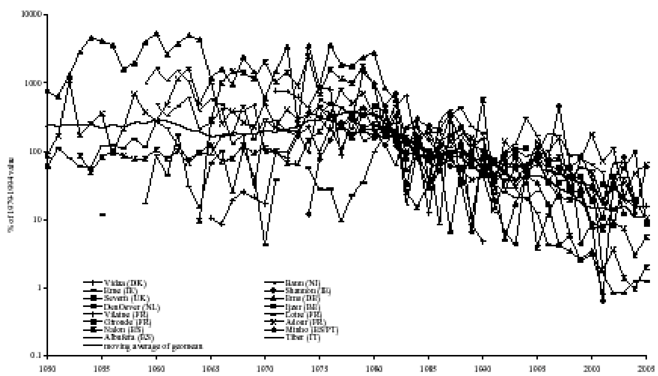

Figure 9.4.9.1 Time-series of **glass eel** monitoring in Europe. Each series has been scaled to the 1979-1994 average. The heavy line indicates the geometric mean of the series from Loire (F), Ems (D), Göta Älv (S), and DenOever (NL), which are the longest and most consistent time-series.

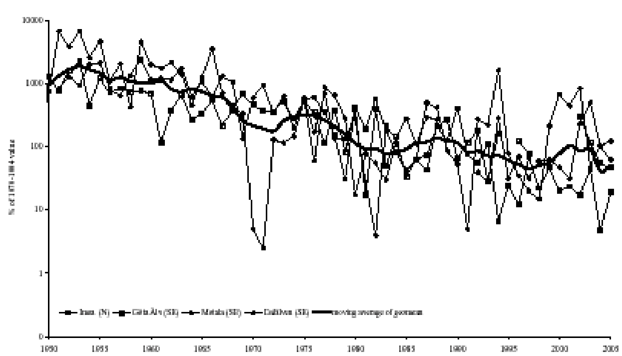

Figure 9.4.9.2 Time-series of **yellow eel** recruitment. Each series has been scaled to the 1979-1994 average. The heavy line indicates the geometric mean of all time-series.

Figure 4: Trends in recruitment and landings of the European eel. Glasseel (above), yellow eel (below). Source: ICES 2006a.

Threat

Although European eels still seem to be common in many areas (mainly due to introduction), they are subject to several threats. Main threats include: fisheries, stream migration blockages, loss of habitat, pollution, parasites and diseases, predatory birds as well as climatic changes of their environment especially during their larval marine migration.

Different life stages of eel are targeted in several countries. The youngest eel stages (glass eel and elvers) are heavily exploited as they are the basis of a worldwide established eel aquaculture industry; yellow and silver eels are also major targets for freshwater and coastal fisheries and their migration into and from rivers is impeded by dams and hydropower stations. Current eel fisheries and eel aquaculture in Europe is based on young eel mainly exported from France, Great Britain and Spain and traded within the EU. A substantial part of European glass-eel catches are traded on the Asian market, mainly to China and Japan. Some 90% of eel consumed in the world is based on eel aquaculture, but like direct fishing, this is based on young eel caught in the wild. The glass eel stage is by far the most commercially important life stage and a substantial proportion (~50%) of European glass-eel catches are for aquaculture, most of which (~85%) are bound for Asian markets (CITES 2007a).

Fisheries: European eel has been commercially heavily exploited in fisheries, though catches in many areas have considerably decreased. The fishing yield of European eel amounts to more than half of the world eel fisheries on all eel species. Annual averages in the 1990s, according to FAO data bases, were of the order of approx. 15,000 tons out of a world fisheries catch of some 29,000 tons (CITES 2007a).

Dekker (2003) and Moriarty & Dekker (1997) reviewed the locations of fisheries with regard to stocking and life history. The fisheries threat is not confined to glass eel, but applies to all life stages including migrating, maturing silver eel. European eels on their spawning migration may also be caught as bycatch in trawl and other demersal fisheries, though the numbers are not believed to be high. The threat situation has been discussed in detail by WGEEL (2006).

It is hoped that the recent June 2007 EC eel regulation should help address the fisheries threat (EC 2007). Assuming the implementation of immediate action, analysis of stock dynamics under different fisheries management regimes indicates that recovery times may vary from 20 up to 200 years, depending on the intensity of implemented fisheries restrictions. However, restrictions on fisheries alone will be insufficient, and management measures aimed at other anthropogenic impacts on habitat quality, quantity and accessibility will also be required (WGEEL 2006).

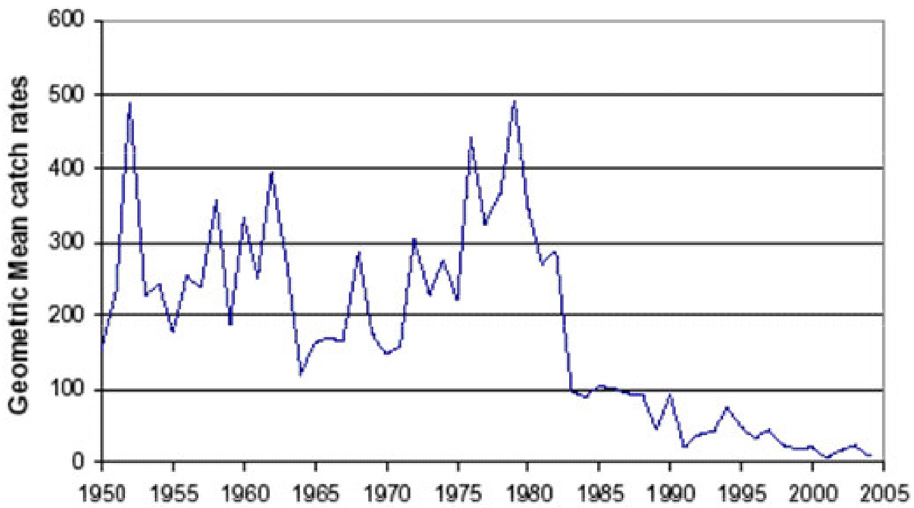

Figure 5: Time series of glass eel monitoring in Europe. The line indicates the geometric mean of the series from the Loire (FR), Ems (DE), and DenOevre (NL), which are the longest and most consistent time series. Source: ICES 2005.

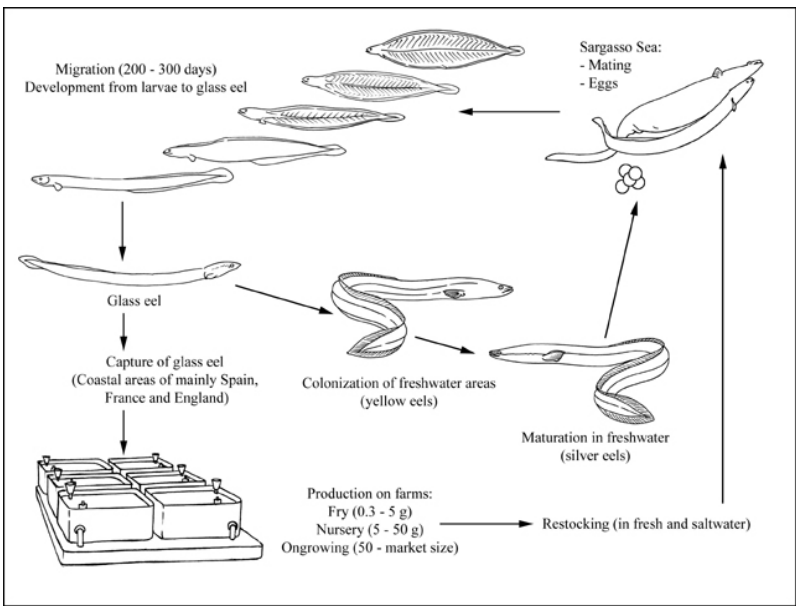

Figure 6: life cycle of European eel. Source: FAO 2007.

Migration blockage: Accessibility between inland waters and the sea is crucial for the natural occurrence and dispersal of European eels. Eels introduced in upstream rivers and streams often never reach the ocean on their spawning migration, due to a multiplicity of possible hazards, mostly electrical turbines, dams, weirs, and drained watercourses.

Pollution: There is evidence that chemical contamination can affect spawning success (WGEEL 2006; EELREP 2005) but there is not sufficient data to evaluate this at the stock-wide level. Most contaminants are not absorbed through the skin, but via the food-chain. There is considerable evidence that eel fat, muscle and internal organs accumulate chemical contaminants such as PCBs, Dioxins, pesticides and heavy metals (WGEEL 2006).

Climate change: There are indications that climate change, as reflected by the North Atlantic

Oscillation Index, is affecting eel recruitment. The drastic decline in recruitment of European eels in the 1970s coincided with an almost identical decline in recruitment of the American eel (*Anguilla rostrata*). A high NAO, indicating warmer oceanic climate with warmer sea surface temperatures and stronger westerly winds seem to have a clearly negative impact on eel larvae.

Diseases: In recent years, eels have been affected by parasites (e.g. the swim-bladder nematode *Anguillicola crassus*), viruses (*EVEX, EVE, HVA*) and other diseases. Effects were reviewed by WGEEL (2006). Parasite infections are not only a reflection of general health problems, but in extreme cases, such as with *Anguillicola crassus,* may cause debilitation and even mortality. *Anguillicola* infections have been shown to damage swim bladders and impair the swimming ability of infected eels (EELREP 2005). The impact of *Anguillicola* has not been evaluated at the stock level.

Relevant additional considerations

Sufficiency of data

Data are considered as sufficient to indicate a severe depletion of stocks that is most probably caused or exacerbated by human activities. However, there is as of yet still no agreed assessment method for European eel. This is due to both methodological issues and lack of data. An assessment method for eel was proposed by Dekker (2000). The current advice on the status of the eel stock is largely based on the recruitment time series and secondly on the landing statistics for adult eel.

National monitoring of the various eel stages is fragmentary. Some traps on rivers provide fairly reliable data on upstream migration of young yellow eels, but there are virtually no regular routine surveys of yellow and silver eel in fresh water or along the coasts. Some of the long-term series may also be terminated in the near future as a consequence of decreased turnover of local fisheries and the impossibility of addressing this large-scale stock decline at the local level (CITES 2007a).

There are also inconsistencies between official statistics on eel landings and ICES estimates. The WGEEL recently (2006) reviewed the available data, and the Workshop on National Data Collection – European Eel, Sanga Saby, Sweden, September 2005, also reviewed and made recommendations for improvements on monitoring and data collection.

Routes of the adult spawning migration, location of spawning sites, spawning habitats and reproductive biology are still largely unknown. The lack of specific knowledge about eel biology, particularly about spawning areas and aspects of larval biology, makes it difficult to identify changes in the environment that might be critical to eel survival. Possible factors include changes in access to food as well as changes in the direction of sea currents that transport the *Leptocephalus* larvae to the European coasts.

Changes in relation to natural variability

Natural variation: While the relative contribution of the various possible influences causing stock decline remain unknown, specific focus is necessarily placed on those processes and influences which are potentially manageable. As indicated above, the coincidence of decline for both the European and Atlantic and Pacific American eel stocks point to a possible common cause, such as climate change, probably augmented by human induced impacts on the eel stock in European waters. Some authors (e.g. Knights 2003) even propose oceanic climate to be the major cause of decline, whereas others do not (see Dekker (2004) for a comprehensive discussion).

Genetic variation: Little is known about the genetic variability and a putative population structure within *Anguilla anguilla*. Earlier molecular genetic studies indicated that European eel exhibits isolation by distance, implying non-random mating and restricted gene flow among eels from different locations (Wirth & Bemachez 2001). However, more recent research has suggested that the European eel is genetically panmictic and the genetic variation found is of mainly temporal and not spatial origin (Albert *et al.*2006, Dannewitz *et al.* 2005, Maes *et al.* 2006 a,b., Pujolar *et al.* 2006). In spite of the apparent genetic similarity with distance, the stock is not biologically homogeneous over its range and there are considerable geographical differences in recruitment patterns, population dynamics (i.e. growth rates, sex ratios, rates of survival, and productivity of the habitat). Taking this into account the ICES Working Group on Application of Genetics in Fisheries and Mariculture (WGAGFM) recommended in their 2007 report that “in the light of emerging information suggesting putative stock structure of European eel it is recommended from the genetic viewpoint that glass eels, elvers and other life history stages should not be trans-located between river basins for restocking purposes“.

Expert judgement

It is most probable that human factors (including fisheries, habitat destruction, chemical contamination and the spread of *Anguillicola* *crassus*) contributed to the depletion of eel stocks, although oceanic and climate change factors cannot yet be discounted (ICES 2006).

The ICES Working Group on the Application of Genetics in Fisheries and Mariculture (WGAGFM 2004) reported on the possible genetic risks of transferring eels over long distances. There is some general agreement that the European eel stock is one panmictic homogeneous stock (Dannewitz *et al.* 2005), but there are dissenters from this view. The ICES WGAGFM concluded that application of the precautionary principle obliges management actions to minimize necessary transfer distances and to manage the natural spawning stock over as wide a geographical area as possible.

ICES WGEEL Evaluation

The ICES/EIFAC Working Group on Eels (e.g. WGEEL 2005, 2006) has evaluated trends in recruitment, stock and yield, modelling of local stock dynamics, monitoring of eel fisheries, and management measures. WGEEL concludes that the population as a whole has declined in most of the distribution area, that the stock is outside safe biological limits and that current fisheries are not sustainable. Recruitment is at a historical minimum and most recent observations indicate the decline continues in many areas. There is some evidence that depensation[2] in the reproductive phase might be involved, triggering a new and heightened level of precautionary advice. Under this situation, the advice is to restore spawning stock biomass above levels at which depensation is expected to occur. Evidence has been given in earlier WGEEL reports that anthropogenic factors (e.g. exploitation, habitat loss, contamination and transfer of parasites and diseases) as well as natural processes (e.g. climate change, predation) have likely contributed to the decline. Measures aimed at recovery of the stock are well known and should be a composite of exploitation, restocking of recruits (though critical due to small number of glass eels and uncertainty whether those eels would find back to the spawning grounds in the Sargasso Sea) and restoration of habitats (including access to and from).

The 2005 WGEEL report proposed to strengthen the knowledge base. The information in this report constitutes a further step in an ongoing process of documenting eel stock status and fisheries and developing a methodology for giving scientific advice on management, specifically for eel. To this end, a line of thought has been generated in previous reports (WGEEL 2000; 2002), and an inventory of ultimately required knowledge assembled (Moriarty and Dekker 1997; WGEEL 2000, 2001).

The 2006 session of the Joint EIFAC/ICES Working Group on Eels at FAO headquarters in Rome (Italy) recommended that:

a. the rapid development and implementation of **management plans** is facilitated in a work programme of workshops and guidelines, *inter alia* for:
   - re-stocking practices,
   - recruiting eel immigration passages,
   - silver eel deflection schemes,
   - monitoring and post-evaluation procedures, potentially in pilot projects,
   - pollution and disease monitoring,
   - development of models and tools for management of the stock;

b. **areas producing high quality spawners** (large sized females, low contaminant and parasite burdens, unimpacted by hydropower stations) be identified in order to **maximise protection** for these areas;

c. **management targets are set for spawner escapement** with reference to the 1950s–1970s, either identifying the actual spawner escapement levels of that period in full, or 30–50% of the calculated spawner escapement that would have existed if no anthropogenic mortalities would have impacted the stock – and where adequate data are absent, with reference to similar river systems (ecology, hydrography);

d. under the implementation of the **WFD eel specific extensions** should be implemented as an indicator of river connectivity and ecological and chemical status.

(WGEEL 2006, p vii)

Threat and link to human activities

Relevant human activity: Fishing, hunting, harvesting; constructions; land-based activities.

Category of effect of human activity: Physical - damage in turbines; chemical – toxin accumulation; biological – removal as target and non-target species by fisheries, diseases, parasites, predatory birds.

[2] Depensation: The effect where a decrease in spawning stock leads to reduced survival or production of eggs, a) through increased predation per egg given constant predator pressure, or b) the 'Allee' effect which is the reduced likelihood of finding a mate.(http://filaman.ifm-geomar.de/Glossary/Glossary.cfm?TermEnglish=depensation)

Due to its unusual and complicated life history, reasons for the decline of the European eel are not fully understood. However, there are indications of linkages between the decline of eels and human activities, especially by fisheries, construction of dams, weirs or embankments in rivers, chemical pollution and loss / damage of eel habitats.

Management considerations

Current management

UNCLOS: Catadromous species (spawning in the sea but often growing and maturing in inland waters) like the European eel are recognised under the United Nations Convention on the Law of the Sea (UNCLOS), under Article 67. In short, the following rules apply:

1. Coastal states/countries are responsible for management, but also states through the territory of which the species migrate are responsible for binding agreements concerning management measures.

2. Fishing at sea is allowed within the Exclusive Economic Zone but prohibited in the high seas.

3. Management must include provisions for secured immigration and emigration of the species.

(noted in CITES 2007a, p14)

CITES Appendix II: In June 2007, the listing of European eel on Appendix II of CITES was adopted. In general, such a listing includes those species that, although not necessarily threatened with extinction, may become so unless trade is strictly regulated in order to avoid utilization incompatible with their survival. International commercial trade in Appendix II species is allowed, but is controlled. Parties may only grant a permit to export such species after it has determined that the export will not be detrimental to the survival of the species. Management can be summarised as follows:

1. An export permit or re-export certificate issued by the Management Authority of the State of export or re-export is required. An export permit may be issued only if the specimen was legally obtained and if the export will not be detrimental to the survival of the species. A re-export certificate may be issued only if the specimen was imported in accordance with the Convention.

2. In the case of a live animal or plant, it must be prepared and shipped to minimize any risk of injury, damage to health or cruel treatment.

3. No import permit is needed unless required by national law. In the case of specimens introduced from the sea, however, a certificate has to be issued by the Management Authority of the State into which the specimens are being brought, for species listed in Appendix I or II.

(CITES 2007b)

EC eel regulation: The Council Regulation (EC) No 1100/2007 establishing measures for the recovery of the stock of European eel was adopted on 18 September 2007 (EC 2007a).

- o It is based on the 2003 Action Plan for management of European Eel (COM 2003-573); 2005 Proposal for a Council Regulation establishing measures for the recovery of the stock of European Eel (COM 2005-472); 2006 European Parliament proposed amendments; and ensuing in-depth discussions.
- o It applies to Community maritime waters and inland waters of EU Member States that discharge into ICES areas III, IV, VI, VII, VIII, IX and the Mediterranean.
- o MS must designate “eel river basins” – natural eel habitat.
- o Because the characteristics and pressures on river basins vary considerably, each MS is asked to submit a separate Eel Management Plan for each eel river basin (or one covering each entire eel river basin territory), by 31 December 2008. In the case of shared river basins, Eel management plans are to be prepared jointly by riparian states. Failure to submit an adequate management plan on time will result in a mandatory 50% reduction in fishing effort.[3]
- o The goal of the management plans should be to allow at least 40% of the silver eels to escape to the sea (measured with respect to undisturbed conditions).[4,5]

[3] It should be noted that ICES recommended the implementation of a **recovery plan for the whole stock** (ICES WG EEL 2005). 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.

[4] It should be noted that ICES advice was 50%, due to the large uncertainties in eel management and biology, and because there is one single stock, spawning only once in their lifetime (ICES 2006b).

[5] ICES also has some concerns using one objective for all fish, since male and females grow to different sizes: “...as females grow bigger than males (>50 cm against <45 cm)

- o 60% of eel <12cm long are to be used in restocking, aiming to increase escapement of silver eel to the sea. (Starting at 35%, ramping up to 60% silver eel to the sea by 2013).[6]

- o Maritime catches are to be reduced to 50% of average 2004-2006 catches, and will be phased in over a five year period from when the regulation enters into force.

(Theophilou 2007; EC 2007b)

Other EU legislation:

- o The Water Framework Directive: The 2003 Action Plan for management of European Eel (COM 2003-573) considered the possibility to include eel as an indicator species for "good ecological status" in relation to "river continuity", *i.e.* as a biological quality element; This could build upon the currently existing quality element "composition, abundance and age-structure of ichthyofauna" (Annex V, items 1.1.1, 1.2.2 of the Directive) the interpretation of which is at the discretion of Member States..

- o The Common Fisheries Policy only applies to eel fisheries in fully marine areas.

  Until the national eel management plans (cf Council Regulation (EC) No 1100/2007) have been approved by the Commission and are put in place, the eel fishery is closed from the 1st to the 15th of each month (COM(2005) 472 final). Fishing could, however, continue during the closed period where a Member State can reliably demonstrate that measures of similar effectiveness guaranteeing the 40% escape rate requirement are already in place. Fishing for glass eel could also continue if these eels are used for restocking rivers but not used for aquaculture. Seasonal closures have been applied locally in several areas. The effects of such closures to restrict fishing have not been evaluated. In some countries there are license systems that control the glass eel fisheries.

- o The EU Habitats Directive: Eel have a very wide ranging area, covering most European inland waters. For this kind of species, the Directive states that "sites will be proposed only where there is a clearly identifiable area representing the physical and biological factors essential to their life and reproduction". However, because eels are very widely distributed, it is difficult within this legal framework to argue that particular sites should receive enhanced protection over others.

HELCOM: HELCOM has listed *Anguilla anguilla* on its List of threatened and/or declining species and biotope/habitats in the Baltic Sea area.

Sweden: Sweden has listed the eel on its national Red List as Criticially Endangered.

Restocking: Restocking has been practised by some countries for decades, generally to maintain fisheries. Since artificial reproduction is currently not possible for eel, all aquaculture and restocking has to be based on capture of glass eels. There is currently no evidence indicating the effectiveness of restocking in improving the spawning stock biomass or recruitment.

Further management

The national management plans for the recovery of eel as required by Council Regulation (EC) No 1100/2007 should target the recovery of the spawning stock rather than the sustainability of the eel fisheries. Restocking measures from the natural glasseel stocks should be minimised and should therefore primarily take place in those waters/river-basins through which the fish can migrate back to the sea, and where environmental conditions (e.g. low contamination) are most favourable to producing healthy eel populations. Here, fishing should be restricted or closed so that a minimum of 40 % of the population can migrate back to the sea. Longterm monitoring is required.

As recommended by ICES (WG Eel 2006) areas producing high quality spawning eels should be closed to fishery. Building on the river-basin management plans for the recovery of eel as required by Council Regulation (EC) No 1100/2007, a recovery plan for the whole stock of European Eel needs to be implemented (ICES WG Eel 2005). This may include 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. Management targets should be set for both eel sexes separately.

---

and sexual differentiation is density dependent, there is a risk that for some river basins the objective is reached with only male escapement due to directed harvesting of large fish. ICES recommends that the objective should be defined in terms of both sexes separately." (ICES 2006b, p118)

[6] In case of significant differences between the price of glass eel destined for restocking and the price of those marketed for other uses, the percentage required to be set aside for restocking will be temporarily reduced in order to counter the price discrepancies.

In rivers and streams adjacent to OSPAR area, fish passes ("ladders") could be constructed that prevent the passage of eels through turbines and favour downstream migration. The content of heavy metals and chemical pollution of freshwater habitats needs to be considered in light of declining eel populations. Licensing of dealers and fishers, where this is not already occurring, should be considered.

Further information

Nominated by:

Separately submitted by Germany and WWF to OSPAR MASH 2006 and BDC 2007. This case report was compiled from those two separate nominations, incorporating comments received from ICES WGEEL review in 2007, and also drawing upon the successful CITES (2007a) nomination document.

Contact Persons

Germany

- o Ronald Fricke, Ichthyology, Staatliches Museum für Naturkunde, Rosenstein 1, D-70191 Stuttgart, Germany;
- o Christian Pusch, Bundesamt für Naturschutz, Außenstelle Insel Vilm, D-18581 Putbus, Germany;
- o Jeff Ardron, Bundesamt für Naturschutz, Außenstelle Insel Vilm, D-18581 Putbus, Germany.

WWF

- o Sabine Christiansen, North-East Atlantic Marine Ecoregion Programme, Hongkongstr.7 D-20457 Hamburg

Useful References

Albert, V., Jónsson, B., Bernatchez, L. 2006. Natural hybrids in the Atlantic eels (*Anguilla anguilla, A. rostrata*): evidence for successful reproduction and fluctuating abundance in space and time. Molecular Ecology 15, 1903-1916.

Åström, M. & W. Dekker. 2006. Speed of recovery of recruitment of the European eel. ICES ASC CM 2006/J:35, 21 pp.

CITES 2007a. Proposal: Inclusion of *Anguilla anguilla* (L). in Appendix II in accordance with Article II §2(a). Convention on International Trade in Endangered Species of wild flora and fauna. Fourteenth meeting of the Conference of the Parties, The Hague (Netherlands), 3-15 June 2007. CoP14, Prop. 18. Document accessed 8 Aug 2007: http://www.cites.org/common/cop/14/raw_props/E-DE04-Anguilla%20anguilla.pdf

CITES 2007b. How CITES works. Convention on International Trade in Endangered Species of wild flora and fauna. Web site accessed 13 Aug 2007: http://www.cites.org/eng/disc/how.shtml

COM 2003-573. Development of a Community Action Plan for the management of European Eel. Communication from the Commission to the Council and the European Parliament. Document accessed 30 July 2007: http://eur-lex.europa.eu/LexUriServ/site/en/com/2003/com2003_0573en01.pdf

COM 2005-472 (final). Proposal for a Council Regulation establishing measures for the recovery of the stock of European Eel. Communication from the Commission to the Council and the European Parliament. Document accessed 30 July 2007: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2005:0472:FIN:EN:HTML

Dannewitz, J., Maes, G.E., Johansson, L., Wickström, H., Volchaert, F.A.M., and Järvi, T. 2005. Panmixia in the European eel: a matter of time? Proc. Royal Society of London, **272**: 1129-1137.

Daverat, F., Limburg, K. E., Thibault, I., Shiao, J-C., Dodson, J. J., Caron, F., Tzeng, W-N, Iizuka, Y., and Wickström, H. 2006. Phenotypic plasticity of habitat use by three temperate eel species, *Anguilla anguilla, A. japonica and A. rostrata.* Marine Ecology Progress Series 308: 231-241.

Dekker, W. 2000a. The fractal geometry of the European eel stock. ICES Journal of Marine Science, **57**: 109–121.

Dekker , W. 2003. On the distribution of European eel (*Anguilla anguilla*) and its fisheries. Canadian Journal of Fisheries and Aquatic Sciences, 60(7): 787-799.

Dekker, W. 2004. Slipping through our hands. Population dynamics of the European eel. Amsterdam (Universiteit van Amsterdam), Akademisch Proefschrift, 188 pp. Document accessed 30 July 2007: http://www.diadfish.org/doc/these_2004/dekker_thesis_eel.pdf

EC 2007a. Council Regulation (EC) No 1100/2007 of 18 September 2007stablishing measures for the recovery of the stock of European eel. OJ L 248, 22.9.2007 p. 17

EC 2007b. Commission welcomes Council´s adoption of measures to rebuild depleted fish stocks, strengthen RACs and control alien species in aquaculture. Press release, 11 June 2007, IP/07/788; accessed 13 Aug 2007: http://europa.eu/rapid/pressReleasesAction.do?reference=IP/07/788&format=HTML&aged=&language=en&guiLanguage=en

EELREP 2005. Estimation of the reproduction capacity of European eel. Final report.

Accessed 30 July 2007: http://www.fishbiology.net/EELREP_final_report.pdf; http://www.fishbiology.net/eelrepsum.html

FAO 2007. Cultured Aquatic Species Information Programme: *Anguilla anguilla*. UN Food and Agriculture Organisation (FAO). Website accessed 13 Aug 2007: http://www.fao.org/fi/website/FIRetrieveAction.do?dom=culturespecies&xml=Anguilla_anguilla.xml

Fricke, R. 2007. HELCOM Red List of Threatened and Declining Species of Fishes and Lampreys of the Baltic Sea. Helsinki.

Fricke, R., Bilecenoglu, M. & Sari, H.M. 2007. Annotated checklist of fish and lamprey species (*Gnathostomata* and *Petromyzontomorphi*) of Turkey, including a Red List of threatened and declining species. Stuttgarter Beiträge zur Naturkunde (A) 706: 1-169.

Froese, R. and D. Pauly. Editors. 2006. FishBase. World Wide Web electronic publication. www.fishbase.org , version (05/2006).

Gärdenfors, U (ed). 2005. The 2005 red list of Swedish species. Uppsala (ArtDatabanken).

ICES 2003. Report of the ICES Advisory Committee on Fishery Management 2002. ICES Cooperative Research Report no. 255.

ICES 2006a. Report of the ICES Advisory Committee on Fishery Management 2006. 9.4.9. European Eel. http://www.ices.dk/committe/acfm/comwork/report/2006/may/eel-eur.pdf

ICES 2006b. Report of the ICES Advisory Committee on Fishery Management, Advisory Committee on the Marine Environment and Advisory Committee on Ecosystems, Book 9. http://www.ices.dk/products/icesadvice/2006PDF/ICES%20Advice%202006%20Book%209.pdf

Knights 2003. A review of the possible impacts of long-term oceanic and climate changes and fishing mortality on recruitment of anguillid eels of the Northern Hemisphere. The science of the Total Environment; 310(1-3): 237-44.

Maes, E. G., Pujolar, J. M., Hellemans, B., Volckaert, F. A. M. 2006a. Evidence for isolation by time in the European eel (*Anguilla anguilla* L.). Molecular ecology **15**: 2095-2107.

Maes, E.G. Pujolar, J.M., Raeymaekers, C., Joost, D. J. & Volckaert, F. 2006b. Microsatellite conservation and Bayesian individual assignment in four *Anguilla* species. Marine Ecology Progress Series 319: 251-261.

Moriarty C. and Dekker, W. (eds.) 1997. Management of the European Eel. Fisheries Bulletin (Dublin) 15: 1-110.

Pujolar, M., Maes, E.G. & Volckaert, F. 2006. Genetic patchiness among recruits in the European eel *Anguilla anguilla*. Marine Ecology Progress Series 307: 209-217.

Schmidt, J. 1909. On the distribution of the freshwater eels (*Anguilla*) throughout the world. I. Atlantic Ocean and adjacent region. Meddr. Kommn Havunders. Ser. Fisk. **3**: 1–45.

Theophilou, C. 2007. The newly-adopted adopted “Eel Regulation.” Presentation to INDICANG Colloque, 19-20 June 2007, Nantes, France.

Tsukamoto K., Nakai I. & Tesch W.-V. 1998. Do all freshwater eels migrate? Nature 396: 635–636.

Vollestad, L.A. 1992. Geographic variation in age and length at metamorphosis of maturing European eel: environmental effects and phenotypic plasticity. J. Anim. Ecol., 61; 41-48.

WGAGFM 2004. Report of the Working Group on the Applications of Genetics in Fisheries and Mariculture (WGAGFM). International Council for the Exploration of the Sea. ICES CM 2004/F: 04.

WGEEL 1999. Report of the EIFAC/ICES Working Group on Eels. Silkeborg, Denmark, 20–24 September 1999. International Council for the Exploration of the Sea. ICES CM 2000/ACFM:6. http://www.ices.dk/reports/ACFM/1999/WGEEL/WGEEL99.pdf

WGEEL 2000. Report of the EIFAC/ICES Working Group on Eels. St. Andrews, N.B., Canada, 28 August - 1 September 2000. International Council for the Exploration of the Sea. ICES CM 2001/ACFM: 03. http://www.ices.dk/reports/ACFM/2000/WGEEL/WGEEL00.pdf

WGEEL 2001. Report of the ICES/EIFAC Working Group on Eels. ICES Headquarters, Copenhagen, 28–31 August 2001. International Council for the Exploration of the Sea. ICES CM 2002/ACFM:03. http://www.ices.dk/reports/ACFM/2001/WGEEL/WGEEL01.pdf

WGEEL 2002. Report of the ICES/EIFAC Working Group on Eels. Nantes, France 2–6 September 2002. International Council for the Exploration of the Sea. ICES CM 2003/ACFM:06. http://www.ices.dk/reports/ACFM/2002/WGEEL/WGEEL02.pdf

WGEEL 2005. Report of the ICES/EIFAC Working Group on Eels. 22-26 November 2004, Galway, Ireland. International Council for the Exploration of the Sea. ICES CM 2005/I:01. http://www.ices.dk/reports/ACFM/2005/WGEEL/WGEEL05.pdf

WGEEL 2006. Report of the 2006 session of the joint EIFAC/ICES Working Group on Eels. Rome, 23–27 January 2006. International Council for the Exploration of the Sea. ICES CM 2006/ACFM:16. EIFAC Occasional Paper No. 38: 352pp. http://www.ices.dk/reports/ACFM/2006/WGEEL/WGEEL06.pdf

Wickström, H. and H. Westerberg 2006. The importance of eels from coastal/brackish water areas. Swedish Board of Fisheries, MS, 6 p.

Wirth, T. &. Bernatchez, L. 2001. Genetic evidence against panmixia in the European eel. Nature 409(6883): 1037-1039.