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EUROPEAN INLAND FISHERIES ADVISORY COMMISSION
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REPORT OF THE SECOND SESSION OF THE JOINT EIFAC/ICES WORKING GROUP ON EEL

IJmuiden, the Netherlands, 23-27 September 1996

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
EUROPEAN INLAND FISHERIES ADVISORY COMMISSION
Rome, 1997

PREPARATION OF THIS REPORT

This report summarizes the presentations, discussions and recommendations of the Second Session of the Joint EIFAC/ICES Working Group on Eel, which took place in IJmuiden, the Netherlands, from 23 to 27 September 1996.

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

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ABSTRACT

The Second Session of the Joint EIFAC/ICES Working Group on Eel took place from 23 to 27 September 1996, in IJmuiden, the Netherlands. The Session was attended by 41 participants from 29 countries, including 23 European countries as well as Australia, Canada, China, New Zealand, Taiwan and USA. Altogether, 32 papers were presented and 7 posters exhibited.

Presentations and discussions covered a wide range of research on the eel, with particular reference to recruitment, contamination, parasitic infestation and fisheries and their effects on stock and yield. The downward trend in recruitment and yield in the whole distribution area of the species elicited a discussion on the need for supra-national management of the stock and the possible application of the precautionary principle. A discussion on oceanographical matters concluded that information on physical oceanography and on the ocean stages of the eel was insufficient to allow any conclusions to be drawn.

Recommendations were made to restrict further expansion of fisheries and to maintain the supply of stocking material at its prevailing levels. In adddition, importation of exotic eels should be fully controlled to prevent the introduction of further parasites. Finally, it was recommended to maintain existing monitoring programmes and to supplement the anticipated Management Plan with a scheme for monitoring and research.

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1. INTRODUCTION

At the 83rd Statutory Meeting of ICES (1995) it was decided (C. Res. 1995/2:56) that the joint EIFAC/ICES Working Group on Eel (Chairman: Mr. C. Moriarty, Ireland) would meet in IJmuiden, the Netherlands from 24-28 September 1996 to:

a) assess trends in recruitment, contamination, parasitic infestation, fisheries and their effects on stock and yield of the species;

b) investigate the infection rate with *Anguillicola crassa* and characterize gas bladder function;

c) hold a special session jointly with oceanographers to consider oceanic factors which might explain recently recorded changes in the abundance of larvae and catches of glass eel;

d) conduct other relevant business.

This decision was in accordance with Recommendations I and II of the First Session of the Joint Working Party, adopted by the 19th Session of EIFAC (1996).

The meeting of the group was attended by 41 participants from 29 countries whose names and addresses are listed in Annex B. The Vice-chairman, Mr. Willem Dekker, was appointed Rapporteur. The Agenda (Annex A) was adopted as proposed.

The structure of this report is as follows:

Chapter 2 presents the Minutes of the Meeting. Chapters 3 through 5 elaborate on the first three items in the terms of reference. Finally, in Chapter 6, the negative trends in the stock are considered and potentially urgent management actions discussed.

2. MINUTES OF THE MEETING

The Chairman announced that the 19th Session of EIFAC, held in Dublin, Ireland, from 11 to 19 June 1996, had adopted the Report of the First Session of the Joint Working Group, held in Oviedo, Spain, 26 September to 1 October 1994.

During the intersessional period, the Chairman received communications from aquaculturists and glass eel merchants concerning the sudden increase in price offered to fishermen and the possibility that increased fishing mortality, resulting from the high prices, could jeopardize the stocks. The Chairman had undertaken to bring these matters to the attention of the Working Group.

The EC's Concerted Action AIR A94-1939 'Enhancement of the European eel fishery and conservation of the species' had been established and its first report would be presented at the Session. This represents the first contribution by the EU to an eel research project.

2.1 Larval and elver studies

The biennial review of glass eel catches throughout Europe was presented by Mr. Moriarty. New data included catch findings over 22 years from the Tiber River, Italy. Overall catches at the monitoring stations continued to be low in comparison with catches during the 1970s, although there were some small increases over the preceding 5 to 10 years. There was a close relationship between total catches from the Bann, Ems and Den Oever stations versus the Loire River indicating reasonably consistent trends Europe-wide. Demand for glass eels had increased dramatically, with prices increasing to as much as 330 ECU/kg.

Mr. Dekker presented analyses of two time-series of glass eel abundance from Den Oever. Since 1938, five dipnet hauls per night (for 100 nights/season) have been carried out to determine the numeric strength of the immigration, while once-weekly samples from 1960 onwards are available to assess trends in length distributions. Variability in average length between years can be as much as 1 cm and exceeds the intra-annual variability throughout Europe. This is accentuated in years when immigration is relatively late, resulting in glass eels being consistently longer throughout the season than those for years when immigration is early.

Overall, average glass eel length was correlated with abundance, while timing showed independent short-term fluctuations. It was felt that if over-fishing was a problem, then the subsequent

reduced abundance of glass eels should result in a trend of increased average size. This has not occurred, and neither has a trend to a later arrival of smaller glass eels which might have been expected if ocean transport was prolonged. These data may indicate that the trends of reduced abundance of glass eels are related to a decline in larval survival at the spawning grounds.

The influence of environmental variables on glass eel catches in the Adour Estuary, France, was presented by Ms. Bru and her colleagues. From a multi-factorial correspondence analysis, it was concluded that glass eel abundance (expressed as cpue) was strongly influenced by moon phase, water temperature, river flows, and cloud cover. Optimal conditions were predicted to occur at higher than normal flows and water temperatures, during the new moon phase and cloudy weather. Multivariate analysis of smoothed cpue data was used to produce a descriptive linear model and confirmed that there was a minimum threshold air temperature of approximately 7ºC and that the combination of a full moon and a clear sky were very unfavourable conditions for glass eel capture.

The controversy surrounding the length of larval life was highlighted by Mr. Tesch who reviewed results form various North Atlantic larval surveys. From the most complete transect data available (1922 and 1979) he concluded that the length-frequency distributions showed the presence of two, and possibly three, distinct year classes. Growth rates, estimated from changes in mean larval length over time, are consistent with this proposal; it was suggested that slow growth during winter may mean that daily growth rings are not formed in the otoliths but result in the formation of large diffuse zones as seen in the otoliths of late stage leptocephali.

Some leptocephali caught in the Bay of Biscay during November 1995 as reported by Desaunay and colleagues, were immersion-dyed in alizarin, and kept alive for periods of 2-13 days. During this time, stage IV larvae transformed to stages V A, V B and VI A, and there were suggestions from preliminary observations that the number of daily growth rings corresponded to the periods the larvae were kept alive. If correct, this would provide the first validation that such growth rings in leptocephali are formed daily. It was also suggested that smaller larvae of any stage show a higher mortality than larger larvae of the same stage, and hence survival of larvae is related to initial growth.

Mr. Jessop reported on the development and management of the fishery for glass eels in the Maritime Provinces of Canada. The fishery commenced in 1989 and about 3,000 kg are presently harvested. Development of the fishery has been tightly controlled - for instance, no fishery is allowed on rivers where larger eels are harvested. Cpue and timing of runs vary geographically but appear to be linked with oceanographic current patterns and differential lags in increasing river water temperatures during spring.

The role of the Environment Agency in managing the glass eel fishery and upstream immigration was presented by Mr. Churchward. With prices now reaching £ 250/kg an increasing number of fishermen (up to 1 000) now catch glass eels along the 50 km Severn Estuary. To facilitate upstream passage, 19 fish passes have been installed at 11 sites on the Avon River, a tributary of the Severn.

Increasing interest in the use of glass eels to seed inland waters and export to Asia, led Messrs. McKinnon and Gooley to study the invasion of *Anguilla australis* glass eels into 17 estuaries in south-east Australia. A preliminary model proved that significant variables associated with cpue were water temperature, conductivity, lunar phase, and tide levels. During the invasion season of May-October, high cpue was most strongly correlated with low salinity, and a temperature range of 10-14°C.

2.2 Oceanographic aspects of migration

Mr. McCleave presented his paper on the transport of eel larvae from the Sargasso Sea to European coastal waters. The net flow of water in the North Atlantic to the east and north east indicates that a passive drift of eel larvae is plausible. The quite recently proposed transport time of less than one year was questioned. The findings of only two to three discrete length groups in the Sargasso Sea contradict a more or less continuous spawning period.

Mr. Westerberg presented his results from studies of young eels along the Swedish coast. Data from drop trapping, trawling and eel ladders were not always consistent. In the same year (1996) glass eels were almost absent at sites in southern Kattegat and in the Sound while on the other hand they were to be found in normal numbers in the Skagerak area. An explanation was proposed, namely that in years with a lack of westerly winds the glass eels settle along the Skagerak coast and are not transported further to the south.

Mr. Russel presented the paper by Moore and Riley describing biomagnetism in eel. They found small magnetic particles, predominantly in the lateral line system on the lower jaw of silver eels. Analyses showed the particles were magnetite and of biogenic origin.

2.3 Yellow and silver eel populations

Due to a possible increase in the minimum legal catch size of eels, Ms. Boëtius had extracted data on length to weight relationships from a historical data set. Samples were available from Holbæk Fjord (southern Isefjord) from autumn 1991 and 1992 and spring 1992. A series of correlation coefficients, r^2 values, slope and intercept values were presented for (i) male + female eels combined, (ii) total males, (iii) total females (iv) male + females (30-45 cm the male size range), (v) females 30-45 cm only, (vi) females > 45 cm. Statistical tests for significant differences between slope and intercept values had not been undertaken.

After a brief review of New Zealand eel species and their distributions, Mr. Jellyman presented data form Lake Ellesmere, a large (20,250 ha) coastal freshwater lake in South Island, New Zealand. Here over the past 50 years there has been a shift in the sex ratio of short-finned eels *Anguilla australis* from a preponderance of females to one of males. Concurrent with this, the mean age of male eels has remained relatively constant while average length has declined by about 20%. It was thought that these changes were the result of environmental factors, particularly the proliferation of a small benthic bully *Gobiomorphus cotidianus* rather than of selective harvest.

The management implications of this were discussed. Mr. Moriarty noted that a similar reduction in female eel length had been recorded over a similar period in both the Shannon and Burrishoole systems in Ireland: the former a large, exploited fishery the latter a small unexploited one. There was no explanation for this finding at present, nor any growth rate information.

Mr. Chisnall presented preliminary results and comments on a study investigating eel stock data in nine hydro impoundment lakes throughout New Zealand. Studies of both *Anguilla australis* and *Anguilla dieffenbachii* were examined. Age structure reflected stocking levels, fewer younger eels being reared from impounded lakes than from ones stocked manually. Growth rates of *Anguilla australis* vary between catchments but were as high as 50-222 mm per annum so that animals may attain market size (220g) after only 2-5 years. Growth of *A. dieffenbachii* was considerably slower. Maintaining low stock densities and improving food availability were seen as the most appropriate management options.

Information was presented (poster presentation) on the verification of specimens of the Australian long-finned eel *Anguilla reinhardti* in New Zealand. Samples provided by a commercial fisherman were identified, by internal and external morphometrics, DNA analysis and vomerine teeth imprints. Age (determined by otolith analysis - burning and cracking) indicated that the *Anguilla reinhardti* caught in the Waikato River have grown 3-4 times as fast as the two native species in the same habitat.

Mr. Klein Breteler presented a preliminary, unrefined (i.e. unweighted variable) Habitat Suitability Index (HSI) model for the eel. The model was applied in a habitat evaluation procedure, which takes into account the area of suitable habitat. In addition, the model contains a series of 17 variables, based on 'common sense' relationships (e.g. a score in relation to marine or freshwater migration distances) and environmental factors (e.g. a score in relation to average temperature during the growing season) where appropriate. These variables were stated for male and female eel separately. Current HSI values for male and female eels were an order of magnitude less than those for the nineteenth century (e.g. 0.06 and 0.65, respectively). Numbers of habitat units (HU) for the Netherlands in the twentieth century were less than 10% of those estimated for the nineteenth century. It was concluded that the quality (i.e. survival) of silver eels was the most crucial factor in the life-cycle, and the importance of protecting eels during the freshwater phase was stressed.

Inspired by the recent capture of an exceptionally large eel in the Netherlands (length 133 cm, weight 6,900 g), Mr. Dekker requested information on maximum and minimum biometric measurements for *Anguilla anguilla.* Eels of the above-mentioned size are obviously rare, this being the biggest eel on record, based on information from approximately 500,000 yellow and 100,000 silver eels.

Mr. Kuhlmann presented a study of eel catch data in the lower River Elbe over a period of 20 years (1966-1986). He showed that during this time there was no significant decrease of the catches. The catch proved to be strongly correlated with the water flow. Correlation with the lunar period was less obvious in general although a closer relation between catch and moon phase was observed for the first and last quarters. A significant decrease in the numbers of smaller eels (< 250 g) started in the early 1980s and lasted through 1996. Similar observations were made in the River Weser, where the average body weight of the eels caught by anglers has steadily increased during the last decade. In 1996 the catches in the River Elbe as well as in the River Weser were extremely low.

Intramuscular levels of Fe, Cu, Zn and Hg were assessed in *Anguilla anguilla* from the estuary of the River Glomma in southeast Norway by Mr. Vøllestad. Eels were sampled at six stations. Size range was 290 to 594 mm and larger, older fish occurred in the upper river sites. Contaminant levels varied greatly between stations with elevated metal concentrations downstream from known pollution sources but there was no evidence of an accumulation with eel age or size. Hg levels increased with eel age and size, indicating that accumulation had occurred. Differences between marine and freshwater stations were discussed.

Mr. Carss presented data from two shallow lakes in northeast Scotland based on standard electrofishing sessions within enclosures of known area. Catches provided estimates of average eel size (length and weight), density and biomass in relation to habitat type. Eels from soft substrates were generally larger (greater median length) than those from rocky habitats. Between 1984 and 1996 there had been significant reductions in the median lengths of eels from both habitats. In general, the size of silver eels had remained the same, as had the proportion of the catch comprising these fish. Current information on water quality, habitat characteristics and otter (*Lutra lutra*) predation have also been recorded.

Despite large numbers of elvers having been stocked into Danish waters (e.g. > 8,000,000 in 1995), little is known about the 'success' of such programmes. The fate of approximately 85,000 eel (15-33 cm), marked with alcian blue dye, was investigated by Mr. Pedersen. These fish were stocked in three sites: a freshwater lake with sluice, a shallow brackish lagoon and an open coastal area. Although some capture rates were relatively high (i.e. up to 22% in one size class from one site) large recoveries were made in the year of release. However, it has been demonstrated that cultured eels released into the wild were capable of adapting to local conditions and growing at an estimated 2-5 cm per year. The Working Party recognized this finding as an important contribution to knowledge in relation to stocking programmes. Other information on the sex ratio of eels was presented and a discussion of marking techniques followed. Most favoured was the mass marking of small eels with coded wire tags but there was debate where these could be best implanted and the logistic limitations of processing large samples of fish quickly.

As part of an investigation into possible reasons for the failure of crayfish stocking in Finland, potential predation by fishes was examined by Mr. Tulonen. A series of ponds were stocked with juvenile signal crayfish *Pacifastacus leniusculus* and appropriate substrate and cover were provided. Some ponds were stocked with a range of fish species (ruffe, roach, burbot, eel and big and small perch) while control ponds contained no fish. After three weeks ponds were drained and crayfish counted. The presence of fish, regardless of species, increased the mortality of crayfish, mortality being highest in ponds with eel or perch. In biomass terms small perch appeared to be the most effective predator, the predatory effects of eels and other fish being much lower. It was acknowledged that the stocking densities of fish in experimental ponds were higher than would be found in natural habitats. Work was planned for 1997 to be based on more realistic fish densities. The geographic areas of crayfish and eel stocking overlap and there is an untested presumption that eel predation may cause crayfish stocking failure. The presentation ended with a short discussion on the habitat requirements and diet/diurnal activity patterns of the native *Astacus astacus* and introduced crayfish species.

Mr. Feunteun presented a study from a small but typical catchment in Northern Brittany, which has been subject to considerable damming. Eel population size and distribution were investigated using a catchment basis approach with a variety of techniques, including electrofishing, for which results were presented. No significant differences were found in eel abundance (density or biomass) with distance from river mouth. However, there were extremely high estimated biomasses in some areas while eels were absent from others but there was no apparent relationship between eel abundance and habitat. There was a general tendency for eels to accumulate immediately below dams with a corresponding reduction in biomass immediately above them. Below the first dam, eels were much smaller compared to the rest of the catchment, indicating that dams can affect the size distribution of eel.

Mr. Tzeng and colleagues reported on attempts to recapitulate the environmental history of eels from Swedish brackish waters and freshwater lakes using the Sr/Ca ratio in otoliths. As the Sr/Ca ratio is much higher in salt than in fresh water, this method provides information on the periods spent by eels in these two environments. Similar work had been undertaken on *Anguilla japonica* by the author. The method proved reliable for otoliths from *Anguilla anguilla* of known environmental history and also gave credible information for eels of unknown origin. Sr/Ca ratios for eels migrating through the salinity

gradient of the Baltic Sea were currently under investigation. It was suggested that the method could help determine the precise timing of leptocephalus metamorphosis.

Mr. Doering presented work in progress on ageing fish. The working hypothesis is that age determination is coded in the 3-D shape and density distribution of otoliths. The intention is to develop and validate a non-destructive age determination technique based on measurement of the external shape of otoliths in combination with other data (e.g. otolith weight). The method involves the use of a newly developed micro X-ray tomography technique which should reduce the subjectivity and high labour intensity required by current microscopic techniques.

The first year results of a two-year EU-funded project were presented by Mr. Moriarty. This project is a Concerted Action, entitled 'Enhancement of the European eel fishery and conservation of the species' and funded by the EU under the AIR scheme. It aims at the preparation of a status report on eel stocks and the formulation of a Europe-wide management plan. Phase 1 of the project consists in preparing an inventory of current knowledge of the eel fishery. This data base was made up of information provided by 17 experts, representing nine EU Member States. The report includes information from throughout Europe assembled into a number of country synopses. All figures are essentially the best estimates available to the group. Information on yield, value, number of fishermen, catch trends (general and local), glass eel recruitment and harvest was presented. Evidence suggests that the eel is a marine fish and, as such, should be eligible for appropriate research funding opportunities.

Current information on (1) the number of farms and (2) the estimated tonnage of eel consumption was presented by Mr. Gelin. Information related to 'intensive eel culture' in both warmwater systems and recirculation systems was given. The Working Group members were requested to provide missing or updated data on a country-by-country basis. Concern was expressed regarding the consequences of high demand for European glass eels from the Far East, the resulting cost increases being borne more easily by commercial farms than by re-stocking interests.

Information on the eel fishery in Lake Võrtsjärv (270,000 ha) was presented by Mr. Kangur. Estimated figures for the summer fishery are 30-50 tonnes per annum but the catch is assumed to be 90-100 tonnes. The lake is stocked with glass eels brought from England but the numbers bought and released fluctuate for economic reasons. In 1995/1996, the winter was very cold and, coupled with very low water levels, led to a large number of dead eels being discovered after the ice had melted. An estimated 20 t of eels were thought to have died. This loss was, however, not reflected in catches which, by the end of August 1996, had reached 30 tonnes, and would be larger by the end of the season. Concern was voiced for the future as water levels in August 1996 were the lowest this century and the forecast is for a similar rainfall during the 1996/97 winter. There appears to be no technical solution to this problem.

2.4 Culture and physiology

Mr. Appelbaum (together with Birkan) presented a paper on an experimental rearing unit for eel: including a unit with particulate-feeding tilapia removing organic particulate matter, and a biological filter unit. High densities (200 kg m^{-3}) were used, thus breaking down the social structure within the eel population. This reduced the level of aggressive interaction between the eels. A commercial-scale unit will be in operation shortly.

Ms. Holmgren (together with Mosegaard) presented a study on plasticity in eel growth, showing not only that growing individuals grow faster at a higher temperature, but also that extremely growth-depressed individuals (for more than two years) can still maintain a high growth potential. In a parallel study, small males (10-40 g) increased faster in weight than females, although small eels of both sexes had equal growth rates in terms of length increase.

Mr. Kamstra (together with van Heeswijk) tested the effect of the fat reserve acquisition on sex determination in eels. They reared a cohort of glass eels for more than one year in a recirculation system. At the end of the experiment they found 53% males, 32% females and 15% of unknown sex. Females had higher fat contents than males. All eels had, however, reached relatively high fat contents at an early stage. Fat content seems not to have any decisive role in the sex determination of farmed eel.

Mr. Lin Hao-Ren reported on an ongoing project on artificial induction (using exogenous and endogenous gonadotropin and different kinds of hormonal treatment) of gonad maturation and ovulation in the Japanese eel. Gonad development and spontaneous spawning were induced using these different treatments. The studies also gave important insights into the hormonal regulation of

gonadal development in eels. The embryonic development and hatching rates are temperature and salinity dependent (acceptable limits for Japanese eels: 20-26 °C, 20-35 ‰ salinity). Maximal survival time of larvae was 23 days post hatching.

Mr. Richter (with co-workers) presented a summary of different experimental studies on sex determination in hatchery-raised eel. The experiments were based on three cohorts of glass eel from the Garonne Basin, France. Undifferentiated gonads were seldom found. This stage can develop directly into ovaries. Differentiation of male sex proceeds via an intersexual stage with male and female sex cells. Differentiation seems to be synchronised with metamorphosis. Sex reversal does not seem to occur. Both males and females continued to eat and grow after becoming silvery, whereas gonadal development gradually stops.

Mr. Knights presented the outline of a literature review which he is undertaking on the risk assessment of contamination of eels with persistent organochlorine compounds. In his presentation of different compounds, hazard identification and hazard analysis, he indicated some important gaps in our knowledge. For example, the recognition of a toxic effect can be confused with a generalised stress response. Further, little is known about the chronic toxicity and mobilisation of fat-stored PCB during, for example, maturation of gonads and migratory activity. Information is also lacking on the bioconcentration/elimination abilities of different size classes. The use of eels as potentially good bioindicators should be evaluated. However, sampling protocol and analytical procedure should be standardized as much as possible.

2.5 Parasitology and contamination

The Working Group had been requested to assess trends in parasitic infection and also, specifically, to investigate the infestation rate with *Anguillicola crassus* as well as to characterize gas bladder function.

There were a number of presentations on *Anguillicola* distribution and infestation rates in different countries.

Mr. Dekker reported that in the Netherlands gross morphological examination for *Anguillicola* was carried out during routine stock monitoring investigations on the IJsselmeer fishery since 1985. A large increase in incidence rates was observed after 1985 in yellow eels from both the southern and northern parts of the lake, with levels >90% in 1986-87. Subsequently, incidence levels had stabilized at a lower level (50-70%), with a lower and stable number of parasites per infected eel. The silver eels showed a similar evolution, with a slightly higher incidence level. The number of adult parasites observed in infected eels had also stabilized after elevated levels in the earlier years of infection, but were higher for silver eels than yellow eels. There had been no clear evidence of eel mortality unequivocally linked to *Anguillicola.* Attention was also drawn to the work of Haenen and van Banning (RIVO); a publication list had been circulated.

Ms. Hahlbeck presented data for eels from coastal areas of the Baltic Sea and some freshwater sites in Germany from recent years. Stages of infestation were assessed at five levels of infection, as described by Hartmann (1993). Samples were collected at similar times, as seasonal changes would otherwise make comparison difficult. *Anguillicola* had been present in the Baltic since 1987 and had now been found at all sites investigated. In 1994/95, degrees of infestation varied from a minimum of 17% to a maximum of 93%. Samples from the outer coast showed the lowest degree of infestation. The number of parasites were higher in samples with higher infestation rates. There was no strong correlation between infestation and the size or condition of the eels. Infection levels had fallen between 1991 and 1993, but had levelled out more recently.

Data for Denmark were provided by Mr. Pedersen. *Anguillicola* was distributed throughout the country in both freshwater and marine environments, although one small sample (n=31) from a fjord had shown no infestation. Infestation rates varied from 14 to 88% at other sites; it was estimated that about one-third of all eels carried the parasite. The average number of adult parasites in infected fish was four. At two sites, longer-term monitoring suggested that levels of infestation had stabilized at approximately 50%, after initially far greater levels (>80%).

Mr. Wickstrom reported that *Anguillicola* had first been detected in Sweden in 1987 in a consignment of eels of Polish origin. Subsequently, infected yellow eels were detected on the Swedish west coast in 1989. At present, the parasite is well established, mainly in brackish waters along the coasts, but also in some freshwater lakes. The prevalence and abundance of *Anguillicola* was high in some localities, and particularly at thermal discharge sites. However, the rate of infestation increase was quite slow at three closely monitored sites, and seemed to be slower than in most of continental

Europe. There was good evidence that the use of yellow eels from the Swedish west coast for stocking purposes had caused the spread of *Anguillicola* to several lakes (eel stocking controls had been introduced in 1991). There was no evidence of a link between the size of eels and the levels of infection.

Investigations of the presence of *Anguillicola* larvae in prey species regurgitated by cormorants in Poland were presented by Ms. Wlasow. The study was conducted at a large cormorant colony on the Vistula lagoon and seven fish prey species (other than eel) were examined (a number of fish are known to be able to act as paratenic hosts for *Anguillicola* larvae). Larvae were detected only in ruffe, the dominant species in the diet of the cormorant (estimated at 58% of the weight of food consumed). On the basis of the infestation rate (33.3%), it was estimated that cormorants ate 150 tonnes of infected ruffe per year and, in this regard, could perhaps be regarded as beneficial. However, it was noted that cormorants could also potentially act as vectors by which the parasite could be transferred from water to water (the larvae remained viable in dead fish for up to 24 hours). The mean number of third stage larvae per infected host was calculated at 1.6.

Ms. Wlasow also reported a further study conducted in northern Poland in which levels of infestation caused by adult, pre-adult and larval *Anguillicola* were determined in eels in a small enclosed lake each year from 1993 to 1995. It was concluded from this study that it was necessary to examine the swim bladder walls (to enable detection of larvae) in order to determine the intensity and prevalence of *Anguillicola* infection adequately. This was especially true during the early phase of anguillicosis in a water body.

Mr. Kangur (poster) indicated that *Anguillicola* were also present in Estonia, probably introduced from Germany in autumn 1989. About half the eels in Lake Võrstjärv are thought to be affected. The mean number of adult parasites in the swim bladders of infected eels was 24 (maximum recorded 92). There was no correlation between the size of eels and number of parasites.

Mr. Baska presented details of three major eel mortalities in Lake Balaton (Hungary) for which the primary causative agent appeared to be the presence of *Anguillicola.* The first mortality had occurred in 1991, when 200 tonnes of eels died in the western part of the lake. Further large mortalities occurred in 1992 (central part of lake) and 1995 (eastern lake). The pattern of mortalities was consistent with the spread of *Anguillicola* in the lake and the highest infestation rates. No other possible causes had been identified, although high water temperatures were probably also a contributory factor in some years. Detailed morphological and histological examinations had been carried out on eels affected with *Anguillicola* and these had shown that it was not only the adult worms in the swim-bladder which caused problems. The migrating larvae were capable of causing extensive tissue damage throughout the body of the eel and greatly increased the chances of secondary infection of such lesions by bacteria. In addition, secondary toxic effects also caused damage to other organs such as the liver.

Levels of *Anguillicola* infection in Belgium were reported to be similar to those elsewhere in Continental Europe. Mr. Belpaire estimated that 78.5% of the eel population in four disconnected meanders of the Rivers Scheldt and Leie was infected, with intensities up to 112 parasites per fish. Prevalence varied between 61 and 90%. Around half the eels analyzed contained between 1 and 10 parasites.

2.6 Co-operative work

During the 1991 meeting, it was decided to set up co-operative projects by the members of the Working Group. Three major fields of interest were designated: the compilation of a **glass eel bank** from all jover the continent; comparison of available **data on growth**; and the compilation of a **review on contamination.**

- The **glass eel bank** was established in 1993 in Dublin, at the Zoology Department of Trinity College (contact Richard Donnelly). Ten countries have made contributions from the start of the project onwards. It has been profitably accessed for genetic studies, as presented by Messrs. Volckaert and Daemen during this meeting. All contributors and the holder of the bank have expressed their willingness to continue their contributions and consequently, the Working Group recommends that this project should be maintained.
- Data on **growth of eels in natural waters** have been compiled from various (published or unpublished) sources all over the continent, but the co-ordinators have not found time to analyze the resulting data set. Since the laborious compilation of basic data has been finished, the Working Group encouraged the co-ordinators to accomplish their analysis for the following meeting.

- A review on the **contamination of eels** had been compiled by Mr. Knights in 1993, with subsequent updates in the following years. In his contribution this year, Mr. Knights stressed the scattered nature of the relevant sources. His expressed intent to proceed with the work was welcomed by the Working Group.

At the 1993 meeting in Olsztyn, a full list of research needs with respect to the European eel stock was compiled (Annex F of the Report of the EIFAC Report of the Eighth Session of the Working Party on Eel, Olsztyn, Poland, 24-29 May 1993, EIFAC/OP27), but no priorities were set. Subsequently, some progress has been made by individual members on a few points which fitted within national frameworks, but balance and co-ordination are completely absent. It was noted that the Working Group has in the past been able to compile national data in internationally co-ordinated data bases, but that the Group does not have the opportunity to steer nationally funded research programmes towards the analysis of subjects relevant to the continent-wide management of the stock. Several joint research initiatives (e.g. in genetics and silver eel migrations) were put forward for international funding last year, but have been kept pending awaiting the report of the ongoing Concerted Action on the status of the eel stocks and the compilation of a Management Plan. During the meeting, some coordination of the ongoing and proposed work was acknowledged. However, it was noted that the Management Plan, due to be formulated under the AIR Concerted Action, would concentrate on management of the stocks rather than on future co-ordinated research. This would imply a weak basis for the management, lacking a clear route for improvement. The Working Group strongly recommended that the Management Plan should be supplemented with an international scheme for monitoring and for more fundamentally-oriented research on eel.

3. TRENDS IN THE STOCKS AND FISHERIES

3.1 Recruitment

The catch of glass eel in European estuaries is monitored at 13 sites throughout Europe. Since the mid-eighties, a prolonged decline had been observed. Observations during the past two years indicate a continuation of very low returns in general, but at some stations a slight increase (at the River Bann and Den Oever) occurred. Following the decline, a drop in continental stocks had been observed in several regions, accompanied by a falling yield to the fisheries. The weight of evidence currently favours hypotheses assuming that oceanographic changes have caused recruitment failure, but in the absence of any actual knowledge on the reproduction process in the wild, there is no way to pass the stage of speculative hypotheses.

The consequences of prolonged recruitment failure for management advice are discussed in section 6.

3.2 Trends in contamination

Levels of organochlorine pesticides and heavy metals have generally continued to decline or stabilize, except for some ‘hot spots', demonstrating the effectiveness of pollution control and prevention measures which have been put into operation since the 1970s and 1980s. PCB levels still remain a concern in some waters but impacts on eel stock survival and recruitment are generally unproven. A review on organochlorine contamination is to be published, followed by one on heavy metals. Monitoring by the Working Party will continue, including a watching brief for any new contaminant problems.

3.3 Trends in fisheries

The number of routinely monitored eel stocks in Europe is extremely low. Data on landings are still based on guesswork in many areas, blocking the analysis of time series on the whole continent. Long-running assessments of local stocks are limited to a few examples, notably the IJsselmeer yellow eel fishery, as well as Lough Neagh and Lake Malaren fisheries, and several of the glass eel recruitment data series. The general trend is one of declining commercial catches in the yellow and silver eel fisheries (at least partly caused by the decline in yield following the recruitment failure) and an increase of effort in the fisheries for glass eels in 1996, due to the extreme prices offered by Eastern Asian eel farmers. There are, however, no signs that this increased effort has resulted in a substantial increase in catches of glass eels. As a consequence of the high prices for glass eels on the international markets, the quantity of glass eels used for stocking purposes in northern, central and eastern Europe has dropped once more. For instance, in the Netherlands, 8,200 kg of glass eel were stocked in 1980 at a purchase price of 40 Dfl/kg; in 1995, 1,595 kg were stocked at a purchase price of 190 Dfl/kg, while in 1996 only 688 kg were stocked at a purchase price of 795 Dfl/kg. This drop in stockings coincides with the drop in natural recruitment, intensifying the drop in stocks.

4. PARASITE INFECTIONS

Anguillicola crassus has continued to spread and high levels of infection and incidence have been recorded in some populations. The parasite now appears to be absent only from Ireland and the west coast of Norway. These infections have been the reason for eel kills in lake Balaton (Hungary) and damage to swim-bladder structure and functions has been identified. However, there is still no proof of major impacts on eel recruitment or stocks. Working Party members will continue to monitor the situation.

Having seen the effect of the man-made introduction of *Anguillicola crassus* to Europe, serious concern has arisen over the possibility of further introductions of exotic parasites. The dangers posed by the introduction of novel parasites were highlighted. *Anguillicola crassus* was in equilibrium with its native host *Anguilla japonica*, but it is now found in greater numbers and at higher levels in *Anguilla anguilla*.

The function of the swim-bladder in the eel during its oceanic migration was unclear. It was thought that the main function may be to enable the eel to maintain depth with a minimum of energetic cost. Evidence from American work indicated that the gas secretion capabilities of the swim-bladder was enhanced in silver eels. It was therefore likely that swim-bladder damage would be a disadvantage to migrating silver eels. Experimental studies of swimming performance in individual eels had suggested swimming speeds were correlated to numbers of parasites present.

The effects of *Anguillicola crassus* on individual eels and eel stocks is not clear except in rare cases such as the eel mortality in Lake Balaton. In addition, it has been impossible to assess the possible effect of parasite damage on the ability of eels to complete their oceanic migration back to the spawning grounds. The effect of the parasite on glass eel and elver is very poorly documented.

The Working Group recognized the need for further experimental work to determine the level of impact of *Anguillicola crassus* on individual eels at various life stages and on eel stocks as a whole with particular reference to evaluating the effect of infection in the following areas:

- Swimming performance of yellow and silver eels
- Development and migration of glass eel and elvers using morphological and histological studies
- Survival of yellow and silver eel in the presence of independent environmental stress

5. OCEANOGRAPHIC FACTORS

Oceanographic factors are implicated in glass eel recruitment failures, but present knowledge is insufficient to reach firm conclusions about cause-effect relationships. Available knowledge on eels in the ocean (both mature adults and their progeny), is rather sketchy. Basic questions such as the migration routes, the duration of the migration and the food being consumed by the larvae have not been settled. No regular sampling of eels in the ocean takes place and yearly research cruises had been abandoned. Research on the biology of the early life stages in the Atlantic is required to explain fluctuations in recruitment.

On the continent, the immigrating glass eels are monitored at 13 stations spread over Europe. Analysis of these time series in relation to oceanographic data series might be feasible, but is likely to produce spurious results. Without access to the actual processes determining the emergent properties, no prior hypotheses can be formulated and no formal testing of results can be achieved. In the meantime, the Working Group will continue to monitor relevant developments in and data from other oceanographic and biological studies in the Atlantic and associated waters.

6. MANAGEMENT OF THE POPULATION

No management objectives other than those expressed in Recommendations 1, 2 and 3 of the Eighth Session of the EIFAC Working Party on Eel (Olsztyn, 1993), had been made explicit. As requirements vary greatly throughout Europe, the Working Group felt unable to address the question of proper management, both because of the scarcity of data from the greater part of the continent and because of the lack of common perspective with respect to management objectives.

However, the status of the eel is unique since it depends on a common spawning stock and artificial propagation has not been made possible in spite of extensive experimental work still in progress. Concern has been expressed as to the survival of the (minimal) spawning stock. Therefore, the Working Group gave favourable consideration to the operation of the 'precautionary principle'.

Objectives aiming at stable or enhanced fisheries might be seen to contradict the aim of conservation of the species. However, the main contributions to the spawner escapement probably originate from areas having a traditional fishery for yellow and silver eels. Enhancement of the stocks in these areas would therefore enlarge the spawner escapement.

The Minimum Biological Allowable Level is unknown, but genetic studies indicated a gene pool in the order of the magnitude of 100,000 individuals, equivalent to about 100 tonnes of silver eel. The escapement of silvers is generally unknown, but in several places there is reasonable evidence of an escapement of this magnitude. These include Lough Neagh, major rivers in Great Britain, the River Rhine, and others. It is therefore considered unlikely that fishing mortality alone has caused the observed decline in recruitment.

A persistent problem in providing management advice on eel has been the inadequacy of knowledge of the biology of the eel. Certain facts have now been established, including:

- dependence on a distant, oceanic spawning ground
- persistent low levels of recruitment, stock and catch over a period of 15 years
- growth rate so slow that normal commercial considerations discourage investment in research and development by the private sector
- effectiveness of man-made redistribution of young stages in maintaining and enhancing the stocks

Although scientific knowledge of the species has not yet advanced far enough to permit the development of a model to forecast the results of a global approach to management, the Working Group concluded that the following recommendations could be made, within the context of the precautionary principle, the use of best scientific evidence available and uncertainties. Whereas the measures are designed to sustain stock level to maintain employment in the fishery at least at current levels (and possibly to explore opportunities to encourage future expansion), the short term aim of the recommendations is in conservation of the stocks.

Spawning stock

Considering the evidence of continuing low glass eel recruitment and low commercial catches, especially of yellow and silver eels, spawner escapement should be maintained and, wherever possible, enhanced as follows:

Restricting glass eel fisheries

It may not be feasible to put limits on current glass eel fisheries and the true value of such action in maintaining or enhancing Europe-wide stocks is, in any case, unproven. However, governments should limit extensions of current fisheries or development of new ones (unless fuller evidence is available) using any current legislation and, where necessary, instituting new measures. Obviously, this restriction does not pertain to the fisheries for stocking purposes.

Stock enhancement

Techniques for enhancement of eel stocks are well established and effective. Restocking, intra-catchment transfers, construction of elver passes, etc. can be used for maintenance or enhancement of the local stocks. Local, and especially, intra-catchment transfers of glass eels and pass-trapped elvers and juveniles should be used to enhance upriver stocks, especially in under-exploited catchments. This will benefit the fisheries but at the same time also increase/secure the spawner escapement. Supplies of recruitment material should be maintained at least at the levels prevailing before the recruitment failure, in the 1960s and 1970s. This will imply that the acquisition of glass eels for stocking purposes attains precedence over direct consumption and aquaculture.

Commercial fisheries

At local and national levels, exploitation of glass, yellow and silver eel should not be allowed to increase above levels prevailing over recent years, unless stock enhancement is being carried out.

7. OTHER MATTERS

The Chairman, Mr. Moriarty (Ireland) announced his intention to resign in accordance with his feeling that, after six years, the Working Group would benefit from a change. His proposal that the Vice-Chairman, Mr. Dekker (the Netherlands) should be recommended to EIFAC and ICES to succeed him was accepted unanimously. The Group also agreed that Mr. Fontenelle (France) should be invited to serve as Vice-Chairman.

8. RECOMMENDATIONS

Considering the indications of poor recruitment over a major part of the eel's range, the decline in stocks and catches and the high incidence of *Anguillicosis*, the joint EIFAC/ICES Working Group on Eel recommended that:

1) The precautionary principle be now applied to fisheries of all life stages. This implies that:

   - fishing be restricted to prevailing levels except in cases where management practice or scientific evidence indicates that expansion may be tolerated without harm to the stocks
   - supply of recruitment material be maintained at least at the levels prevailing before the recruitment failure

2) Despite the drops in immediate commercial yields, monitoring programmes be maintained or enhanced, in order to allow for the meaningful application of the precautionary principle above.

3) Importation of exotic species of eel be fully controlled to prevent the introduction of further parasites.

4) The team responsible for EU Concerted Action AIR A94-1939 'Enhancement of the European eel fishery and conservation of the species' accompany their management advice with a complementary scheme for monitoring and research.

9. NEXT MEETING

The Working Group agreed to ask the Danish Institute for Freshwater Research to host the next meeting at their laboratory in Silkeborg in 1999. In consideration of the fact that the regular meetings of the Working Group do attract workers in the field of eel fisheries management, but do not attract all relevant expertise in the field of Anguillid research, the Chairman was requested to consider organizing a Symposium on Anguillid Eels with the possible collaboration of one or more other fishery organizations. The work of the Working Group in providing management advice should, where appropriate, be continued.

ANNEX A

AGENDA OF THE MEETING AND TITLES OF PAPERS PRESENTED

Monday 23rd September

European elvers

Moriarty, C.: Glass eel supply and demand in Europe in 1995 and 1996.

Dekker, W.: Long-term trends in glass eels immigrating at Den Oever, the Netherlands

de Casamajor, M.N. and P. Prouzet: Glass eel in the Adour basin: production and influence of the environmental factors on their catchability

Tesch, F.-W.: Calculations on available data of eel larvae *Anguilla* sp. lengths in the North Atlantic with respect to age and growth

Bru, N. and S. Dossou-Gbete: Exploratory analysis of the evolution of the cpue of glass eel in the Adour estuary by smoothed PCA

Desaunay, Y., D. Guerault, P. Grellier, and G. Williamson: Eel larvae caught by French RV *Thalassa* in the Bay of Biscay continental slope in November 1995: otolith marking experiment and daily rings validation

American and Australasian elvers

Jessop, B.: The biology and management of the elver fishery of the Maritime Provinces

McKinnon, L.J. and G.J. Gooley: A preliminary model of the invasion of *Anguilla australis* glass eels into estuaries in south-east Australia

Oceanographic aspects of migration

McCleave, J.D.: Do leptocephali of the European eel swim to reach continental waters? Conflicting results from biology and oceanography?

Westerberg, H.: Oceanographic aspects of the recruitment of eels to the Baltic

Tuesday 24th September

Yellow and silver eel populations

Boetius, I.: Comparison of length/weight relations in male and female wild eels

Jellyman, D.: Changes in the size and age structure of migrating male *Anguilla australis* from Lake Ellesmere, New Zealand over 20 years

Chisnall, B.: *Anguilla* population parameters in depleted and stocked New Zealand hydro-electric impoundments and options for management

Klein Breteler, J.G.P.: Historic changes in the suitability of Dutch waters for eel

Carss, D.N.: Unexploited yellow eel stocks in two shallow lakes: spatial and temporal trends

Pedersen, M.: Recapture rate, growth, sex and silvering of liberated cultured eels *Anguilla anguilla* (L.)

Tulonen, J.: Predation by eel *Anguilla anguilla* (L.) and four other fish species on juvenile signal crayfish *Pacifastacus leniusculus* (Dana) in small experimental ponds

Feunteun, E., J. Guillouet and A. Legault: Spatial distribution and characteristics of an eel population in a coastal catchment of northern Brittany (France). Effects of hydraulic works and eel passes.

Tzeng, W.N., K.P. Severin and H. Wickstrom: Use of otolith microchemistry to investigate the environmental history of European eel

Moriarty, C.: The state of the European eel fishery in 1995

Genetics

Daemen, E., F. Volckaert, T. Cross and F. Ollevier: Population structure of the European eel *Anguilla anguilla*: application of genetic variation at microsatellite loci and mitochondrial DNA sequences

Volckaert, F.A., E. Daemen, B. Hellemans, J. Bogerd, H.J.T. Goos and F. Ollevier: The genetic sex of European eel *Anguilla anguilla*

Wednesday 25th September

Excursion to IJsselmeer, Zuiderzeemuseum, Batavia.

Thursday 26th September

Culture and physiology

Appelbaum, S.: Small-scale water recirculation for experimental rearing of eels

Holmgren, K.: Plasticity in growth of indoor reared European eels

Kamstra, A. and R. van Heeswijk: The sex-ratio and fat content in a cohort of eels reared under semi- commercial circumstances

Lin Hao Ren: Artificial induction of gonadal maturation and ovulation in the Japanese eel *Anguilla japonica*

Richter, C., K. Beullens, F. Ollevier, J.H. Komen: Sex differentiation in hatchery raised eel

Parasitology and contamination

Knights, B.: Discussion on contamination

Dekker, W. and J. van Willigen: *Anguillicola* in eels in the IJselmeer

Hahlbeck, E: Information on the distribution and abundance of *Anguillicola crassus* in eels from the Baltic Sea and adjacent coastal waters and freshwater of Germany in 1994-1995

Pedersen, M: The occurrence of *Anguillicola* in Danish waters

Wickstrom, H.: *Anguillicola* in Sweden: present status

Friday 25th September

General discussion and conclusions

Proposals for inter-sessional studies, date and place of next meeting

Adoption of the report

Posters exhibited

Chisnall, B.: Australian longfinned eel *A. reinhardtii* surfaces in New Zealand

Dekker, W. and J. van Willigen: Short, long, thin, fat eels

Gelin, C.: The status of intensive eel culture in Europe, 1996

Kangur, A.: *Anguillicola crassa* in Lake Võrtsjärv (Estonia)

Vøllestad, A.: Intramuscular levels of Fe, Cu, Zn and Hg in European eel *Anguilla anguilla* (L.) in a polluted Norwegian estuary

ANNEX B

LIST OF PARTICIPANTS

Appelbaum Samuel
Ben Gurion University
The Jacob Blaustein Inst.
Desert Aquaculture Unit
Sede Boker Campus
84990 Israel
tel: +972 7 57 565 0871
fax: +972 7 656 5871
email: sappl@bgumail.bgu.ac.il

Baska Ferenc
Vet Medical Research Institute
Hungarian Academy of Sciences
P O Box 18
H -1581 Budapest
Hungary
tel: +36 1 252 2455
fax: +36 1 252 1069

Belpaire Claude
Institute for Forestry and Wildlife Management
Duboislaan 14
B -1560 Groenendaal Hoeilaart
Belgium
tel: +32 2 6570386
fax: +32 2 6579682
email: cbelpaire@ibw.be

Boetius Inge
Grantstuevej 20
DK-2840 Holte
Denmark
tel: + 45 42 42 42 50
fax: +45 42 42 42 50

Bru Noëlle
INRA
Station d'hydrobiologie de St.Pée-sur-Nivelle
BP 3
F - 64310 Saint-Pée-sur-Nivelle
France
tel: +33 59 51 59 51
fax: +33 59 54 51 52

Carrs David
Institute of Terrestrial Ecology
Banchory
Kincardineshire AB31 4BY
Scotland
tel: + 44 1330 82 3434
fax: +44 1330 82 3303
email: DNC@wpo.nerc.ac.uk

Chisnal Ben
NIWA
P.O.B. 111-15
Hillcrest, Hamilton
New Zealand
tel: + 07 8561772
email: CHISNALL@hamilton.niwa.cri.nz

Churchward Alan
The Environmental Agency
Riversmeet House
Tewkesbury
Gloucestershire GL20 8JG
England
tel: +44 1684 850951
fax: +44 1684 293599

Daemen Edgar
Katholieke Universiteit Leuven
Zoological Institute
Naamesestraat 59
B - 3000 Leuven
Belgium
tel: +32 16 32 39 66
fax: +32 16 32 45 75
email: aquabio@bio.kuleuven.ac.be

Dekker Willem
RIVO-DLO
PO Box 68
NL - 1970 AB IJmuiden
Holland
tel: +31 255 564 712
fax: +31 255 564 644
email: Willem@rivo.dlo.nl

Doering Peer
Essener Str 8
D - 10555 Berlin
Germany
tel: +49 30 392 8447
fax: +49 30 392 86 73
email: peer_doering@bln.de

Feunteun Eric
University of Rennes I, UMR CNRS 1853,
Laboratoire d'Evolution des Systèmes Naturels & Modifiés
Avenue du Général LECLERC
F - 35042 Rennes Cedex France
tel: +33 99 28 14 39
fax: +33 99 28 14 58
email: eric.feunteun@univ-rennes1.fr

Gelin Curt
Scandinavian Silver Eel
Box 902
S-251 09 Helsingborg
Sweden
tel: +46 42 142433
fax: +46 42 143176

Halhbeck Eka
Bundesforschungsanstalt für Fischerei
Institut fur Ostseefischerei
An der Jägerbak 2
D - 18106 Rostock 5
Germany
tel: +49 3 8181 0350
fax: + 49 3 8181 0445

Hao Ren Lin
Department of Biology
Zhongshan University
Guangshou
China
tel: +86 20 84191215

Holmgren Kerstin
Institute of Freshwater Research
S -178 93 Drottningholm
Sweden
tel: +46 86200438
fax: +46 875 90338

Jellyman Don
NIWAR
Kyle Street
Riccarton
PO Box 8602
Christchurch
New Zealand
email: DON@chch.niwa.cri.nz

Jessop Brian
Fisheries and Oceans
P O Box 550
Halifax NS
B3J 2S7
Canada
tel: +1 902 426 2158
email: Brian.Jessop@sfnet.dfo.ca

Kamstra Andries
RIVO-DLO
PO Box 68
NL-1970 AB IJmuiden
Holland
tel: +31 255 564 753
fax: +31 255 564 644
email: Andries@rivo.dlo.nl

Kangur Andu
Võrtsjärv Limnological Station
EE2454 Rannu
Estonia
email: andu@lim.tartu.ee

Klein Breteler Jan G P
OVB
Postbus 433
NL-3430 AK Nieuwegein
Holland
tel: +31 30 605 8411
fax: +31 30 603 9874

Knights Brian
University of Westminster/NRA
Applied Ecology Research Group
115 New Cavendish Street
London W1M 8JS
England
tel: +44 171 911 5000
fax: +44 141 911 5087

Kuhlmann Holger
FA-Fischerei Institut fur Fischereiökologie
Aussenstelle Ahrensburg
Wulfsdorfer Weg 204
D-22926 Ahrensburg
Germany
tel: +49 4102 51128
fax: +49 4102 51128

McCleave Jim
School of Marine Sciences
University of Maine
5741 Libby Hall
Orono ME 04469-5741
USA
tel: +1 207 581 4392
fax: +1 207 581 4388
email: mccleave@maine.maine.edu

Moriarty Christopher
Department of the Marine
Fisheries Research Centre
Abbotstown
Dublin 15 Ireland
tel: +353 1 8210111
fax: +353 1 820 5078
email: Moriarty@FRC.IE

Nasar S S
TIIRR
Y C James Yen Center
Silang
Cavite
Philippines

Os Betty van
RIVO-DLO
PO Box 68
NL-1970 AB IJmuiden
Holland
tel: +31 255 564 677
fax: +31 255 564 644
email: Betty@rivo.dlo.nl

Pedersen Michael
DFU
Afd. for Ferskvandsfiskeri
Veilsovej 39
DK - 8600 Silkeborg
Denmark
tel: +45 33 96 31 00
fax: +45 33 96 31 50

Richter Carel
Dept. Fish. Cult.
Wageningen Agricultural Univ.
PO box 338
NL-6709 PG Wageningen
Holland
tel: +31 8370 82 465
fax: +31 8370 83 937
email: hans.komen@alg.venv.wau.nl

Russel Ian
Ministry of Agriculture, Fisheries & Food
Directorate of Fisheries Research
Pakefield Rd
Lowestoft Suffolk NR33 0HT
England
tel: +44 1502 524330
fax: +44 1502 513865
email: i.c.russel@CEFAS.CO.UK

Schaap Leo
RIVO-DLO
PO Box 68
NL-1970 AB IJmuiden
Holland
tel: +31 255 564 716
fax: +31 255 564 644
email: Leo@rivo.dlo.nl

Souter Nick
Kaiela Research Station
P. O. Box 1226
Shepparton 3632
Victoria
Australia

Tesch F-W
Biologische Anstalt Helgoland
Notkestr. 31
D-22607 Hamburg
Germany
tel: +49 40 8969 3156
fax: +49 40 8969 3115

Tulonen Jouni
Evo State Fisheries & Aquaculture
SF-16970 Evo
Finland
tel: +358 17 135 251
fax: +358 17 135 250

Tzeng W - N
Department of Zoology
National Taiwan University
Taipei, Taiwan 10617
Republic of China
email: wnt@ccms.ntu.edu.tw

Volckaert Philip
Katholieke Universiteit Leuven
Zoological Institute
Naamesestraat 59
B-3000 Leuven
Belgium
tel: +32 16 32 39 66
email: aquabio@bio.kuleuven.ac.be

Vøllestad Asbjørn
Department of Zool., Biological Inst.
University of Oslo
P.O. Box 1050
Blindern, Norway
tel: + 22 854640
email: asbjorn.vollestad@bio.uio.no

Westerberg Håkan
Nat. Bd. Fisheries
Inst. Coastal Research
Nya Varvet, hus 31
S - 426 71 Västra
Frölunda, Sweden
tel: +46 31 69 78 22
fax: +46 31 69 11 09
email: hakan.westerberg@fiskeriverket.se

Wickström Håkan
Institute of Freshwater Research
S - 178 93 Drottningholm
Sweden
tel: +46 86200407
fax: +46 875 90338
email: hakan.wickstrom@fiskeriverket.se

Willigen Jan van
RIVO-DLO
PO Box 68
NL - 1970 AB IJmuiden
Holland
tel: +31 255 564 721
fax: +31 255 564 644
email: Janvw@rivo.dlo.nl

Wlasow Teresa
Dept. Basic Fish. Sci.
Univ. Agr. Techn.
10-718 Olsztyn-Kortowo
Bl 37 Poland
tel: +48 89 233 456
fax: +48 89 234 772

ANNEX C

EUROPEAN PRODUCTION OF CULTURED EEL *ANGUILLA ANGUILLA* IN 1995

The information which follows was provided by members of the Working Group from their personal knowledge. This update was made by C. Gelin (SE).

Country	Number of farms	Estimated total tonnage
Belgium	2	140
Denmark	30	1200
France	1	25
Germany	10	100
Greece	9	550
Hungary	1	?
Italy	120-150	3000
Netherlands	45	1800
Norway	1	200
Portugal	4	110
Spain	4	250
Sweden	4	200
United Kingdom	1	25