6 PROPOSED MANAGEMENT ACTIONS

6.1 Introduction

The FAO Technical Guidelines on the Precautionary Approach to Capture Fisheries (FAO, 1996) call, among other things, for *'prior identification of undesirable outcomes and of measures that will avoid or correct them'*. It is thus desirable that managers determine how they will react to a problem before it occurs, and that management strategies should define the actions that will be taken if, for example, stocks approach or fail to meet limit reference points. Without such a predetermined decision structure a tendency for social and economic justifications may be used to water down or delay management actions. This may present particular problems for the management of the European eel because stocks are already in a depleted state.

The application of a precautionary approach requires that *'any fishing activities must have prior management authorization and be subject to periodic review'*. A concern in this regard is that managers in many parts of Europe may currently be poorly placed to regulate and monitor eel fishing activities, due to only limited, if any, mechanisms for controlling effort or catches in eel fisheries. Providing an appropriate legislative framework, whereby appropriate controls can be introduced, within the context of a wider European strategy, should therefore be a high priority for managers.

The management and conservation options available to managers in a number of European countries have previously been summarized by Moriarty and Dekker (1997). These highlighted the marked regional variation in approaches, reflecting the widely differing traditions relating to both, eel fishing and consumption, in these countries. More recently, in light of the continuing decline in recruitment, some countries have introduced additional measures. In particular, measures have been proposed/introduced to restrict glass eel fishing by tighter controls on fishing by unlicensed (non-professional) fishermen (France) or by the prevention of any extension of glass eel fishing into new fishing areas (England and Wales).

In England and Wales a national eel management strategy has been introduced (Environment Agency, 2001), which sets out a framework for management of national eel fisheries and populations in the light of the need for a precautionary approach. Key objectives of the strategy are:

- improved stock and fishery sustainability (recognising the need to work towards appropriate conservation limits);
- an improved legislative and regulatory framework; and
- increased knowledge and awareness (including specific recommendations for monitoring).

It should be noted that aspects of this plan take a long-term view and that full implementation will be dependent on available resources. There have been no similar initiatives in other European countries, although national 'reviews' have been completed in some cases (e.g. Sweden, the Netherlands, Brittany/France). However, there is widespread recognition of the need for a co-ordinated, over-arching European management strategy for the eel that will apply to all life stages and fisheries across the range of the species.

6.2 Management actions that may lead to the required escapement

With reliable data on catches, effort and the status of stocks it would be possible to consider long-term management, define well-derived reference points for fishing mortality and spawning stock biomass and co-ordinate management efforts across the range of the

European eel. However, the current data-poor situation requires a pragmatic approach before such facts and figures are available.

Where stocks are depleted, application of the precautionary approach requires that recovery plans are set up to restore stocks quickly, i.e. commonly 1-2 generations, for eel equal to a time span of 15 to 20 years. This is probably an appropriate time period to have in mind as a basis for management.

A range of factors, other than just fisheries, are likely to be involved in the decline of the European eel stock, and action is likely to be required in many areas. For example, to improve or increase access to freshwater habitats (e.g. Moriarty and Dekker, 1997; Knights and White, 1998; ICES, 2001), or restrict the impact of hydro-power installations or other anthropogenic impacts (ICES, 2001). Thus the application of a precautionary approach to the management of eels should not only affect the regulation of fisheries; it should also relate to non-fisheries factors, such as the management of freshwater, estuarine and coastal habitat. It may also require attention to other activities such as aquaculture insofar as this can affect, for example, market forces, transfer of recruits and the possible introduction of diseases and parasites.

Management options (discussed in more detail below) include measures to limit exploitation by fisheries, protect and improve the productive capability of eel habitat, and enhance production through expansion of accessible habitat and the stocking of under-utilized or inaccessible habitat.

6.2.1 Measures to limit exploitation by fisheries

Measures to limit exploitation by fisheries will commonly be site/area and circumstance specific and will generally function by regulating the length of time that individual eels are potentially vulnerable to fisheries. Consideration may also need to be given to the potential volatility of eel market demands and hence possible short-term but large fluctuations in fishing pressure.

Prohibition of fishing

Prohibition of fishing can be life-stage specific or area specific. For example, commercial glass eel fishing is banned in countries where supplies are low (Sweden, Denmark, Germany, N. Ireland, Ireland, the Netherlands, Belgium). Within England and Wales precautionary measures have been drawn up to introduce a byelaw to limit glass eel fishing to the principal existing fishing zones, thus preventing further expansion of the fishery. It is prudent to prohibit extension of existing fisheries and introduction of new fisheries in England and Wales as well as elsewhere.

Total allowable catches/quotas

Ideally, application of total allowable catch/quota restrictions requires knowledge of abundance and identification of escapement targets. Quotas put an upper limit on the total catch; however, with the diverse nature of eel fisheries, it is difficult to envisage how an individual quota on a panmictic stock would be shared and subsequently managed/enforced in the scattered inland fisheries in Europe. Required data are not currently available for different life-stages of eel and therefore TAC approaches are probably not workable.

Gear controls

Controls on, for example, number, size, mesh-size, usage and location of gear are already enforced in several eel fisheries to control fishing mortality. For example, in the Severn, fishing for glass eel from a moving boat is not allowed and only hand-held dip nets of a set size can be used. In some silver eel fisheries (e.g. Lough Neagh) gaps have to be left to allow some escapement. Where they do not exist, gear controls should be introduced and in other areas strengthened.

Landing size limits

Minimum size restrictions could help to reduce excessive exploitation of yellow and pre-spawner eel; such measures are already in place in some countries (e.g. the Netherlands, Ireland, Denmark) and have recently been strengthened in Sweden. Minimum mesh size limits for fyke and other nets have been set in many areas. Limits on maximum size would promote escapement of larger (female) pre-spawners, but could also result in increases in fishing effort aiming at depletion of the stock of smaller sizes.

Closed seasons

These are currently in operation in some countries, but are commonly based on traditional or practicable fishing season (e.g. Ireland) or are primarily related to requirements to allow unhindered migration of salmonids (e.g. Denmark and N. Ireland). The effectiveness of fishing time controls is affected by temporal variations in eel activity and migrations, often as a result of changing environmental parameters. Only banning of fishing over relatively long time periods would be fully effective, e.g. if extending beyond the duration of local glass eel immigration or silver eel emigration runs. The timing of closed seasons must be related to local characteristics of eel and fisheries, and has to primarily consider closure during periods of vulnerability. There are no seasons in which all eel fisheries in Europe are in operation.

Closed areas

These could be locally effective, e.g. in preventing extension of fisheries (particularly for glass eel/elvers) into new areas or for protection of vulnerable glass eel/elver or silver eel runs. Alternatively, closed areas could be used to designate ‘reserve’ or ‘refuge’ areas where no exploitation would be permitted. Such an approach is currently used in the management of eel stocks in New Zealand and could be applied to watersheds in parts of Europe where unexploited eel populations are known to exist where the simplicity of closed areas is preferred over other regulations, more difficult to control.

Licensing of fishermen and dealers

Licensing specific to eel fishermen and their gear and dealer licensing could help provide, via catch returns and market statistics, improved information for monitoring catches and compliance with targets. The quality of such information is currently often poor, but licensing of fishermen and gear, in conjunction with adequate enforcement of regulations, offers opportunities for controlling and monitoring fishing effort and, ultimately, fishing mortality. In England and Wales it is planned to introduce a revised system of licensing and compulsory catch returns for fishermen in the near future.

6.2.2 Measures regarding eel habitat

Measures should be taken to insure and promote the access of eels to all reaches within catchments. The higher natural quality of freshwater catchments will promote healthy eel populations. Proper enforcement of the EU Water Framework Directive and guaranteeing full accessibility of eels to freshwater habitats should be a management priority

Eel management needs to be considered at the minimum level of the river basin scale, from the estuaries to the sources and from the river basin (including land biogeochemical cycles of contaminants) to the estuaries. In particular, it is necessary to improve the measures and technology to protect, manage, enhance and restore habitats; to ease migration and movements of eels, upstream (accessibility) and downstream (escapement of silver eels and contribution to spawning stock).

These proposed actions meet the requirements of the EU Water Framework Directive, which states that '…EU countries should prevent further deterioration of their waters as well as protect, restore and enhance and restore them in order to achieve good or high ecological status in all their water bodies. To achieve this goal, countries must begin developing river basin management and monitoring programmes…'.

Insure habitat accessibility

This should be achieved by increasing the number of fish passages in existing dams and insuring that new dams are equipped with passages. The highest priority should be given to those in the lower part of rivers that block or hamper the early ascent of glass eels. The effectiveness of old and new fish passages in allowing the migration of eels should be measured and improved where necessary. Measures to insure and promote the maintenance of eel passages should also be enacted.

Reduce habitat loss

Measures to protect existing wetland habitats should be taken, since these areas sustain considerable eel stocks. Efforts directed towards the restoration of wetland habitats and degraded river sections will augment existing eel habitats and ultimately result in increased escapement figures.

Insure habitat quality

Measures should be taken to restore habitat quality, chemically and ecologically. This involves collaboration with ongoing restoration efforts as recommended by the EU. Improvements of eel habitat quality is assumed to increase the breeding potential of spawners.

Insure downstream migration

Up to date, no measures have been taken to reduce mortality of downstream migrating silver eels through hydroelectric turbines and dam bypass systems. Efforts to insure upstream migrations of glass eels or elvers and restocking efforts can be futile if downstream migration of eels is not insured. Mortality of downstream migration of silver eels across dams should be minimized by the construction of properly designed downstream passes for silver eels. These measures should be taken into account when building new dams. Similar mortality reducing measures should be also be applied to existing dams. Both, technical measures and management procedures can be utilized to insure minimal mortality levels. Such management plans should be designed for complete river systems in order to restore downstream migration from upper reaches to the ocean.

7 SCIENTIFIC BASIS FOR ADVICE

7.1 Introduction

In sharp contrast to assessment information collected for species populations with a relatively narrow range, the widespread but fragmented spatial distribution of European eel is such that truly representative monitoring may not be achievable. Many life history characteristics vary throughout the distribution range. The scale of impacts to eel life history varies widely from localized to oceanic levels. International research programmes on eel require an international co-ordination framework. Coherent research plans focusing on stock-wide management have been prepared (EIFAC, 1993; Moriarty and Dekker, 1997;

ICES, 2000), but actual research programmes have been influenced only marginally. A co-ordinated, international effort to collect relevant data would allow better management advice to be given than is currently possible.

Therefore, it is strongly recommended that an international commission be formed to organize monitoring and research. The commission would serve as a clearing house for regular exchange of information regarding landings and resource status, and it would provide insight on research needs.

So far, internationally co-ordinated studies, such as the EU 1993 Concerted Action on Management of the Eel and the running EU 1998 Concerted Action on Establishment of a Recruitment Monitoring System, have depended entirely on the initiative of concerned scientists, have relied amongst others on national research budgets and have not covered execution of basic monitoring and continuation of existing data series.

All current monitoring is based on national management interest only. Several of the long lasting series have come under pressure of budget cuts, because of the low state of the local eel fisheries and the impossibility of addressing the stock decline at the local level properly. The responsibility for the management of the stock far exceeds the competence of the local authorities. The continent-wide monitoring programmes needed for stock-wide management require continued concern of local and trans-national managers. However, in practice it is rather difficult to attract the attention of managers to the monitoring of a stock which is currently in severe distress and therefore of little economical importance.

In recent years, monitoring of recruitment at Imsa (Norway), Vidaa (Denmark), Ems (Germany), IJser (Belgium) and Nalon (Spain) have (effectively) been discontinued, and at Tiber (Rome) and Den Oever (Netherlands) have come under financially motivated pressure. Lack of progress in the development of an international management plan for the European eel has been cited as an argument. Landing data provided by several major eel fishing countries (Italy, the Netherlands, Denmark) to FAO Fishery Information, Data and Statistics Unit have become unreliable, because of mixing of fisheries and aquaculture production. Consequently, the situation of inadequate or insufficient documentation on the status of the stock is rapidly deteriorating.

Therefore, it is strongly recommended that the development of a stock recovery plan is taken up as a matter of urgency and meanwhile current monitoring efforts are sustained at least at present/recent levels.

7.2 Development of harvest rate models

To be both, biologically realistic and widely usable, an eel population model must embrace the eel's peculiar demographic features, including high variability in growth rate and its consequences, and also be capable of implementation with limited data. This section presents a stochastic life table model in which natural mortality and maturity schedule depend on size, and size at age varies according to a randomized growth function. The model is suitable for use where eels are exploited at the yellow stage, and growth and mortality are not controlled by density-dependent factors. Data requirements are length at age, a length-weight relationship, and length-frequency distributions for exploited and unexploited populations. The model estimates fishing mortality and summed natural mortality/emigration rate, and evaluates compliance with conservation reference points based on spawning per recruit (SPR) reduction as a function of fishing mortality.

7.2.1 Model structure and inputs

Data from American eel populations on Prince Edward Island (PEI), in the southern Gulf of St. Lawrence, Canada, are used as inputs to the model. Eels are fyke netted in PEI tidal estuaries and adjoining bays between mid-August and mid-October. The minimum legal size is 50.8 cm. In the estuaries of the Pinette River system, sampled eels were smaller in 1973, when the area was exploited, than in 2000, when no fishery existed (Figure 13). Similarly, eels sampled in exploited estuaries in 1997-2000 were smaller than Pinette eels sampled in 2000 (Figure 14). Length frequencies from exploited estuaries declined with a slope of -1.38 between the modal length and the point where the percent length frequency fell below 2.5 percent. For the unexploited (Pinette) estuaries, the slope was -0.43.

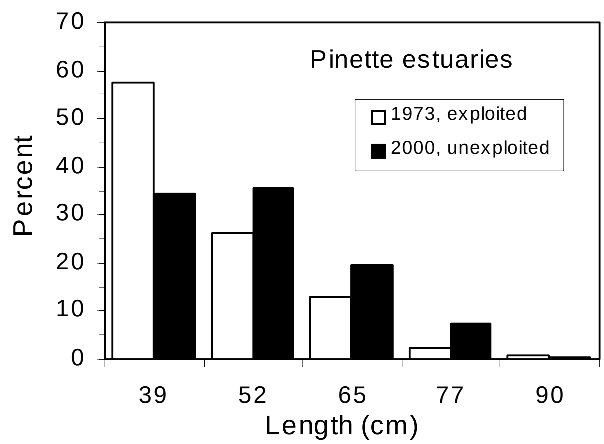

Figure 13. Length frequency distributions of American eels sampled in the estuaries of the Pinette River system, Prince Edward Island, Canada in 1973 when the site was commercially exploited and in 2000 when it was not.

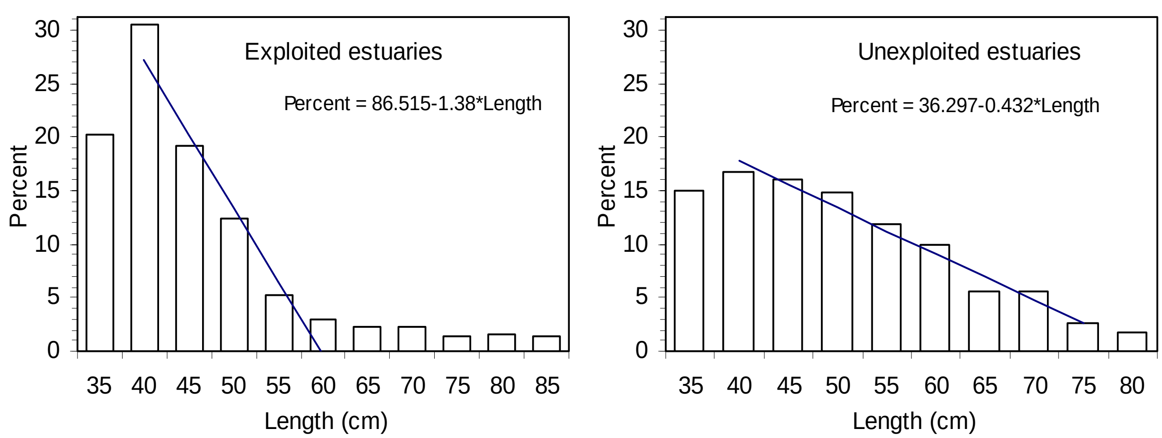

Figure 14. Frequency distributions of American eel lengths in exploited (n=2284) and unexploited (N=531) estuaries of Prince Edward Island. Percents are based on eels > 35 cm long. Regression lines are for percent frequencies in the range between the modal length and the point where the frequency falls below 2.5 percent.

A von Bertalanffy curve was fitted to length at age of 130 eels sampled from marine and freshwater habitats by using Microsoft Excel Solver to minimize squared residuals (Figure 15). Weight (W, in g) of PEI eels is related to length (L, in cm) by the equation $W = 0.000535 \times L^{3.3089}$ based on measurements of 2668 eels.

The life table model tracks the major demographic processes of eel cohorts between arrival at the coast as glass eel and egg deposition in the Sargasso Sea. The model assumes that glass eels arrive on 1 June, and that all glass eels are destined to become female.

During their continental residency modelled eels grow in length according to the von Bertalanffy equation for PEI data (Figure 15). Variability in growth rate is achieved by varying the L coefficient of the von Bertalanffy equation according to a normal distribution. The coefficient of variation of the von Bertalanffy L term was adjusted until modelled length outputs for age 3 eels had the same coefficient of variation as lengths at age 3 in aged PEI samples (Figure 15). Figure 15 also illustrates the scatter of lengths at age produced by the randomization procedure. Weight is calculated from length according to the PEI length-weight equation.

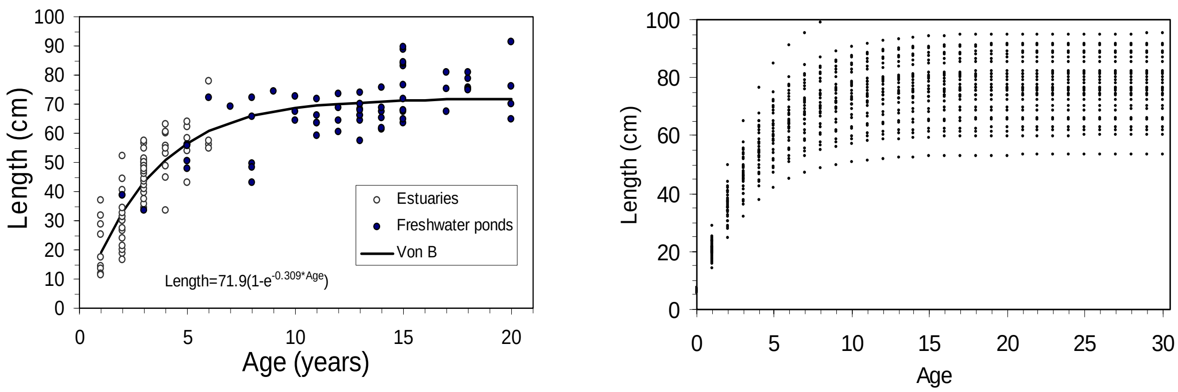

Figure 15. Length at age of American eels. Left panel: data for eels from Prince Edward Island, with a von Bertalanffy curve fitted. Right panel: length at age simulated by the life table model. Lengths are generated by the von Bertalanffy equation with the L term varied according to a normal distribution which produces the same coefficient of variation (0.15) of lengths for age three in the simulated population as was found in the real data.

Natural mortality (M) in fish depends closely on weight, and can be modelled through allometric equations of the type $M = aW^b$. M is modelled with Lorenzen's (1996) equation $M = 3.00 \cdot W^{-0.288}$. The exponent b of M-W equations is assumed to be relatively uniform (McGurk, 1996), but the coefficient a may vary. Hence in the life table model the exponent b (-0.288) is held constant, but the term a (3.00) is multiplied by adjustment factors. This method is used to calculate M for all stages between glass eel arrival and female spawning.

The run of juvenile eels to the Petite rivière de la Trinité in the north-western Gulf of St. Lawrence was estimated in the mid 1980s and emigration of silver eels was estimated in 1999 (ICES, 2001, see also Fournier and Caron, 2001). About 2 percent of the estimated juvenile run survived to leave as silver eels. Application of the unadjusted Lorenzen (1996) equation produced a cumulative survival of only 0.002 percent. When the natural mortality coefficient was multiplied by 0.164, the cumulative survival became 2 percent. An adjustment factor of 0.164 was therefore adopted as a starting point for mortality analysis.

Modelled eels are subject to fishing mortality after attaining 50.8 cm, the minimum retention size on PEI. The model assumes that a user-specified proportion of eels emigrate to the spawning ground after a threshold size is reached. This threshold was set at 50 cm, based on the appearance of silver coloration in eels this size and larger on PEI. Emigrating eels depart on 2 October, and spawn on 7 February. Fecundity is calculated from weight by Barbin and McCleave's (1997) formula ($F = 14608 \times W^{0.9153}$).

The life table model was prepared in two versions. Version I tracks a single cohort of 1 million glass eels through its life cycle. Model output is the aggregate sum of 1,000 trials (except in SPR analysis when 10000 runs were used). Version II tracks the fate of cohorts that arrive in 20 successive years. Initial cohort strength (mean 1 million) is randomly varied according to a normal distribution whose coefficient of variation (0.50) matches that of the elver run in East River Sheet Harbour, Nova Scotia (N=10) (ICES, 2001). Each year is assigned a randomly selected cohort population, which it retains in each of 1000 runs. The model compiles demographic data on eels that are alive in year 20, derived from glass eel cohorts that arrived in each of the 20 previous years.

7.2.2 Model output

Natural mortalities and emigration rates were adjusted in Version I of the life table model to seek combinations that yield length frequencies whose right-hand limbs have slopes that resemble those of real data. When the natural mortality adjustment factor was set at 0.164 (as estimated for the Petite Trinité, see above), an annual emigration rate of 18 percent above 50 cm yielded a length frequency whose right-hand slope resembled that of the unexploited population (Figure 16). When the natural mortality adjustment factor was 0.5, an emigration rate of 13 percent produced a distribution whose right-hand slope resembled that of the distribution for unexploited eels. When fishery mortalities were introduced, the slope of the right-hand limb of the frequency distributions steepened. Under both adjustment factor assumptions (0.164 and 0.5), the slope most closely resembled those of exploited populations when F was set at 0.60 (Figure 17). This suggests that eel fishing mortality in the PEI eel fishery is approximately 0.6.

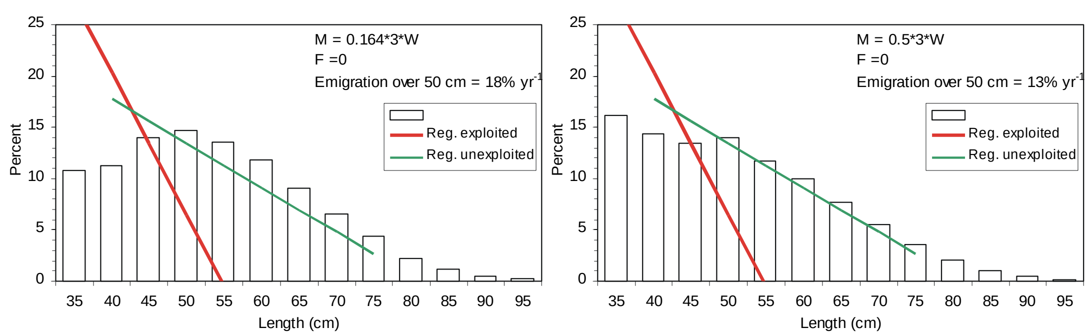

Figure 16. Length frequencies of resident American eels calculated by the life table model for unexploited populations. Adjustment factors for mortality equations and emigration rates have been adjusted so that the slope of the declining limb of the length frequency distribution matches regression lines for length frequencies from an unexploited population.

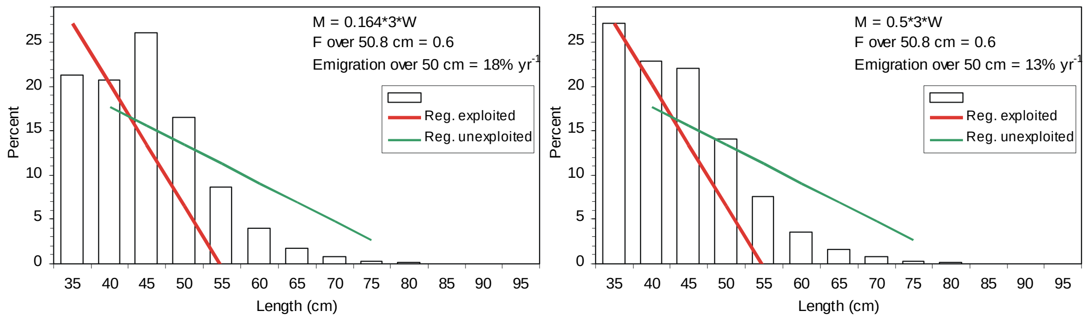

Figure 17. Length frequencies of resident American eels calculated by the life table model for exploited populations. Adjustment factors for mortality equations and emigration rates are as in Figure 16, and fishing mortality has been adjusted so that the slope of the declining limb of the length frequency distribution matches regression lines for length frequencies from measured exploited populations.

Version I of the life table model is based on single cohorts, but actual eel populations at any given time consist of multiple cohorts, derived from initial populations that may have varied inter-annually. If length structure is largely determined by cohort size variation rather than by mortality and emigration rates, then the estimation of mortality and emigration rates from the length frequency outputs of life table models would be invalidated. To examine the effects of inter-year variability in recruiting cohort size on population length structure, Version II was run 10 times with a mortality adjustment factor of 0.164 and an emigration rate of 18 percent (Figure 18). Frequencies of lengths under 50 cm varied substantially among runs, but at greater lengths, length distribution showed relatively little inter-run variation. Trials with an adjustment factor of 0.5 and an emigration rate of 13 percent also showed little inter-run variation in distribution of eels above 50 cm. This suggests that comparisons between simulated and measured length frequencies can be used to estimate mortality and emigration rates, provided that comparisons are based on size classes above 50 cm.

Effects of fishing mortality on spawn output was modelled in Version I by calculating egg deposition as a percent of egg deposition in an unexploited population. Total egg deposition was modelled rather than female escapement. Total egg deposition reflects contribution to the next generation better than numbers of escaping females because fishery regimes affect size distribution of female escapees, and sizes influence mortality rate during transit and fecundity.

Two scenarios were modelled. First, the natural mortality adjustment factor was 0.164 and the emigration rate over 50 cm was 18 percent, and second, the adjustment factor was 0.5 and the emigration rate was 13 percent. In both cases, the percent of maximum egg deposition declines at first sharply with increasing F, and then more gradually at higher F's (Figure 19). At a given F, percent of maximum egg deposition was less when the adjustment factor was 0.5 than when the adjustment factor was 0.164.

A 50 percent reduction in egg deposition (F_{pa}) was reached when F was 0.16 and 0.2 for mortality adjustment factors of 0.164 and 0.5, respectively. A 70 percent reduction in egg deposition (F_{lim}) was reached when F was 0.34 at adjustment factor 0.164 and 0.42 at adjustment factor 0.5. At the estimated F for the PEI eel fishery (0.6), reductions in egg deposition were 83 percent for the 0.164 adjustment factor and 79 percent for the 0.5 adjustment factor.

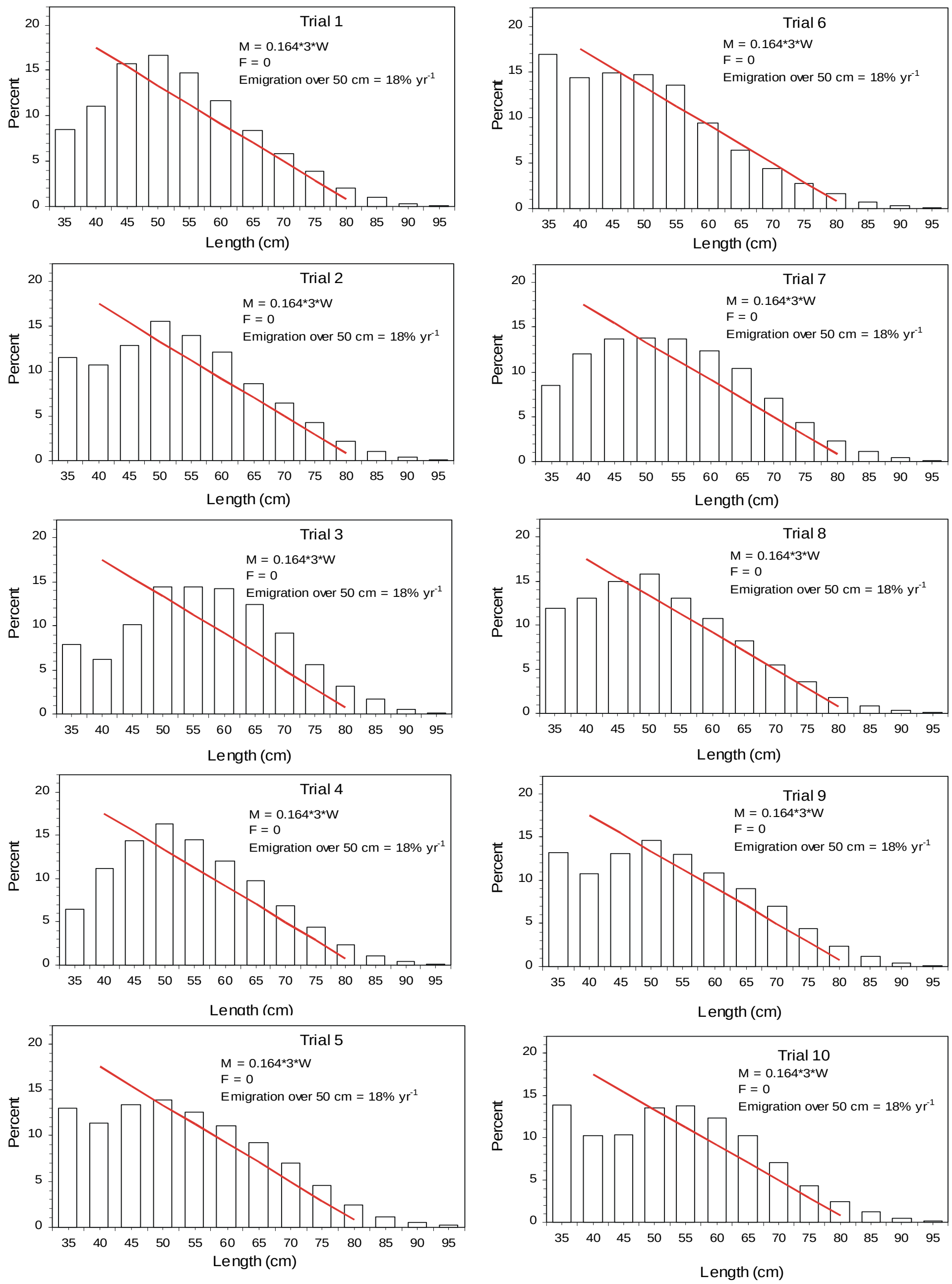

Figure 18. Length frequencies of American eel populations simulated by the life table model. Recruiting populations vary annually, with a coefficient of variation of 0.5. The straight lines are from the regression equations for length frequencies of unexploited eel populations.

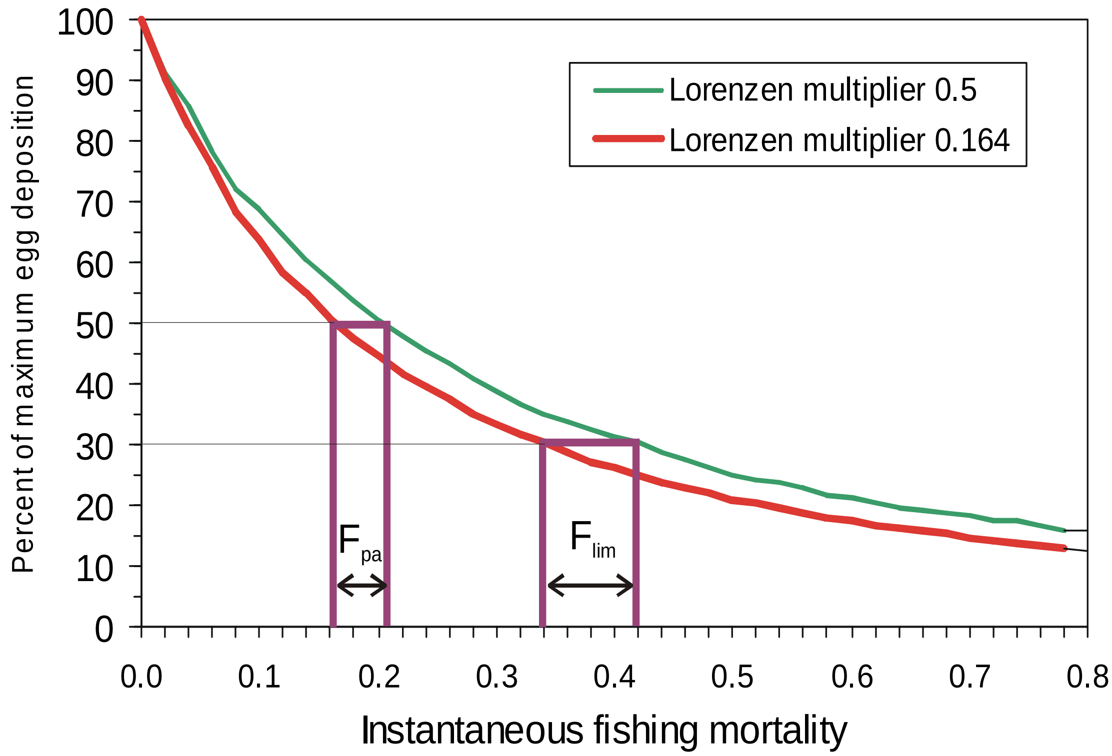

Figure 19. Relation between fishing mortality and egg deposition in American eels of Prince Edward Island as a percent of egg deposition in the absence of exploitation. Natural mortality is given by Lorenzen's (1996) weight-based formula, adjusted by the multipliers given in the legend

7.3 Migration

7.3.1 Fish passes for upstream migration of recruits

The efficiency of fish passages on upstream migration has been shown by a number of studies. For example, in the Vilaine River, a dam was built in the early 1970s and consequently, the eel stock was very much depleted in the 1980s. An eel pass was built in 1995 enabling a tenfold increase of the eel densities and an extension of the distribution area (Briand and Fatin, 1999; Briand *et al.*, 2000a). In some small coastal river systems, eel passes enable to maintain eel stocks and distribution at their carrying capacity.

Eel ladders enable passage of important quantities of eels right up to the upstream reaches of large rivers (Legault, 1994). However their efficiency still needs to be improved as studies showed that only 30 percent of eels used the ladders, the remainder staying downstream of the obstruction and thus being subjected to increased mortality rates (Briand *et al.*, in press, a; Briand *et al.*, in press, b).

7.3.2 Downstream migration of silver eel

The technology concerning downstream migration, and mitigation of mortality through turbines and hydraulic by pass systems is very poorly known (Legault *et al.*, in press). The technology to reduce mortality through turbines is not cost effective as the only efficient solutions which were proposed up to now were to reduce significantly the water flow through turbines therefore resulting in drop of electricity generation. Therefore models were developed to predict periods of migration peaks during which electricity generation would be reduced which would favour escapement over the dams (Feunteun *et al*., 2000a). Another solution proposed by Electricité de France was to develop a silver eel fishery in heavily developed rivers, as Rhône or Rhine, in order to translocate eels downstream. On a 14 m dam built for water supply a by pass system was installed to insure minimum legal water discharge. This system which originally created about 100 percent mortality was modified and silver eel mortality was reduced to about 10 percent and enabled the passage of about 10 percent of the migration runs (Legault *et al*., in press).

7.4 Habitat improvement

Considering eels are highly ubiquitous species, they colonize practically every kind of water body available and accessible over the distribution range. They especially invade and establish permanently in wetland habitats as river flood plains, coastal marshes in marine areas or lakes and lagoons. These areas are known for their high productivity and related trophic value (consistent food supply). Therefore, they are able to host dense eel stocks of 50-300 g/m^2 (Feunteun *et al*., 1999). Experiments show that restored water bodies and wetlands, provided they are correctly connected to migration routes, are rapidly colonized by dense populations of eels. For example, in the Brière Marshes, 300 ha of water bodies were restored to mitigate effects of land abandonment. These habitats were rapidly colonized by a dense eel population (Eybert *et al*., 1999). In coastal marches of western France which were obstructed by silt because of shift in management practices (Feunteun *et al*., 1992) a project was conducted to restore pristine habitat conditions over 350 ha. The eel population rapidly approached prior reference levels of about 50 kg/ha (Baisez, Rigaud and Feunteun, 2000).

8 FURTHER DEVELOPMENT OF ADVICE ON EEL

8.1 Interaction between management and research

In comparison with other species, the management of eel stocks and fisheries is rather complicated. Several facets of the basic biology of the species are unknown, and biological characteristics of the eel vary from region to region and from habitat type to habitat type. The stock and fisheries are distributed over most of Europe, northern Africa and a minor part of Asia. In contrast, many typical eel fisheries operate in small water bodies, fished by a few fishermen at a time, from which hardly any information is derived. Consequently, establishment of a management system for the eel cannot proceed along the same lines as for other, more typical marine or freshwater species. It has been recommended that a stock recovery plan should be compiled. Completion of such a plan will necessarily entail additional research and monitoring, to clarify uncertainties and to investigate unknowns.

Although the advice given in this report is based on prolonged discussions on required and feasible management regimes, it is recognized that further development of the advice, and furthering our scientific knowledge, cannot proceed without close co-operation between managers and scientists. The periods between the first observation of the eel stock collapse (1985), the first management advice (1996), the compilation of comprehensive research plans (1997), the urgent recommendation to compile a stock recovery plan (1998) and the ultimate implementation of stock-wide management measures influencing the eel stock and fisheries (when?) do not encourage an optimistic view. Improvement of the advice depends crucially on agreement to, and implementation of, an international management process with appropriate feedback to scientific advisory bodies.

8.2 Facilitation of provisional management measures

It is recommended that provisional limit reference levels are set in respect of exploitation of the European eel. Additionally, it is recommended that the effect of habitat loss (upstream or downstream migration barriers as well as physical loss of habitat) on the production of spawners is given due consideration. Noting that the continental eel stock is fragmented over myriads of water bodies, in thousands of jurisdictional entities, implementation of provisional targets would be greatly facilitated by the development of practical guidelines for managers. This might include advice on: implementing a management regime; options for monitoring and fisheries management; building of fish passes and downstream migration facilities; habitat restoration; etc. This should also include recommendations for the development of proximate criteria, for the few data rich situations as well as for the most common data-poor conditions. It is recognized that the implementation of limit reference levels and controls on exploitation will probably have socio-economic implications, especially since eel fisheries play a crucial role in coastal rural communities. It is therefore recommended that socio-economic effects are also considered further.

At the international level, management targets will have to be defined and refined. The current advice sets limits relative to the unexploited state, although this is not clearly quantified. Investigations of unexploited systems as well as analytical studies of exploitation by fisheries might fill this gap. Subsequently, procedures will have to be developed for post-evaluation, for both data rich and data-poor conditions. Additionally, it is recommended that the effect of habitat loss on the stock should be considered, although no clear targets have been set here. Development of targets for these habitat-related factors (not related to exploitation) is an option.

8.3 Development of the required knowledge base and methodology

Management options discussed in this report primarily refer to whole-stock conservation limits which need to be translated into appropriate local-system targets. Local management will depend on the locally available knowledge. However, several aspects of the biology of eel and several methodologies are currently inadequately understood to enable development of local management schemes. Co-ordinated research and development will facilitate local management. This should comprise:

- analysis of density-dependent processes (growth and mortality) and their impact on spawner escapement;
- quantification of the (positive) impacts of management measures not directly related to exploitation, e.g. habitat restoration, fish passes, re-stocking, etc.;
- development of harvest rate models for eel fisheries in data-rich systems;
- development of proximate criteria for management of fisheries in data-poor systems;
- development of procedures to post-evaluate potential effects of eel fisheries management measures, in both data-rich and data-poor systems.

8.4 The way ahead

Coherent research plans focusing on stock-wide management of the European eel have been prepared before (EIFAC, 1993; Moriarty and Dekker, 1997; ICES, 2000), but their impact on actual monitoring and research programmes has been marginal. The Terms of Reference for the current (2001) meeting of the Working Group on Eels allowed for consideration of a broad range of issues, to facilitate improving the scientific basis for advice. However, due to the lack of a co-ordinated management framework and the low priority of national and local research programmes on eel, lack of progress has been reported on several issues, while others had to report only marginal progress. In addition, concerns have been raised about the ability to maintain existing monitoring efforts and time-series of data. Consequently, the Working Group has had to express its views on further development of the advice, without having the opportunity to fully address the Terms of Reference. Thus, some pragmatic reduction in the scope for development of further advice would appear to be appropriate in setting the Terms of Reference for coming meetings. However, cutting the coat to the cloth should not be read as an implicit statement that all management requests for advice could be fulfilled within such a pragmatically reduced setting.

A judicious choice for a feasible workload could include:

- Development of harvest rate models, including the derivation of exploitation levels corresponding to pre-set escapement targets and including the derivation of less data-demanding proximate criteria;
- The analysis of density dependent processes (growth, mortality and migration) and their effect on the production of escaping spawners;
- The analysis of habitat loss and the derivation of management goals for habitat restoration.

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

Review of the available information on the status of the stock and fisheries of the European eel supports the view that stock is in decline in most of the distribution area and that fisheries is outside safe biological limits. Evidence has been given that anthropogenic factors (exploitation, habitat loss, increased predation, contamination and transfer of parasites and diseases) as well as natural processes (climate change) have contributed to the decline. Latest recruitment data (spring 2001) are indicative of further deterioration of the status of the stock.

The European eel stock extends through Europe and northern Africa and fisheries are scattered over many large and small water bodies. Management at the local level has failed to address the global decline of the stock, while effective management measures to restrict exploitation and to enhance the state of the stock are available.

Current scientific knowledge is inadequate to derive management targets specific for eel. However, anthropogenic impacts have been shown to exceed reasonable provisional targets in many places and management actions in compliance with provisional targets have been specified. Considering the many uncertainties and the uniqueness the eel stock (supposedly single panmictic, spawning only once in their lifetime), a precautionary reference point must ultimately be more strict than the universal reasonable first estimate (30 percent; ICES, 1997).

Noting the continuation of the decline in most recent recruitment indices, implementation of an international stock recovery plan is of utmost urgency.

9.2 Recommendations

The EIFAC/ICES Working Group on Eels at its 2001 session in Copenhagen (Denmark) recommends that:

- An international commission for the management of the European eel stock be formed, organizing monitoring and research on eel stocks and fisheries, serving as a clearing house for regular exchange of information regarding landings and resource status, and facilitating and co-ordinating management action;

- A recovery plan for the eel stock be compiled and implemented as a matter of urgency and that fishing mortality be reduced to the lowest possible level until such a plan is agreed upon and implemented;
- A provisional limit reference point be set at an escapement from currently available habitat of female silver eel of at least 30 percent relative to the unexploited state, to be achieved by exploitation regulations and/or habitat restoration measures;
- Monitoring of recruitment, stocks, fisheries and escapement at least be sustained at recent levels, until a stock recovery plan is agreed upon and implemented, including a comprehensive monitoring and research plan.

10 REFERENCES

Aprahamian, M.W. 1988. Age structure of eel, *Anguilla anguilla* (L.), population in the River Severn, England, and the River Dee, Wales. *Aquaculture and Fisheries Management*, 19:365-376.

Avise, J.C., Helfman, G.S., Saunders, N.C. & Hales, L.S. 1986. Mitochondrial DNA differentiation in North Atlantic eels: population genetics consequences of an unusual life history pattern. *Proceedings of the National Academy of Sciences, USA*, 83:4350-4354.

Avise, J.C., Nelson,W.S., Arnold, J., Koehn, R.K., Williams, G.C. & Thorsteinsson, V. 1990. The evolutionary genetic status of Icelandic eels. *Evolution*, 44:1254-1262.

Baisez, A., Rigaud, C. & Feunteun, E. 2000. Hétérogénéité de répartition de l'anguille européenne (*A. anguilla*) dans un marais endigué de la côte atlantique (marais breton). *Cybium*, 34(3):23-32.

Barak, N.A.E. & Mason, C.F. 1992. Population density, growth and diet of eels *Anguilla anguilla* L., in two rivers in eastern England. *Aquaculture and Fisheries Management*, 23:59-97.

Barbin, G.P. & McCleave, J.D. 1997. Fecundity of the American eel *Anguilla rostrata* at 45° N in Maine, USA. *Jounal of Fish Biology*, 5:840-847.

Barral M. 2001. Etude préliminaire à la mise en place d'un "Tableau de bord anguille" sur le bassin Rhône-Méditerranée-Corse. Arles, France, Association Migrateurs Rhône-Méditerranée, 112 p.

Berg, S. & Jørgensen, J. 1994. Stocking experiments with 0+ eels (*Anguilla anguilla*) in Danish streams: post-stocking movements, densities and mortality. *In* I.G. Cowx, ed., *Rehabilitation of Freshwater Fisheries*, Oxford, Fishing News Books, pp. 314-325.

Boisneau, P. & Mennesson-Boisneau, C. 2001. Faisabilité de la mise au point d'un indice d'abondance de l'anguille d'avalaison en Loire. Paper presented at Journées anguilles du Groupe de Recherche Interdisciplinaire sur les Poissons Amphihalins (GRISAM), 26-29 Mars 2001, Tour du Valat, Arles, France.

Briand, C. & Fatin, D. 1999. Estuarine and fluvial recruitment of European glass eel in an Atlantic exploited estuary. Paper presented at 11th Session of the EIFAC/ICES Working Group on Eel, Silkeborg, Denmark, 20-24 September 1999.

Briand C., Feunteun, E., Fatin, D. & Fontenelle, G. 2000a. Assessment of mark recapture methods for glass eels (*Anguilla anguilla*) in Vilaine estuary, France. Paper presented at the International congress on eel research North American Fishery Society. Saint Louis, Missouri, United States

Briand C., Feunteun, E., Fatin, D. & Fontenelle, G. in press a. Development of a validated stock recruit model (*Anguilla anguilla*) in Vilaine river, France. *American Fisheries Society Symposium*

Briand, C., Fatin, D., Mounaix, B. & Feunteun, E. in press b. Mortalité des civelles en fonction de leur date d'arrivée en estuaire de la Vilaine. *Bulletin Français de la Pêche et de la Pisciculture*

Castonguay, M., Hodson, P., Moriarty, C., Drinkwater, K. & Jessop, B. 1994. Is there a role of ocean environment in American and European eel decline? *Fisheries Oceanography*, 3(3):197-203.

Ciccotti, E. 1997. Italy. *In* C. Moriarty & W. Dekker, eds, 1997. Management of the European Eel. *Fisheries Bulletin (Dublin)*, (15):91-100.

Dahl, J. 1967. Some recent observations on the age and growth of eels. In *Proceedings of the Third British Coarse Fish Conference*. Liverpool, University of Liverpool, pp. 48-52.

De Casamajor M.-N., Bru, N., Prouzet, P. & Sanchez, F. 2001. Suivi du recrutement de civelles (*Anguilla anguilla* L.) dans l'estuaire de l'Adour. *In* Océanographie du golfe de Gascogne. VIIème colloque international Biarritz, 4-6 avril 2000, edited by J. d'Elbée & P. Prouzet. *Actes de Colloques IFREMER,* 31:346-354.

Dekker, W. 1999. Is the European eel overfished? Paper presented at the 11th Session of the EIFAC/ICES Working Group on Eels, Silkeborg, Denmark, 20-24 September 1999.

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

Dekker, W. 2000b. A Procrustean assessment of the European eel stock. *ICES Journal of Marine Science,* 57:938-947.

Dekker, W. 2000c. Impact of yellow eel exploitation on spawner production in Lake Ijsselmeer, the Netherlands. *Dana*, 12:17-32.

Egusa, S. 1979. Notes on the culture of the European eel (*Anguilla anguilla* L.) in Japanese eel-farming ponds. *Rapports et Proces-Verbaux des Reunions, Conseil International pour l'Exploration de la Mer*, 174:51-58.

EIFAC 1993. Report of the Eighth Session of the Working Party on Eel, Olsztyn, Poland, 24-29 May 1993. *EIFAC Occasional Paper*, (27):21 p.

EIFAC/ICES 2001. Report of the Eleventh Session of the Joint EIFAC/ICES Working Group on Eels, Silkeborg, Denmark, 20-24 September 1999. *EIFAC Occasional Paper*, (34):31 p.

Environment Agency 2001. National Eel Management Strategy. Bristol, Environment Agency, 16 p.

Eybert, M.C, Bernard, J.Y., Constant, P., Feunteun, E., Hédin, J. & Questiau, S. 1999. Marsh meadow restoration in the Brière marsh (France): evolution of flora, birds and fishes. *Gibier Faune Sauvage*, 15:999-1016.

FAO 1996. Precautionary approach to capture fisheries and species introductions. *FAO, Technical Guidelines for Responsible Fisheries*, (2):52 p.

Feunteun, E., Rigaud, C., Elie, P. & Lefeuvre, J.C. 1992. Le marais doux endigué de Bourgneuf Machecoul (Pays de Loire). Premiers éléments de connaissance de la faune piscicole. Relations ichtyofaune-habitat et problèmes majeurs de gestion. *Revue des Sciences de l'Eau*, 5:509-528.

Feunteun, E, Acou, A., Guillouët, J., Laffaille, P. & Legault, A. 1998. Spatial distribution of an eel population (*Anguilla anguilla* L.) in a small coastal catchment of northern Brittany (France). Consequences of hydraulic works. *Bulletin Français de la Pêche et de la Pisciculture*, 349:129-139.

Feunteun, E., Rigaud, C., Elie, P. & Lefeuvre, J.C. 1999 Les peuplements piscicoles des marais littoraux de l'ouest de la France : un patrimoine à gérer ? *Bulletin Français de la Pêche et de la Pisciculture*, 352:63-79.

Feunteun, E., Acou, A., Laffaille, P. & Legault, A. 2000a. The European eel (*Anguilla anguilla*, L.): prediction of spawner escapement from continental population parameters. *Canadian Journal of Fisheries and Aquatic Science*, 57:1627-1635.

Feunteun, E., Boullier, J., Briaudet, J. & Laffaill, P. 2000b. La population d'anguille du Rhône aval: étude préliminaire en vue de l'élaboration d'un protocole de suivi et de restauration. Rennes, France, Direction Régional de l'Environnment Rhône Alpes, Electricité de France - Centre Nucléaire Production Electrique de Saint Alban, et Université de Rennes 1, 114 p.

Fournier, D. & Caron, F. 2001. Travaux de recherche sur l'anguille d'Amérique (Anguilla rostrata) de la Petite Rivière de la Trinité en 1999 et 2000. Quebec, Canada, Societé de la faune et des parcs du Québec, Direction de recherche sur la faune.

Francis, R.I.C.C. & Jellyman, D.J. 1999. Are mean size data adequate to monitor freshwater eel fisheries? *Marine and Freshwater Research*, 50:355-366.

Hilborn, R. & Walters, C.J. 1992. Quantitative Fisheries stock assessment: choice, dynamics and uncertainty. New York, Chapman and Hall, 570p.

ICES 1988. European eel assessment working group report, September 1987. Doc. ICES C.M. 1988/Assess:7, Copenhagen, Denmark, ICES.

ICES 1997. Report of the Study Group on the precautionary approach to fisheries management. Doc. ICES 1997/Assess:7, Copenhagen, Denmark, ICES

ICES 2000. Report of the ICES Advisory Committee on Fisheries Management, 1999, Part 1. *ICES Cooperative Research Report*, (236.1): 416 p.

ICES 2001. Report of the EIFAC/ICES Working Group on eels, St Andrews, N.B., Canada, 28 August - 1 September 2000. Doc. CM2001/ACFM:03. Copenhagen, ICES, 87 p.

Jones, T.A. & Hughes, J.M.R. 1993. Wetland inventories and wetland inventory studies: a European perspective. *In* M. Moser, R.C. Prentice & J. van Vessem, eds, *Waterfowl and wetland conservation in the 1990s: a global perspective. Proceedings of the IWRB Symposium, St. Petersburg, Florida, November 1992.* Wetlands International Publication No. 26.

Kamstra, A. 1999. Haltung, Fütterung und Aufzucht. *In* F.W. Tesch, *Der Aal*. London, Chapman and Hall, pp. 289-299.

Klein Breteler, J.G.P. 1994. Stockings of pre-winter and post-winter glass eels and of elvers from aquaculture: growth and survival in mesocosms. Paper presented at the 1994 Session of the EIFAC Working Party on Eels, Oviedio, Spain, 26 September - 1 October 1994.

Knights, B. 1997. Risk assessment and management of contamination of eels (*Anguilla* spp.) by persistent xenobiotic organochlorine compounds. *Chemistry and Ecology*, 13:171-212.

Knights, B. & White, E.M. 1997. An appraisal of stocking strategies for the European eel, *Anguilla anguilla* L. *In* I.G. Cowx, ed., *Stocking and Introduction of Fish*. Oxford, Fishing News Books, pp 121-140.

Knights B. & White, E.M. 1998. Enhancing immigration and recruitment of eels: the use of passes and associated trapping systems. *Fisheries Management and Ecology*, 5:459-471.

Knights B., Bark, A., Ball, M., Williams, F., Winter, E. & Dunn, S. 2001. Eel and elver stocks in England and Wales – Status and management options. R&D Technical Report No. W248. Bristol, United Kingdom, Environment Agency, 294 p.

Knösche, R., Zahn, S. & Borkmann, I. 2000. Fischereiliche Betroffenheitsanalyse zur Wasserkraftnutzung in Sachsen-Anhalt. Research report. Potsdam-Sacrow, Germany, Institute of Inland Fisheries, 76 p.

Lande, R., Sæther, B.-E. & Engen, S. 1997. Threshold harvesting for sustainability of fluctuating resources. *Ecology*, 78:1341-1350.

Legault, A. 1994. Preliminary study of the fluvial recruitment of eels. *Bulletin Français de la Pêche et de la Pisciculture*, 335:33-41.

Legault, A., Acou, A., Guillouët, J. & Feunteun, E. in press. Suivi de la migration d'avalaison d'anguilles dans une conduite de débit réservé. *Bulletin Français de la Pêche et de la Pisciculture*

Leopold, M. 1976. Efficiency and perspectives of eel management - summary and some economic approaches. Paper submitted to the Joint ICES/EIFAC Symposium on Eel Research and Management, Helsinki, Finland, 9-11 June 1976, Doc. 17, 17 p.

Lorenzen, K. 1996. The relation between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. *Journal of Fish Biology*, 49:627-647.

Mace, P.M. 1994. Relationships between common biological reference points used as thresholds and targets of fisheries management strategies. *Canadian Journal of Fisheries and Aquatic Science*, 51:110-122.

Maes, G. & Volckaert, F. 1999. Genetic structure of (sub)adult European eel based on allozyme markers. Paper presented at the 11th Session of the EIFAC/ICES Working Group on Eels, Silkeborg, Denmark, 20-24 September 1999.

Mann, R.H.K. 1995. Eel stock assessment in the UK. Report to MAFF, Project No. SF0305, IFE Project No.T11063al. London, Ministry of Agriculture, Fisheries and Food, London, 86 p.

McCarthy, T.K., Allison, J., Callaghan, R., Purcell, P. & Copely, L. 1994a. Yellow eel stocks in the River Shannon and the development of the fyke net fishery. Report to the Electricity Supply Board, Dublin, Ireland.

McCarthy, T.K., Cullen, K., Faherty, K. & O'Farrell, M.M. 1994b. River Shannon silver eels: population biology, factors influencing downstream migration and commercial fishing. Report to the Electricity Supply Board, Dublin, Ireland.

McGurk, M.D. 1996. Allometry of marine mortality of Pacific salmon. *Fisheries Bulletin*, 94:77-88.

Moriarty, C. 1987. The eel stocks of the Shannon system and prospects for the development of the fishery. Fishery Leaflet No. 139. Dublin, Department of the Marine, 8 p.

Moriarty, C. 1990. Eel management practice in three lake systems in Ireland, *In* W.L.T. van Densen, B. Steinmetz & R.H.Hughes, eds, *Management of Freshwater Fisheries*. *Proceedings of a Symposium organised by EIFAC, Göteborg, Sweden, 31 May - 3 June 1988*. Wageningen, Netherlands, Pudoc, pp. 262-269.

Moriarty, C. & Dekker, W. (eds) 1997. Management of the European eel – Enhancement of the European eel fishery and conservation of the species. *Fisheries Bulletin (Dublin)*, (15):110 p.

Moriarty, C. & McCarthy, D. 1982. Eel. *In* EIFAC, Report of the symposium on stock enhancement in the management of freshwater fisheries. *EIFAC Technical Paper*, (42):3-6.

Mower, D. 1998. Leighton Moss elver study, 1997-8. Unpublished report. Leighton Moss, United Kingdom, Royal Society for the Protection of Birds.

Mower, D. 1999. Elver study at Leighton Moss 1999 in relation to commercial elver fishing. Unpublished report. Leighton Moss, United Kingdom, Royal Society for the Protection of Birds.

Naismith, I.A. & Knights, B. 1988. Migrations of elver and juvenile European eel, *Anguilla anguill*a L., in the River Thames catchment. *Journal of Fish Biology*, 42:217-226.

Naismith I.A. & Knights, B. 1993. The distribution, density and growth of European eel, *Anguilla anguilla* L., in the River Thames. *Journal of Fish Biology*, Suppl.A:161-175.

Nicola, G.G., Elvira, B. & Almodóvar, A. 1996. Dams and fish pasaje facilities in the large rivers of Spain: effects on migratory species. *Acta Hydrobiologica*, Suppl.152: 375-379.

Pedersen, M.I. 1997. Denmark. *In* C. Moriarty & W. Dekker, eds, Management of the European Eel. *Fisheries Bulletin (Dublin)* (15):53-56.

Pedersen, M.I. 2000. Long-term survival and growth of stocked eel, *Anguilla anguilla* (L.) in a small eutrophic lake. *Dana*, 12:71-76.

Pedersen, M.I. & Dieperink, C. 2000. Fishing mortality on silver eels, *Anguilla anguilla* (L.), in Denmark. *Dana*, 12:77-82.

Pursiainen M. & Toivonen, J. 1984. The enhancement of eel stocks in Finland; a review of introduction and stockings. *EIFAC Technical Paper*, (42, Suppl.1):59-67.

Rasmussen, G. & Therkildsen, B. 1979. Food, growth and production of *Anguilla anguilla* L. in a small Danish stream. *Rapports et Proces-Verbaux des Reunions, Conseil International pour l' Exploration de la Mer*, 174:115-123.

Robinet, T. & Feunteun, E. 2002. Sublethal effects of exposure to chemical compounds: a cause for the decline in Atlantic eels? *Ecotoxicology*, 11:265-277.

Rosenberg, A., Mace, P., Thompson, G., Darcy, G., Clark, W., Collie, J., Gabriel, W., MacCall, A., Methot, R., Powers, J., Restrepo, V., Wainwright, T., Botsford, L., Hoenig, J. & Stokes, K. 1994. Scientific review of definitions of overfishing in U.S. Fishery Management Plan. Silver Spring MD, USA, U.S. National Oceanic and Atmospheric Administration. NOAA Tech. Memor. NMFS-F/SPO-17, 205p.

Sparre, P. 1979. Some necessary adjustments for using the common methods in eel assessment. *Rapports et Proces-Verbaux des Reunions, Conseil International pour l'Exploration de la Mer*, 174:41-44.

Svärdson, G. 1976. The decline of the Baltic eel population*. Report. Institute of Freshwater Research, Drottningholm*, 55:136-143.

Svedäng, H. 1999. Vital population statistics of the exploited eel stock on the Swedish west coast. *Fisheries Research*, 40:251-265.

Turnpenny, A.W.H. 1989. Field studies on fisheries in acid waters in the United Kingdom. *Society for Experimental Biology Seminar Series*, (34):45-65.

Valente, A. 1993. Impactes de emprendimentos hidroeléctricos sobre as comunidades piscícolas. *Recursos Hídricos*, 13(3): 9-14.

Vøllestad L.A. 1986. Growth and production of female yellow eels (*Anguilla anguilla* L.) from brackish water in Norway. *Vie et Milieu, Paris*, 36(4):267-271.

Vøllestad L.A. & Jonsson, B. 1988. A 13-year study of the population dynamics and growth of the European eel *Anguilla anguilla* in a Norwegian river: evidence for density-dependent mortality and development of a model for predicting yield. *Journal of Animal Ecology*, 57:983-997.

Walters, C. & Maguire, J.-J. 1996. Lessons for stock assessment from the northern cod collapse. *Reviews in Fish Biology and Fisheries*, 6:125-137.

Westin, L. 1998. The spawning migration of European silver eel (Anguilla anguilla L.) with particular reference to stocked eel in the Blatic. *Fisheries Research*, 38(3):257-270.

White, E.M. & Knights, B. 1994. Elver and eel stock assessment in the Severn and Avon. NRA R&D Project Record 256/13/ST. Bristol, United Kingdom, National Rivers Authority, 141 p.

White, E.M. & Knights, B. 1997a. Dynamics of upstream migration of the European eel, *Anguilla anguilla* (L.), in the Rivers Severn and Avon, England, with special reference to the effects of man-made barriers. *Fisheries Mangement and Ecology*, 4:311-324.

White, E.M. & Knights, B. 1997b. Environmental factors affecting the migration of the European eel in the Rivers Severn and Avon, England. *Journal of Fish Biology*, 50:1104-1116.

Wickström, H. & Hamrin, S. 1997. Sweden. *In* C. Moriarty & W. Dekker, eds, 1997. Management of the European Eel. *Fisheries Bulletin (Dublin)*, (15):46-52.

Wickström, H., Westin L. & Clevestam, P. 1996. The biological and economical yield from a long-term eel stocking experiments. *Ecology of Freshwater Fish*, 5:140-147.

Wirth, Th. & Bernatchez, L. 2001. Genetic evidence against panmixia in the European eel. *Nature*, 409:1037-1040.