

Theme Session J

Is there more to eels than SLIME?

ICES CM 2006/J:01 – Poster

Estimation of the abundance of Japanese eels *Anguilla japonica* in the Kao-Ping River estuary of Taiwan using the mark-recapture method

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The Japanese eel (*Anguilla japonica*) is an economically important aquaculture species in Taiwan, and fish farmers mostly still depend on juvenile eels (elvers) collected in the estuaries. Recently, populations of temperate eels, including the Japanese eel, have declined worldwide to below biologically safe limits, which raises concerns about eel resource management and conservation. To increase elver recruitment, hormone-injected adult eels have been released every year since 1976 by the Taiwan Fishery Research Institute. But to date few studies on the population status of eels in Taiwan have been documented. Thus we attempted to estimate the abundance of Japanese eels in the downstream region of the Kao-Ping River in southwest Taiwan by the mark-recapture method. A total of 867 cultured and wild yellow eels were tagged on September 28, 2005, including 561 individuals marked with electronic chips and 306 individuals marked by clipping their pectoral fins. Daily recaptures were reported by fishermen. Up to February 2006, a total of 23 marked eels had been returned among the 866 eels caught in the estuary. Eel abundance in the recapture area was estimated as 3,380 (95% CI: 1,670 ~ 6,842) eels by the Chapman method, which was much smaller than an estimate made in 2001 in the same area (7,364 eels). This indicates that the eel population in the study area has decreased. Accordingly, a recovery plan, including controls of fishing, restocking, and habitat restoration, is urgently needed.

Keywords: population abundance estimation, *Anguilla japonica*, mark-and-recapture.

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ICES CM 2006/J:02 – Withdrawn

ICES CM 2006/J:03

Effect of management measures on glass eel escapement

Laurent Beaulaton and Cédric Briand

We develop a Glass Eel Model to Assess Compliance (GEMAC) with eel recovery objectives. This model was presented for the first time in the Working Group on Eel (ICES, 2005), is part of the SLIME project and thus will only be briefly presented. We then focus on the usefulness of the model in "real life" to test the effect of management measures. The major obstacle to apply GEMAC at a large scale for management purposes is the lack or imprecision of input data. We explore two kinds of imprecision: noisy data and temporal aggregation (monthly or annual data instead of daily data). The robustness of the model is tested considering its main output, i.e. the percentage of settled 0+ eels per glass eel but also considering secondary output such as pigmentation composition. Noisy data were simulated by assigning random error or a constant bias to each input data. The effect of temporal aggregation is assessed with real data on well documented watersheds where official imprecise data coexists with scientific precise data. Four alternative management measures for a 50% reduction of fishing effort were analysed for effective fishing mortality reduction: seasonal fishing closure, alternative fortnight closure, gear or licence regulation. This work is still in progress in two well documented watersheds with contrasted fishing pressure: the dam-closed Vilaine estuary, heavily fished with an estimated exploitation rate higher than 90% and the large Gironde estuary, moderately fished.

Keywords: GEMAC, glass eel, management.

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ICES CM 2006/J:04

Assessment of population size and migration routes of female silver eel (*A. anguilla*) in the River Rhine: a two-year combined telemetry and mark-recapture study

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In 2004 and 2005, downstream migration of female sil-

ver eel (> 50 cm) was studied in the Lower Rhine, Germany, and the Rhine delta, The Netherlands. In both years, more than 3000 silver eels were captured in the Mosel tributary. After batch-marking with heliotrope-blue the eels were released into the free flowing River Rhine near Cologne. On several occasions during the migratory period, the eel catches of professional fishermen in all branches of the Delta were counted and checked for batch-marked individuals. Depending on very low numbers of recaptured eels, the mark-recapture study allowed only a rough estimation of about 0.9 million female silver eel per year migrating downstream in the River Rhine. In the second part of our study, passive transponders were surgically implanted in 150 female eels each year. Downstream migration of transpondered eels was registered at more than 20 detection stations distributed all over the Delta. From the registrations of individual eels, the Waal branch was identified as the main migratory route. Only about 60% of the transpondered eels were detected at least once, of which about 1/3 reached the North Sea. The results of this study will be discussed with regard to the EU proposal to establish catchments based eel management plans aiming at the recovery of the endangered European eel.

Keywords: European eel, migration, telemetry, mark-recapture, population size.

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ICES CM 2006/J:05

The status of New Zealand freshwater eel stocks and management initiatives

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New Zealand has two main species of freshwater eel, the shortfin *Anguilla australis* shared with southeast Australia, and the endemic longfin eel, *Anguilla dieffenbachii*. Both species are subject to extensive commercial and customary fishing. The shortfin is the shorter-lived species with generation times for females of 25–30 years, whereas generation times for longfin females are double this. The distribution and abundance of both species have been compromised by habitat modifications, with shortfins, the more lowland species, being affected by wetland loss, and longfins by weirs and dams. While there are few concerns about the status of shortfins, there is increasing evidence of over-exploitation of longfins, including reduced recruitment, reduction in CPUE, reduction in abundance and average size, and a regional reduction in the proportion of females. Eels are managed under the Quota Management System, although individual and regional quotas are set from catch histories as biological parameters are inadequate. Maori, New Zealand's indigenous people were allocated 20% of the commercial quota, with an additional quota set for customary take. The annual commercial catch has halved over the past

decade, and is now about 700–800 t, with shortfins comprising 66% of catches. Recent management developments have included enhancement of upstream waters with juvenile eels, the consolidation of processing into fewer but larger units, setting aside of additional reserve areas to increase escapement of silver eels, increased management involvement of Maori, and development of regional management strategies.

Keywords: *Anguilla*, freshwater eels, status, abundance, recruitment, exploitation, Maori, management, quota.

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ICES CM 2006/J:06

Getting to grips with European eel (*Anguilla anguilla*) population dynamics at two spatial scales

Dave Carss

This paper examines European eel (*Anguilla anguilla*) population dynamics at two spatial scales, and two levels of resolution. At the local scale, an unexploited yellow eel stock in a small (42 ha), shallow (average depth = 1.5 m) Scottish lake was sampled annually. Eels were caught by electrofishing in standard enclosures (area = 130–630 m²) around the lake during nine summers (1990–2002). Here, the relationship between eel density and standing crop (biomass) suggested that local density dependence was operating within this eel stock. At the continental scale, the geographical ranges of eels and the predatory bird the great cormorant (*Phalacrocorax carbo*) overlap almost completely. Moreover, across Europe, these birds are widely reported to eat large eels. Many of the eels eaten by cormorants are thus likely to be female. Based on a broad-brush pan-European synthesis, this paper offers a first attempt at quantifying cormorant predation (numbers, biomass, sex) on European eel stocks. Possible reasons for, and consequences of, local density dependence within yellow eel stocks are discussed. Similarly, the importance of cormorant predation on eels at an international scale is considered in relation to European eel population dynamics studies.

Keywords: European eel, *Anguilla*, density dependence, predation, great cormorant, *Phalacrocorax carbo*, population dynamics.

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ICES CM 2006/J:07

Assessment of eel stock status in Garonne and Dordogne water bodies by analysing length structures

Patrick Lambert, Laurent Beaulaton, Françoise Daverat, and Christian Rigaud

We analysed the length structure of European eel (*Anguilla anguilla*) stocks with a simple size-structured model including a linear trend of recruitment, a linear growth curve, a negative exponential mortality, and a silvering process based on a logistic function. Eels shorter than 30 cm were excluded from the analysis in order to limit effect of sex determinism, colonization process, and gear selectivity. The data sets used in this study were obtained from the Water Framework Directive (WFD) survey and sampling that can be assimilated to the Data Collection Regulation (DCR) survey in the Garonne and Dordogne basin covering seven "WFD water bodies" (from downstream estuaries to upstream tributaries). Even though the calibration remained very sensitive to parameter boundaries, this approach allowed calculation of percentages of silver eels per settled yellow eels in each water body. The resulting percentages obtained for each water body matched our knowledge of the corresponding anthropogenic pressure levels. The information about eel stock status provided by the present analysis urges the implementation of management actions in each compartment. The difference between WFD and DCR results are highlighted. This analysis also shows that the trend in median length of silver eels between compartments can be inverted only by changing mortality and growth. This result explains why the longest eels are presently produced upstream where mortality rate is the lowest even though in putative pristine conditions, they would be produced in the estuary.

Keywords: *Anguilla anguilla*, length structure, silvering, growth, mortality.

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ICES CM 2006/J:08

Monitoring of European eel stocks in North-East Germany

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Eel catches of commercial fisheries in the federal state of Brandenburg have decreased to less than one third over the last 20 years. In order to detect the main reasons for this tendency and to set up a basis for the development of effective management strategies, a monitoring programme consisting of three major parts was established in 2005.

For a quantitative monitoring of immigrating elvers, eel ladders were installed at four locations, two of them in the tributary of rivers Elbe and Oder, respectively. In addition, two special elver fyke nets were placed in fish passes. Between May and October, a total of 45,000 upstream migrating elvers of 7–40 cm in length were registered in the Elbe system. During the observed time span, migration intensity varied to a large extent with a number of peaks between the end of May and the beginning of September. Taking into account some periods with malfunction of ladders and fyke nets because of high water levels, the amount of elvers migrating into the river Havel as the main tributary to river Elbe was estimated at 70,000 for 2005. In contrast, elver migration into the Oder tributary seems to be negligible. Just 42 specimens could be registered.

In a second approach, six small lakes (< 20 ha in area and < 20 m deep) without drainage ditch have been stocked with 50 g/ha glass eels and 500 g/ha bootlace eels. Glass eels were either marked with OTC or with Alizarin red and bootlace eels were tagged with coded wire tags in the dorsal musculature. A recapture of eels with electric fishing, fyke nets, and bush traps has been started to study growth, sex ratio, and mortality of different stocking material. First results are expected in summer 2006.

Aiming at an estimation of fishing mortality during migration, 150 silver eels caught at three locations in the river Havel with a stow net and fyke nets in autumn 2005 were marked with orange visible implant elastomer tags (VIE) and released one kilometre upstream. Marked eels were recaptured in the fyke nets four to nineteen days after release and in the stow net already after one day. Fishing mortality was estimated at 2.7% for the stow net and 1–4% for fyke nets.

In combination with stocking and catch statistics, these approaches will allow for modelling the status and dynamics of eel population within the drainage systems of rivers Elbe and Oder.

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ICES CM 2006/J:09 – Poster

Sex-dependent habitat use of the Japanese eel *Anguilla japonica* in Taiwan

W. N. Tzeng

The Japanese eel is traditionally known as a catadromous fish, but it has recently been discovered that use of fresh water by this species at the yellow stage is facultative. However, the strategy of habitat selection is unknown. To understand if habitat use by Japanese eels differs between the sexes, we examined the Sr/Ca ratios in the otoliths of 201 eels by Electron Probe Micro Analyzer to understand their past environmental history. The speci-

mens were collected from the Kaoping River of south-western Taiwan from May 1998 to September 2003.

According to the life history scan of the Sr/Ca ratios, habitat use of yellow-phase eels was divided into 5 types: FF (freshwater resident), SS (seawater resident), BFS (estuarine resident, migrating between freshwater and seawater), FS and SF (freshwater then seawater, and vice versa). Habitat use was significantly different between males and females for silver eels ($\chi^2=22.79$, $d.f.=4$, $p<0.01$) and for the overall stages ($\chi^2=13.15$, $d.f.=13.15$, $p=0.011$). Females were dominant in BFS while males dominated in FF. In other words, females preferred estuaries while males migrated upstream. The mean size of silver eels was larger in females than in males. The carrying capacity and productivity of the environment may play significant role in determining the habitat use of the eel.

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ICES CM 2006/J:10

EelTrace – Life history traits and migration behaviour of European eel. The effects of habitat choice on eel spawner quality

Karsten Zumholz, Eva Jakob, and Reinhold Hanel

Recent research has indicated that the quality of the European eel spawners escaping from the continent might be seriously impaired by pollution, diseases, and parasites. In a new attempt we combine life history information as revealed by otolith microchemistry with detailed information on the individual health status of silver eels. Investigated parameters include parasite infestation, viral infections, contamination with heavy metals, and organic pollutants.

For the reconstruction of migration pathways of fish, their otolith chemistry is analysed by two advanced methods, namely LA-MC-ICPMS (laser ablation-multi collector-inductively coupled plasma mass spectrometry) and SYXRF (Synchrotron x-ray Fluorescence) microprobe analysis. Both techniques, primarily used for material science and earth sciences, provide outstanding possibilities for trace element analyses of biomineralized tissues.

The micro-scale resolution combined with extremely low detection limits makes both techniques very accurate tools to gather life history information of individual eels from their otoliths. Not only the differentiation between residence in freshwater and seawater, but also between different river systems via isotopic fingerprints seems possible.

Keywords: *Anguilla anguilla*, otolith microchemistry, migratory history, spawner quality, trace elements, isotope ratios, LA-ICP-MS, SYXRF.

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ICES CM 2006/J:11

The current status and temporal trends in stocks of the European eel in England and Wales

Tony Bark, Brian Knights, and Beth Williams

To establish the status of eel stocks in England and Wales upon which appropriate management actions can be based, an extensive four-year programme of catchment surveys, data collection, and model development of eels has been funded by the Department for Environment, Food and Rural Affairs (Defra) 'Establishment and Implementation of Biological Reference Points for the Management of the European Eel'. Nine test catchments representing different geographical areas and catchment types have been studied, covering fourteen rivers, two estuaries, and a freshwater lagoon. Data were collected via electric fishing, fyke netting, fixed eel racks, and elver traps. A total of 13500 eels have been caught, their length and weight recorded, with a sub-sample of 1800 eels sexed and aged. Physical data have been collected at each survey location to assess river habitat and water quality. These data will be reviewed in relation to geographical- and catchment-scale patterns across England and Wales. Possible reasons for apparently aberrant patterns in some rivers will be discussed. Three catchments will be discussed in the light of temporal trends using historic and contemporary data. Long-term temporal changes in population structure such as sex ratios, densities, and biomass will be addressed. An example of high natural inter-annual variability in recruitment from a catchment which appears to show a stable long-term recruitment pattern will also be discussed. Implications for management and the development of a management model (Scenario-based Model for Eel Populations, SMEP) will be reviewed.

Keywords: European eel, recruitment, survey, temporal trends, populations, management.

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ICES CM 2006/J:12

Eels: contaminant cocktails pinpointing environmental contamination

Claude Belpaire and Geert Goemans

Recently some scientific evidence has indicated that insufficient quality of the silver eels leaving the continental waters for migrating to the spawning areas might be a key factor explaining the overall decline of the stock. High contaminant accumulation in the eel and poor

physiological condition might be responsible for failure of migration and/or impairment of successful reproduction. During a 12-year study on a relatively small area within the river basins of Ijzer, Scheldt, and Meuse (ca. 13,500 km²) 2613 eels were harvested covering a dense monitoring network of 351 stations. Eels sampled were analysed for a series of ca. 100 chemicals. These include PCBs, organochlorine pesticides, heavy metals, brominated flame retardants, volatile organic pollutants (VOCs), endocrine disruptors, dioxins, perfluorooctane sulfonic acids (PFOSs), metallothionines, and polycyclic aromatic compounds. This series represents only a very small fraction (less than 0.5%) of the more than 30,000 chemicals currently marketed and used in Europe. Two major conclusions can be drawn. The indicator value of eel as a tool for monitoring environmental contamination, both for local matters and for international issues (evaluating the chemical status of the Water Framework Directive) is evident. Considering the variation in contaminant profile and intensity it is highly likely that the degree and potential of reproduction for eels leaving our system will vary a lot, dependent on the level of pollution in the habitat where the eels grew up.

Keywords: European eel, *Anguilla anguilla*, Flanders, bioaccumulation, spawner quality.

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ICES CM 2006/J:13 – Poster

Comparing the population structure of temperate *Anguilla japonica* with tropical *A. armorata* in the Northwestern Pacific Ocean

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Because of its worldwide distribution when compared to other freshwater eels, *Anguilla marmorata* can hardly form a single population. Unlike the temperate eel *A. japonica*, *A. marmorata* elver has two peaks of recruitment periods. The present report deals with the comparative study of the genetic structures of *A. japonica* and *A. marmorata*, and the geographical and seasonal genetic variations of tropical elvers in Vietnam and Taiwan using polymorphic microsatellite markers. Genetic homogeneity of the Taiwan elver samples between summer and winter of 2001 indicates that all progeny of *A. marmorata* belonging to the same spawning group. Although *A. marmorata* larvae are drifted by different current systems, its genetic structure is highly identical ($I = 0.790\text{--}0.917$). A higher polymorphism in microsatellites further confirms the single population hypothesis of previous studies based on mtDNA data sets. The strong gene flow ($Nm > 1$) among samples of different localities indicates that the population in the northwestern Pacific Ocean is panmictic. Comparison of population structures suggest that different migration patterns exist for elvers of *A. japonica* and *A. marmorata*.

Keywords: *Anguilla marmorata*, microsatellite, genetic homogeneity, gene flow, panmictic.

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ICES CM 2006/J:14

Effectiveness of different measures for the recovery of the European eel (*Anguilla anguilla*) stock: an analysis for the Camargue lagoons

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The European eel (*Anguilla anguilla*) stock has been declining since the early 1970s and is presently considered outside safe biological limits. EU Member States have been asked by the Commission of the European Communities to set recovery plans with the aim to achieve the escapement to the sea of 40% of the adult eel biomass (with respect to non-exploitation conditions) from each river basin. We have developed a stochastic demographic model that explicitly accounts for age, length, and sex structure and for the most peculiar features of the continental phase of the eel life cycle, namely: 1) high plasticity in body growth and strong sexual dimorphism; 2) sexual differentiation and maturation, as well as fishing mortality, related to body size rather than age; 3) huge fluctuations of recruitment at the glass eel stage; 4) density-dependent survival of juvenile eels. The model has been calibrated on an 11-year data series collected in the Camargue lagoons and has been then used to assess the effectiveness of different measures. We show that simple fishing restrictions do not guarantee a real effort reduction whilst other measures (like limiting the maximum number of nets per hectare per month or increasing the mesh size of the fishing gears) could turn out to be more effective, even though they might be difficult to enforce in practice. As the model has been specifically calibrated for the Camargue population, we discuss the general validity of our results and how this approach can be extended to different sites.

Keywords: European eel, demographic model, bio-economic analysis, recovery plans.

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ICES CM 2006/J:15

Age, growth and condition of European eel (*Anguilla anguilla*) from six lakes in the river Havel system (Germany)

Janek Simon

A total of 146 female yellow European eels (*Anguilla anguilla*) of length 23.0 to 64.5 cm and ages 3 to 13 years were collected from six lakes in the river Havel system (Germany) in spring 2001 by electric fishing. Growth rates estimated by means of otolith increments and condition of eels varied between individuals of one lake and between lakes. Highest growth rates were recorded from the lake Blankensee with a mean growth of 5.2 cm per year, and lowest growth rates were recorded from the lakes Eiserbuder See and Sacrower See with a mean growth of 4.0 cm per year. In all lakes together the overall mean annual increment was estimated at 4.5 cm per year. The highest annual increment in the otoliths generally occurred in all lakes in the first, often also in the second year of growth in freshwater with 6.4 to 7.7 cm per year. In the following ten years the annual increment then remained almost constant or decreased slightly with 5.6–2.3 cm per year. In the lakes of the river Havel system the time between stocking of lakes with glass eels and recapture of the eels with 300–350 g body mass amounts to nine to ten years. With the Ford-Walford-Plot the investigated L_{∞} values of the physiologically possible maximum length of eel were 100–130 cm. Fulton's condition factor (K) of the investigated yellow eels in the lakes was 0.12 to 0.24 and the gross energy content varied between 4.6 and 15.3 MJ/kg. Comparing the individual lakes, no significant differences were found between eels in condition factor (mean average values of the lakes: 0.16 to 0.18) and gross energy content (mean average values of the lakes: 6.3–9.9 MJ/kg). In comparison with investigations in the past, only a trend towards a slower growth rate can be observed.

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ICES CM 2006/J:16 – Poster

Effects of habitat and restocking on the growth of European eel *Anguilla anguilla*

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The European eel *Anguilla anguilla* is traditionally known as a catadromous fish, but recently the habitat use of the eel at yellow eel stage was found to be facultative. The restocking program in Lithuania by releasing glass eels imported from France or UK in freshwater has been conducted since 1960. To understand the effect of habitat use and restocking on growth, 128 female eels were collected from the Baltic Sea, the Curonian lagoon, and two

inland lakes of Lithuania in 2004, and their otolith Sr:Ca ratios, age, and length-at-age were examined. The life history scan of Sr:Ca ratios in otolith indicated that the eels from the Baltic Sea were all naturally recruited; those from the lakes were all restocked, while those from the lagoon were comprised of both naturally recruited and restocked ones. Mean growth rates and back-calculated lengths-at-age of the eels from the Baltic Sea and lagoon were significantly larger than those from lakes. However, no significant differences in growth rate were found for the eels with different migratory histories within habitats. In addition, the length-at-age indicated that restocked eels grew faster than naturally-recruited ones from age 5 ~ 8 in the lagoon. These findings suggested that the growth rate of the eels was influenced by both habitats and restocking. The restocked eels did not migrate across the Baltic Sea and might allocate more energy for growth.

Keywords: European eels, *Anguilla anguilla*, restocking, Sr:Ca ratios, growth.

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ICES CM 2006/J:17

Effect of El Niño on migration and larval transport of the Japanese eel, *Anguilla japonica*

Hee-Yong Kim and S. Kimura

The recent collection of 2-day-old pre-leptocephali of Japanese eel in the Pacific Ocean around the West Mariana Ridge gives us a clue to the better understanding of long-term and long-range migration of this species. For the migration of the Japanese eel, the salinity front in the North Equatorial Current (NEC) has been considered as an important oceanic condition and its interannual variability associated with ENSO probably leads to a reduction in the transport of the larvae to the Kuroshio, causing poor recruitment in East Asia. In addition to fluctuation of the salinity front, bifurcation of NEC into the Kuroshio and the Mindanao Current east of the Philippines should be considered as another important feature of the ocean systems in the NEC. To clarify the effect of El Niño events on the migration and transport of the eel larvae including the bifurcation of the NEC, the migration difference of the larval eels both in El Niño years and in non-El Niño years were compared quantitatively in a numerical particle tracking model. In El Niño years, only 10% of the eel larvae migrated into the Kuroshio while the rate in non-El Niño years was greater than 38%. These quantitative results correspond well to statistic catch data of the glass eel around Japanese Islands. It is concluded that the variability of ocean systems due to the interannual climatic change determines the recruitment of the Japanese eel in East Asia.

Keywords: Japanese eel, El Niño, salinity front, NEC bifurcation, larval migration.

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ICES CM 2006/J:18

Stock discrimination of the European eel *A. anguilla* in Lithuania waterbodies by otolith Sr:Ca ratios and other elemental signatures

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Glass eels purchased in the UK and France have been directly released into Lithuanian inland waters and mixed with naturally recruited eels for several decades. The study aimed to discriminate between both stocked and naturally recruited eels, to evaluate the contribution and interaction of the two possible eel origins to each population of the studied sites. To distinguish the restocked eels from naturally recruited ones and to understand the migratory environmental history of the eel, Sr/Ca ratios in otoliths were examined by wavelength dispersive X-ray spectrometry with an electron probe microanalyzer; laser-ablation ICPMS was used for Na/Ca, Mg/Ca, Mn/Ca, and Ba/Ca analyses, to distinguish between eels from the freshwater lagoon and lake. The eels were sampled from the brackish Baltic Sea, a freshwater Curonian lagoon, and an inland lake in the eastern part of the country. Stocked eels were identified by the freshwater signature ($\text{Sr/Ca} < 2.24 \times 10^{-3}$) on the otolith after the glass eel stage. Naturally recruited eels were characterized by an extended sea/brackish water signature ($\text{Sr/Ca} > 3.23 \times 10^{-3}$) after the glass eel stage. Stocked eels accounted for 20% of the eels from the Curonian Lagoon and 3.8% of eels sampled in Baltic coastal waters, while all eels from the inland lake were of stocked origin. One-way ANOVA tests indicated that both Ba/Ca and Na/Ca ratios in eel otoliths were significantly higher for the eels in the lagoon than those of the lake ($p < 0.05$); 83% of the eels could therefore be correctly assigned to their sampling locations. However, otolith Mg/Ca and Mn/Ca ratios were similar for eels from the two environments.

Keywords: *Anguilla anguilla*; European eel; migratory history; stocking; otolith microchemistry; elemental composition, laser-ablation ICP-MS.

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ICES CM 2006/J:19 – Withdrawn

ICES CM 2006/J:20

Going with the flow – Can managing flow regimes aid in promoting silver eel spawner escapement from the Irish River Shannon system?

Paula Cullen and T. K. McCarthy

The River Shannon in Ireland (catchment area 15,500 km², mean annual discharge 186 m³ s⁻¹), is harnessed for hydroelectricity generation in its lower reaches. In contrast with upper catchment locations where the lunar cycle is the dominant factor influencing migratory patterns, the management of flow for power generation and flood control purposes has a large influence on the migration patterns in the lower reaches of the catchment. Analysis of 25 years (1981–2006) of daily catch statistics from the Killaloe silver eel weir on the lower catchment was carried out in relation to flow patterns. The eel weir is located 3 km upstream of a regulating dam which splits the river sending a statutory 10 m³ sec⁻¹ down the main river channel and up to 450 m³ sec⁻¹ down the 12.6 km head-race canal to the power station. However, in times of high water three undershot gates at the regulating weir can be lifted to allow greater discharge of water down the main river channel. This process is referred to as spillage. The results of the analysis highlighted the importance of flow regimes, in particular spillage, in determining the patterns of eel migrations in the lower River Shannon. These results were further substantiated by a series of tagging experiments carried out using a combination of batch, Floy and PIT tags. Spawner escapement from the system is currently boosted through trapping of migrating eels at fishing weirs located upstream of the power station and transporting them towards the estuary. The additional benefits of flow management are discussed, with particular reference to the potential for spawners to safely escape the system when spillage occurs.

Keywords: *Anguilla anguilla*, silver eel, migration pattern, flow-attraction, current.

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ICES CM 2006/J:21 – Poster

The influence of habitat choice on parasite infestation of European eel in northern Germany

Eva Jakob, Karsten Zumholz, and Reinhold Hanel

By reconstructing the migratory history of European eel sampled in the North Sea, the Baltic Sea, and various freshwater sites we want to augment understanding of the influence of environmental parameters like salinity on spawner quality, characteristics like parasite infestation and viral infections, but also on sex differentiation. Some parasites are known to directly affect eel spawner

quality. While the east-asian swim bladder nematode *Anguillicola crassus*, imported to Europe in the early 80s, has been shown to impair spawner quality by preventing successful eel spawning migrations to the Sargasso Sea, nothing is known about the possible effects of other metazoan parasites.

Detailed life history information derived from otolith microchemistry enables us to quantify the duration of residence of individual eels in fresh-, brackish, and marine water bodies and therefore the dependence of specific parasite species on ambient salinities. First results are presented for the comparison of the parasite communities of eels from three sampling sites along a steep salinity gradient.

Keywords: *Anguilla anguilla*, otolith microchemistry, migratory history, spawner quality, parasite infestation.

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ICES CM 2006/J:22

An experimental field study on the migratory behaviours of glass eel at the interface of fresh and salt waters, with implications to the management and improvement of glass eel migration

T. P. Bult and W. Dekker

Glass eels are known to reach the shores of Holland by using ocean currents and selective tidal transport (DM – Downstream Movements). Most of the fish ladders that are installed at the interface of salt and fresh waters, however, are designed for fish that are attracted by freshwater currents and that actively move upstream (Upstream Migratory (UM) behaviours). From this, we questioned the efficiency of these fish ladders for glass eel immigration.

We tested our hypothesis of UM versus DM behaviours by comparing the catch of glass eel in two experimental fish ladders: a siphon and an eel trap, appealing to DM and UM behaviours respectively. These traps were installed at two sluice complexes in Holland and operated at night during the glass eel season of 2005. These experiments were supplemented by direct scuba observations.

The results showed that most glass eels gained access to inland waters by DM instead of UM behaviours. At low tide, none of the glass eel were observed to reach fresh waters as the water velocities in the cracks of the sluice doors were too high for upstream migration. At high tide, many glass eels were observed to reach fresh waters by DM-behaviours and small cracks in the sluice doors. These results suggested that DM-behaviours are important to glass eel migration at the interface of fresh and salt waters. Access to inland waters may be improved by

providing small openings in or around sluice doors that allow for DM behaviours at night.

Keywords: Glass eel, migration, sluice, movement, fish ladder, siphon.

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ICES CM 2006/J:23

Recruitment and the status of the European eel in Britain and NW mainland Europe: a critical assessment

Brian Knights, Tony Bark, and Beth Williams

Recruitment of glass eels of the European, American, and Japanese eel has fallen since the late 1970s, implying common causes, probably ocean-climate changes affecting survival of leptocephali in both the N. Atlantic and N. Pacific. Recruitment is higher to NW European rivers closest to the Atlantic migration pathways, these therefore have relatively high densities and, due to density-dependent sex determination, males predominate. Densities decline with distance from the tidal limits due to density-dependent migrations and random dispersal. Minima generally occur at ~60–70 km in rivers with natural migration barriers (e.g. steep gradients or falls) and in regulated rivers with weirs and other obstructions. Lower densities in upstream regions and in stillwaters result in higher female production. These characteristic patterns provide means of assessing the status of populations in different rivers, aiding assessment of ecological status in Water Framework Directive terms. Good quality time-series are sparse but extensive analyses and re-analyses of a wide range of data sets suggest there are relatively few catchments where populations or yellow and silver eel fisheries have been significantly impacted by recruitment declines. Over long time scales, falling recruitment is compensated by an increase in production of females and hence overall fecundity. Eels are facultative catadromes and show high plasticity in migratory behaviour and choice of habitat. It is proposed that coastal and estuarine stocks are as important, if not more so, than freshwater ones. It is concluded that the European eel is not as endangered as commonly perceived.

Keywords: European eel, recruitment, catadromy, migrations, sex determination, populations, management.

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ICES CM 2006/J:24 – Poster

Just go with the flow? – How individual behaviour and river discharge affects silver eel mortality in the river Meuse

H. M. Jansen, H. V. Winter, M. C. M. Bruijs, and H. Polman

The European eel, *Anguilla anguilla*, population shows a strong decline over the past decades. Fisheries and hydropower-induced mortality during the downstream migration of silver eels presumably plays an important role. River discharge is assumed to play an important role in the onset of migration. This study therefore focuses on the effects of river flow on mortality of downstream migrating silver eel. Furthermore, the impact of individual behaviour on mortality is discussed. To quantify the impact of hydropower and fisheries on silver eel mortality, radio-telemetry experiments were performed in the river Meuse in 2002–2006. A total of 300 silver eels were surgically implanted with Nedap-transponders. This experiment distinguishes between individuals entering the turbine and individuals passing over the adjacent weir. Furthermore, the timing of migration and passage behaviour near detection stations was determined. Mortality rates caused by hydropower stations depended on the number of eel passing the weir/HPS and the water flux through the turbines. Observed behavioral factors, such as hesitation and avoidance of individual eels in front of a hydropower station are discussed. Furthermore, river discharge influences fisheries mortality by affecting the migration route of silver eel in the downstream area. Fishing intensity, and therefore fishery mortality, differs between the routes. The effect of river discharge and individual behaviour on fisheries and hydropower mortality will be discussed in a management context.

Keywords: migration, individual behaviour, river discharge, radio telemetry, hydropower, fishery, silver eel.

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ICES CM 2006/J:25

Against all odds: silver eel mortality in the River Meuse in a population perspective

H. V. Winter and H. M. Jansen

The population of the European eel *Anguilla anguilla* is in strong decline. Among many factors, mortality due to hydropower generation and fisheries on the downstream run of silver eels in rivers plays an important role. To quantify these impacts on the silver eel stock in the River Meuse, radio-telemetry experiments were performed in 2002–2006. For this study, 15 fixed detection stations (Nedap Trail-System®) covering the entire river width at different locations in the River Meuse, and 2 stations across the entrance of the two hydropower plants were

used. The latter stations allowed distinguishing individuals entering the turbine from individuals passing over the adjacent weir. Recaptures in fisheries are used to assess fishing mortality. In total 300 silver eels were surgically implanted with Nedap-transponders. Mortality rates for each river stretch were assessed and attributed to the different mortality factors. The overall impact of hydropower and fisheries on the River Meuse silver eel run is the product of these mortalities and the spatial distribution of the eel within the catchment. This integral impact assessment is explored, using information from yellow eel surveys, and the flux of silver eels at two locations. Consequences on the population level of the Meuse catchment and management are discussed.

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ICES CM 2006/J:26

Silver eel migration behaviour in the Baltic

Håkan Westerberg, Ingvar Lagenfelt, and Henrik Svedäng

During the 2005 eel migration season 16 female silver eels (*Anguilla anguilla*) were tagged with data storage tags (Lotek LTD 2000 series) and released on the Swedish east coast at approximately 56°30'N. Until now 8 (50%) have been recaptured and it has so far been possible to recover data for 4 of these. In all 56 days of migration is documented and the data show a very consistent and regular behaviour both between individuals and over time. Essentially all swimming activity was between dusk and dawn, starting when the light level at the surface falls below 60–80% of full daylight and stopping in the morning at approximately the same light level. In the daytime the eels were quiet at the bottom, at bottom depths varying between 9 and 36 m. The only exception to this diurnal behaviour was one eel during one night where the bottom depth was in excess of 30 m. In this case the eel continued migration in the daytime following the thermocline at 8- to 12-m depth.

At nighttime the swimming depth was very close to the surface. As much as 95% of the time was spent within 0.5 m of the surface, which corresponds to the resolution of the pressure sensor. Short dives were made down to the thermocline depth or occasionally down to what probably was the bottom. The duration of such dives were typically 5 to 10 minutes. The mean migration speed along the coast between release and capture site was around 16 km/day. This gives an average swimming speed of 0.4 m/s when the eels were active, which fits with swimming speeds recorded in telemetry experiments. This implies that the movements of the eels were relatively steady along the coast and that the depth in daytime can be used to give offshore distance, which in combination with the accumulated swimming time since release can be used to reconstruct the trajectory.

Keywords: migration, swimming depth, geopositioning, diurnal behaviour.

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ICES CM 2006/J:27

Modelling of *Anguilla anguilla* production and silver eel escapement for the river Severn, compliance with targets and development of management plans

Alan M. Walker, Miran W. Aprahamian, Mike Pawson
E. Williams, A. Bark, and B. Knights

The River Severn supports the largest glass eel fishery in the UK, with a current annual catch estimated in the region of 10 t. Since the 1980s, there has been a decline in the catch and CPUE (an index of recruitment) of glass eel of ~70%, with the main decline happening in 1983/1984. Yellow and silver eel fisheries in the Severn catchment are negligible.

Comparison of the results of eel-specific surveys undertaken in the late 1990s and between 2002 and 2004 with those during the early 1980s indicates that there has been 1) no change in eel distribution, 2) no overall change in density or biomass, and 3) no change in the size structure of the eel population in the Severn. This suggests that escapement of silver eels is similar to that during the late 1970s and early 1980s, when the glass eel fishery was much larger (~40 t). Although a Reference Condition Model has successfully been applied to the Severn catchment, it has not been possible to assess definitively whether (1) the current level of escapement is sufficient to meet the 40% management target based on currently available habitats or if (2) removal of the fisheries would achieve this. The amount and suitability of habitats available to eels in the Severn is perceived to have declined since the 1950s, and it is thus considered very unlikely that the 40% escapement target is being met when compared with undisturbed (“pristine”) conditions, i.e. the conditions pertaining prior to the 1950s, but in the absence of any water quality problems.

A number of management actions are suggested which would lead to an increase in silver eel output. In the short term, it is suggested that glass eel be translocated from the estuary to the middle reaches of the Severn catchment and Avon where habitat is suitable, but under-utilised. In the long term, it will be necessary to improve access to the many watercourses either fully or partially obstructed by weirs or tidal flaps and to increase the amount of wetland available to eel.

The presentation will also discuss the need for an enhanced (over current) monitoring programme, and the development of tools to assess compliance with the EU target, to quantify the impact of the glass eel fishery on escapement, and the impact of other anthropogenic factors.

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ICES CM 2006/J:28

The diet of large eels in relation to food availability

Hendrik Dörner, Christian Skov, Søren Berg, Torsten Schulze, Douglas Beare, and Gerard Van der Velde

The aim of the present study was to analyse and compare the feeding behaviour of large eels *Anguilla anguilla* (> 30 cm total length) in two lakes of different environmental state and corresponding differences in food availability. Investigations were conducted in Lake Großer Vätersee, Germany (clear water, mesotrophic, submerged macrophytes present) and in Lake Vallum, Denmark (turbid, eutrophic, no submerged macrophytes). We focused our study on diet patterns. Fish were sampled monthly over the vegetation period by electrofishing in 2002. Additionally, samples over the whole food web were taken for stable isotope analysis in 2003. The availability of macrozoobenthos was higher in Lake Vallum (3,500 ind. m⁻²) than in Lake Großer Vätersee (1,500 ind. m⁻²), which was due to a high density of insect larvae in Lake Vallum (2,700 ind. m⁻²) compared to 680 ind. m⁻² in Lake Großer Vätersee. Both the abundance of eels and small prey fish (40–99 mm TL) were higher in Lake Vallum.

Despite the latter, fish was unimportant as prey for eels in Lake Vallum which instead fed on invertebrates and in particular on chironomid larvae. In contrast, in Lake Großer Vätersee where availability of insect larvae was low eels used fish as the main food component. These findings were also corroborated through stable isotope analysis undertaken on samples of the whole food web of both lakes. Based on these results as well as similar observations for smaller eels, we suggest that the level of piscivory among eels to a wide extent is generally triggered by the availability of insect larvae.

Keywords: *Anguilla*, piscivory, predation, prey fish, invertebrates, zoobenthos.

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ICES CM 2006/J:29 – Poster

The interaction between *Anguilla anguilla* (Linnaeus, 1758) and *Halobatrachus didactylus* (Bloch & Schneider, 1801) and potential consequences of climatic changes

José Lino Costa, Isabel Domingos, Armando Jorge Almeida, Eric Feunteun, and Maria José Costa

The distribution of the European eel, *Anguilla anguilla*, includes the Mediterranean and the Atlantic coasts of Europe and North Africa, from Scandinavia to Mauritania. The Lusitanian toadfish, *Halobatrachus didactylus*, is a benthic voracious fish with a distribution ranging from Cabo Carvoeiro (centre of Portugal) to the Gulf of Guinea. Although this subtropical fish is primarily a marine species, in the northern range of its distribution area (southwest of Portugal), due to reproductive thermal constraints in the sea, it colonizes mostly brackish water systems where it becomes dominant. Therefore, in the southwest of Portugal both species occur in sympatry in estuaries and open coastal lagoons. The aim of this work was to analyse the ecological consequences of such sympatry considering the Mira estuary as a case study. Both species showed similar habits and a high diet overlap. Moreover, the toadfish predated on glass eels and yellow eels which together with its dominance in the estuary contributes to push the anguillids to peripheral areas upstream (freshwater and upper estuary) and downstream (*Zostera* banks near the sea). This spatial segregation reduces habitat availability for eels which may have serious consequences for a population that has already been subjected to an extensive loss of habitat induced by human influence. This situation may become more unfavourable to eels since subtropical species such as the Lusitanian toadfish may spread northward as a result of raising temperatures caused by climatic changes.

Keywords: European eel, Lusitanian toadfish, trophic relations, spatial segregation, Mira estuary, Portugal

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ICES CM 2006/J:30 – Withdrawn

ICES CM 2006/J:31

Consequences of unreliable age determination in the management of the European eel, *Anguilla anguilla* (Linnaeus, 1758)

Isabel Domingos, José Lino Costa, and Maria José Costa

This study focus on the discrepancies in age estimation for the European eel, *Anguilla anguilla*, throughout its distribution area considering both estuarine and freshwater habitats. Despite considerable effort, estimating age

and growth of anguillids remains a difficult task mainly due to the recognized difficulty in interpreting otolith marks. As a consequence, big discrepancies in age estimation have been found not only among localities but also among readers. Although the inevitable influence of latitudinal differences, environmental conditions, and individual variability cannot be underestimated, such discrepancies might reflect differences in the interpretation of ring periodicity as well as differences in absolute age. Due to many constraints, age validation methods have not been fully successful in clarifying this situation. In the present study, the periodicity of growth increment formation was determined from the otoliths of eels sampled in the freshwater system of a southern river, the Mondego River. Marginal increments on saggita, measured monthly, were used to validate the periodicity and revealed that in this type of habitat, growth band deposition reflects a bi-annual incremental formation. The first ring, corresponding to winter was laid down between December and March whereas a second ring was laid down in summer between July and August. Unfavourable conditions such as high summer temperatures, typical of southern latitudes, can account for these results and affect growth similarly to what happens with low temperatures during winter. The possible extension of these conclusions to eels from other systems and the implications on the population dynamics and management issues are addressed.

Keywords: age, interrupted summer growth, southern latitudes, brackish and freshwaters, eel management.

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ICES CM 2006/J:32

Challenges in using genetics for European eel management: current status

Gregory E. Maes and Filip A. M. Volckaert

Marine organisms experience a wide range of intrinsic and extrinsic influences during their life cycle, which considerably impact their population dynamics and genetic structure. Subtle genetic differences reflect the continuity of the marine environment, but also pose challenges to define management units. The catadromous European eel *Anguilla anguilla* (Anguillidae; Teleostei) represents no exception. Its spawning habitat in the Sargasso Sea and vast migrations across the North Atlantic Ocean qualify it fully as marine. But the synergy between variable currents and a shifting climate in the open sea, and the impact of habitat degradation and overfishing in continental waters has brought this intriguing species to the brink of extinction. The protracted spawning period, variance in age-at-maturity, parental contribution and reproductive success, and the difficulty to sample the spawning region, all may mask a weak geographical genetic differentiation. Recent molecular data report evi-

dence for as well spatial as temporal differences between populations. However, temporal heterogeneity between intra-annual recruitment waves and annual cohorts exceeds spatial differences. Despite its common name of "freshwater eel", the European eel should be managed on a European scale. The fishery should be curtailed, migration routes kept open and water quality restored. Eel aquaculture has to focus on efficient rearing in the short term and controlled breeding in the long term. Future research should focus on (1) establishing a biological baseline from pre-decline historical collections for critical long-term monitoring of genetic composition, and (2) on the occurrence of adaptive genetic polymorphisms (genes under selection), to detect adaptive divergence between populations, requiring separate management.

Keywords: clinal variation, effective population size, genetic patchiness, isolation-by-distance, isolation-by-time, population genetics, recruitment; reproductive variance.

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ICES CM 2006/J:33

Why has the American eel (*Anguilla rostrata*) declined in the St. Lawrence River but not the Gulf?

D. K. Cairns

American eel (*Anguilla rostrata*) populations have shown dramatic declines in the upper St. Lawrence River, modest declines in the lower St. Lawrence River, and increases in the Gulf of St. Lawrence. A low North Atlantic Oscillation Index in the late 1960s/early 1970s may have bolstered eel numbers in both the River and the Gulf. However, conditions in the Atlantic Ocean cannot account for subsequent divergent population trends between River and Gulf. The timing of changes in the extent of river blockage by dams, of chemical contamination, of zebra mussel populations in Lake Ontario, and of fisheries harvest does not match the timing of changes in upper St. Lawrence River eel populations. Young eels ascend estuaries by swimming in the water column at flood tide and holding on the bottom at ebb tide. Deep waters of the St. Lawrence estuary have become hypoxic, which precludes use of this method of transport. The timing of the oxygen decline matches the timing of the eel decline in the upper St. Lawrence River. However, bottom waters on both the north and south sides of the estuary remain oxygenated, and eels could readily use these routes for upstream migration. I suggest that density-dependent upstream movement of eels, under conditions of overall lower recruitment from the ocean, can explain why eels have declined dramatically in the upper St. Lawrence River but only modestly in the lower River. However, an explanation for the difference between River and Gulf population trends remains elusive.

Keywords: American eel, *Anguilla rostrata*, St. Lawrence River, Gulf of St. Lawrence, population change.

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ICES CM 2006/J:34

Are dioxin-like contaminants responsible for the eel (*Anguilla anguilla*) drama?

A. P. Palstra, V. J. T. van Ginneken, A. J. Murk, G. E. E. J. M. van den Thillart

Eel populations world-wide are dangerously close to collapse. Our study is the first to show that current levels of dioxin-like contaminants are strong candidates, because of their devastating effects on development and survival of eel embryos. Female and male silver eels were artificially stimulated to maturation and reproduction by treatment with carp pituitary extracts and hCG respectively. During maturation of female European silver eels about 60 g fat per kg eel is incorporated in the oocytes. Together with the fat however, persistent organic pollutants such as dioxin-like polychlorinated biphenyls (PCBs) are incorporated too. The total dioxin-like toxic potency of the individual gonad batches was determined as TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxine) equivalents (TEQs), using an *in vitro* reporter gene assay. The observed differences in development and survival showed a significant negative correlation with the TEQ levels in the gonads, already at levels far below the maximal allowable level for fish consumption, i.e. 4 ng TEQ/kg fish. The clear inverse relationship between the TEQ-level and the survival period of the fertilised eggs strongly suggest that the current levels of dioxin-like compounds seriously impair the reproduction of the European eel. The peak of the environmental levels of dioxin-like PCBs and the decline of eel coincide world-wide, further suggesting that, in addition to other threats, these contaminants contributed significantly to the current collapse of eel populations.

Keywords: Sargasso, fish, decline, migration, maturation, reproduction, spawning, contamination, teratogenicity, polychlorinated biphenyls PCBs, fertility, embryology.

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ICES CM 2006/J:35

Speed of recovery of recruitment of the European eel

Mårten Åström and Willem Dekker

The European eel population has declined over the past decades in most of its distribution area, and the stock is outside safe biological limits. The European Union has taken up the challenge to rapidly design a management system that ensures the escapement of 40% of the adult spawning stock biomass, relative to unexploited, unpoluted circumstances in unobstructed rivers. This is ultimately in order to restore the spawning stock to a level where glass eel recruitment is not impaired, i.e. to restore to full historic glass eel recruitment. Current recruitment is at a historical minimum of around 2.5% of mid-20th century recruitment levels, and current spawner escapement, based on the recruitment of nearly one eel generation time ago, will already be much below the 40% level.

In order to explore the trajectory from the current depleted state to full recruitment recovery, we developed a simple model of stock dynamics, based on a simplified stock-recruitment-relationship and the conventional dynamic pool assumptions. Recruitment trajectories under different future fishery regimes are explored, for the medium (one generation time) and long time span (until full recruitment recovery). Reducing fisheries to zero, recovery is expected within 60 years, while under an ultimately sustainable fishing regime of about 10% of the present fishery mortality rate, recovery may take between 150–200 years. Moreover, management regimes, apparently leading to slight recovery of the stock in the coming 5–15 years, might still be unsustainable in the long term. Practical consequences of these findings are discussed.

Keywords: recruitment decline, recruitment recovery, fishery, simple model.

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ICES CM 2006/J:36 – Poster

Recruitment and migration behaviour of glass eel in the Oria River: Preliminary results from the 2005–2006 season

Jaime Castellanos, Marina Santurtún, and Estibaliz Díaz

The present study is part of the INDICANG project that aims to obtain a synoptic view of the status of the European eel by setting up an information and action network. For that reason, different Atlantic basins have been selected; one of them being the Oria river basin (Basque Country; North of Spain). The area of the basin is 888 km², the mean river flow 26 m³ s⁻¹ and the main river of the basin, the Oria, has a length of 77 km. Although the three eel stages are included in INDICANG; the present

study is focused on glass eel; and its specific objectives are: (1) to determine the recruitment, and (2) to study the migrating behaviour of glass eel in the Oria basin. In order to achieve these objectives, ten experimental glass-eel fisheries have been carried out during the fishing period (October 2005–March 2006). Three sampling points have been determined: the river mouth, an intermediate zone (4.5 km) and the upper limit of the tidal influence (6.5km). At these points, transects to obtain glass eel abundance were carried out with two different sieves, one in the deep and another one at the surface. During these samplings, data were collected on salinity, temperature, turbidity, and current in the water column. Size, weight, and the pigmentation stage were determined in the laboratory. Additional information provided by the fishermen catches report, and from an eel-trap installed 11 km from the river mouth is included to complete the study.

Keywords: *Anguilla anguilla*, glass-eel, recruitment, migration, pigmentation

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EELBASE: A 4-year eel research proposal submitted to the Belgian Research programme "Science for a Sustainable Development"

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The European eel (*Anguilla anguilla* (L.)) is a wide-spread species in decline and current fisheries are considered outside sustainable limits. The glass eel recruitment is now only 1% of what was observed before 1980. The European Commission has proposed that the primary instrument for management of European eel should be the development by Member States of "Eel Management Plans", including the implementation of monitoring actions for the EU Data Collection Regulation. A research project proposal has been submitted to the Belgian Research programme "Science for a Sustainable Development". Partners involved are institutes and universities in Flanders and Wallonia. The project is entitled "Progressive extinction of the eel: biological basis for a national recovery plan" and has the acronym "EEL-BASE". The objective is to set the scientific base for the development of the national Eel Management Plans by developing an eel database (EELBASE), designing a Belgian eel restocking programme and collecting new data about the key factors affecting the eel stocks throughout Belgium. Field studies in selected basins will focus on ecological aspects including habitat evaluation of yellow eel, silver eel escapement, and impact of turbines and pumps. Another objective is to evaluate interactions between the different environmental and physiological parameters by means of an extensive assessment

of biological traits of eels at polluted and unpolluted sites. For this, several aspects of health and condition of local pre-silver and silver eel populations will be studied (a series of physiological parameters, quality of gametes, parasitological and viral agents, etc.).

Keywords: European eel, *Anguilla anguilla*, management, stocks, migration, physiology.

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Minho river basin catchment area suitability for the European eel

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As all around Europe, the European eel (*Anguilla anguilla*) population present in Minho river, Northern Portugal, faces the challenges resulting from habitat disruption. The most referred problems are water pollution and obstacles to the free passage to suitable areas. The official data for the glass eel and yellow eel fisheries shows a decreasing trend. This progressive declining trend was confirmed by experimental fishing done since 1981. On one hand, the authors are addressing efforts to monitor habitat use of both glass and yellow eel in the Minho river basin catchment area, their physical condition, and to identify better indicators of the population status. On the other hand, some abiotic factors considered relevant when analysing the European eel population, such as sediment quality and obstacles degree of impassability, are also under investigation. It is the authors' belief that adequate indicators can reveal the population condition and its tendency in a near future, and this may be useful

for understanding eel habitat requirements contributing in that way to adequate management plans.

Keywords: European eel, Minho river, indicators.

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Variation in sex ratio of silver eels in the lower River Shannon, Ireland

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Silver eel catches at the Killaloe eel fishing weir have been monitored since 1992. A decline in the proportion of males was recorded until 2001 and this appears to be linked to an overall decline in the eel stocks of the Shannon River system. However, in recent years the patterns of juvenile eel stocking and of fishing pressure have been changing. Increased silver eel fishing in the upper and middle sections of the river has greatly reduced the catches at Killaloe and reduced the numbers of females reaching the lower section of the river. This has resulted in localised changes in eel sex ratio within the river system. As a consequence the proportion of males in the catches at Killaloe is now increasing again. The significance of these changes will be discussed with reference to management of River Shannon eel populations and the need to ensure adequate spawner escapement from the system

Keywords: Silver eel, *Anguilla*, sex ratio, River Shannon.

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