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Eel Management in France: How Are We to Face the Dilemma of a European Wide Species ?

Abstract

The objective of this paper is to review how the French strategy on eel management has evolved over the last years in the face of a very serious threat against this species.

In the mid-1980s, a National French Eel Group, was formed to make a rapid appraisal of the degrading situation and to propose recommendations. The backbone of the French strategy suggested that each country should optimize their incoming glass-eels under a watershed management approach.

In 1998, French scientists also proposed escapement targets of silver eels for each watershed. Since then, more works on watersheds have focused on stock assessments and population dynamics from incoming young eels up to the descent of potential spawners. An additional tool might be precise management monitoring of upstream migrating eels related to the water temperature and fishing seasons to determine in-season exploitation targets.

In order to prevent the European Fisheries Commission from implementing a total ban of eel fishing throughout the continent, all the countries now are forced to join their efforts towards a European strategy, which is not an easy task because of the short-term interests and the very different fishing sectors and markets. Finally, this paper suggests a new fair collaboration with Asia and North America to integrate their own situations for native species within a worldwide aquaculture and market network.

Key words : European eel, France, Management

The European eel *Anguilla anguilla* is an Atlantic species found in most of Europe and in parts of Africa in over 90000 km^2 of continental waters. This species reproduces in the a middle part of the Atlantic ocean (Sargasso Sea) under unknown conditions[1-3]. Even if some recent genetic findings[4-6] call for revisiting this hypothesis, we still have to consider this species as a single species able to colonize all European and some Northern African waters. For decades, this species has

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undergone an extensive human exploitation: both fisheries and aquaculture that depend only on natural recruits. Today, more than 25,000 people get an income in Europe from exploiting this species, which corresponds to about 30,000 tons annually of production (all stages) and 180 million Euros in value [7]. This exploitation was recently boosted by an increasing demand from aquaculture and consuming markets. Moreover, the whole market is segmented worldwide and induces an exploitation, which can target all the life stages of this species (glass eels, yellow and silver eels) with some variations according to country. France is now one of the most important European countries involved in such an exploitation for export purposes. This long export history deals with young yellow eels to Italy for on-growing and with glass eels to Spain. However, the growing eel aquaculture industry in Europe (Netherlands, Denmark, Italy) and mainly in Asia shifted this export toward The Far East, mostly China.

Once considered as an unlimited resource because of its amazing potential to live in all water-bodies (seawater, brackish and fresh waters), the European eel population has displayed some troublesome warnings. The reduced distribution of yellow eels within continental waters and the decline in glass-eel catches and upstream migrants suggest a general decline of the species on a European scale. French authorities addressed this issue in the early 1980s through a nation-wide working group formed to identify causes for this decline and to put into practice related solutions. New policies emerged in France and were embedded within another European policy directed at managing this species.

Beyond a description of the French progress, the objective of this paper is to point out how France and other countries did shift their policies towards a better sustainability of this common pool resource without forgetting that a worldview should be used to make it more relevant.

The eel in France: from an unlimited to a threatened species

In France, the eel was never considered a valuable resource until the late 1970s when the demand seemed to exceed the supply[8-9]. It was already true for the young yellow eels trapped in Mediterranean lagoons and exported to Italy for on-growing "valliculture" and for the glass eels caught along the Atlantic coast sold as a delicacy for the Spanish market. After high catch records in 1976, the small-scale and coastal fisheries started experiencing a possible decline that could jeopardize their annual revenue. Operating within estuaries, this fishery was almost unknown by the French National Fishery Statistics Service and very few reliable data was available. Fortunately, the national fishing organization helped scientists build a reliable database to address this issue. Similarly, the National Institute for Fisheries Research (ISTPM) created a working group in which some monitoring programs were discussed. This was one of the first steps toward a national working group that pooled efforts from three Ministries (Agriculture, Fisheries and Environment).

Within freshwaters, the eel was often considered as a predator against all other fish like salmonids. Hence, for decades, removing eels out of most trout rivers was the usual way to manage other fish populations. It was a common leitmotiv to consider this species as preventing most planted trout and salmon fingerlings or eggs from surviving. But when general surveys were conducted in most Atlantic regions rivers in the 1970s and 1980s, the standing biomass and density of eels were very high[10-11]. This led people not to pay much attention to what was happening to in-coming runs of glass eels. Freshwater and seawater scientific institutes and ministries were split and very little communication occurred between all of them. The assumption was only salmon and trout were worth working on.

In 1984, the French National Working Group on Eel made a national survey and wrote a report to the

Ministries[12] to assess the current status of this species. Some recommendations were proposed, among which were changes to Freshwater and Fisheries laws and regulations. The eel status shifted from an abundant and common species to a threatened and valuable species. The data collected from various sources (commercial fishers, fish brokers, scientists,) highlighted changes in abundance of glass eels, yellow eel and silver eel (catch, biomass, decreasing size in lagoons).

In any case, observations (via catches or monitoring), have detected a declining trend in population since the mid-1970s (Fig. 1, 2, 3) throughout France and Europe[9-7-13-15]. Tragically, this decline is continuing today.

The general survey (RHP) in French river systems conducted by the C.S.P. (Conseil Supérieur de la Pêche) also emphasized a drastic reduction in eel densities in all river systems (Figure 4)[16]. This reduction is mainly related to flow regulating impoundments (dams, dikes, water-gates, sluices) combined with water and land management since the 1950s. Almost no fish ladder devices to facilitate the eel migrations (in and out of river systems) were in action in France whilst some existed in many other European countries[17].

Furthermore, the Group realized the outbreak of a parasitic infestation *Anguillicola crassus* of some eel populations which seemed to come from Asia through uncontrolled imports. This infestation kept spreading throughout Europe[18].

Even if there was no specific explanation for such a decrease in eel stocks, all agree that many factors could be involved by their combination. This realization was early embedded within the European situation through a stronger involvement of French eel biologists in the FAO/EIFAC Working Group on Eel and the ICES Working Group on Assessment of the European Eel. Moreover, the picture became bigger: what was happening in France could be related to a similar trend on a European scale and even at an Atlantic scale with the American eel *Anguilla rostrata*[19].

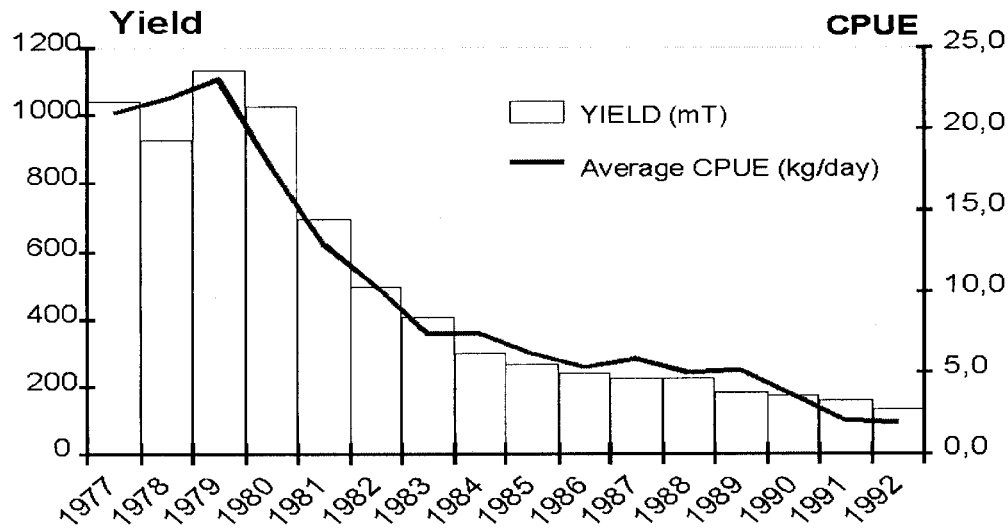

Fig. 1. Trends of the three most important glass eels fisheries in France (Loire, Gironde and Vilaine Rivers) from 1977 to 1992 expressed as yields (metric tons) and in CPUE (kg/day). Adapted from Castelnaud G., Guerault D., Desaunay Y. and P. Elie (1994) [44].

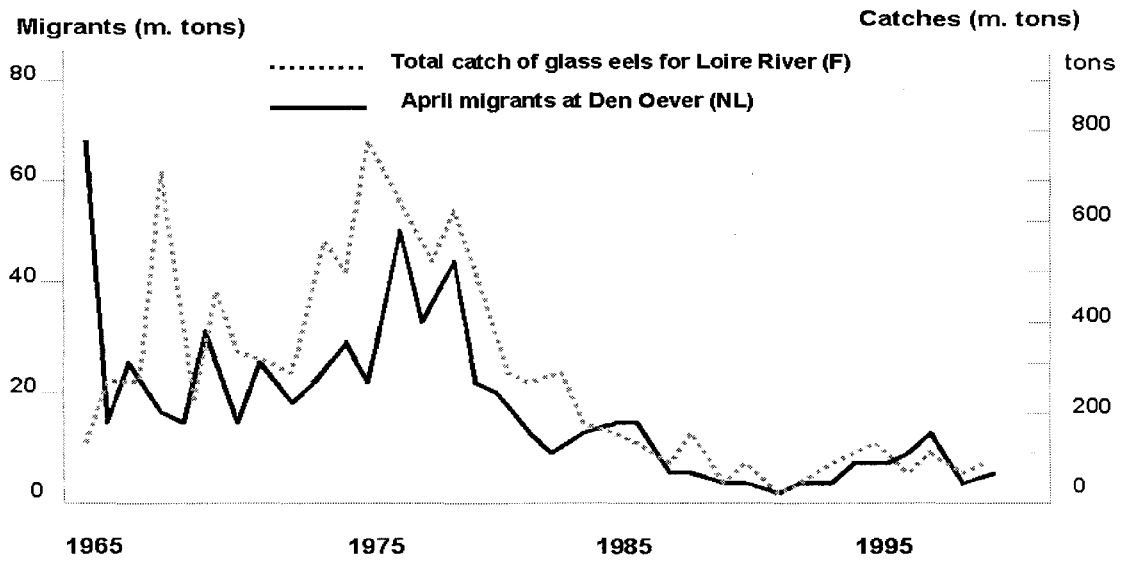

Fig. 2. Trend of European glass eel runs from 1965 to 1998 at two reliable European sites (right scale : commercial catches for Loire River, France ; left scale : sampling at Den Oever, The Netherlands). From Data ICES CM 2000/ACFM[15].

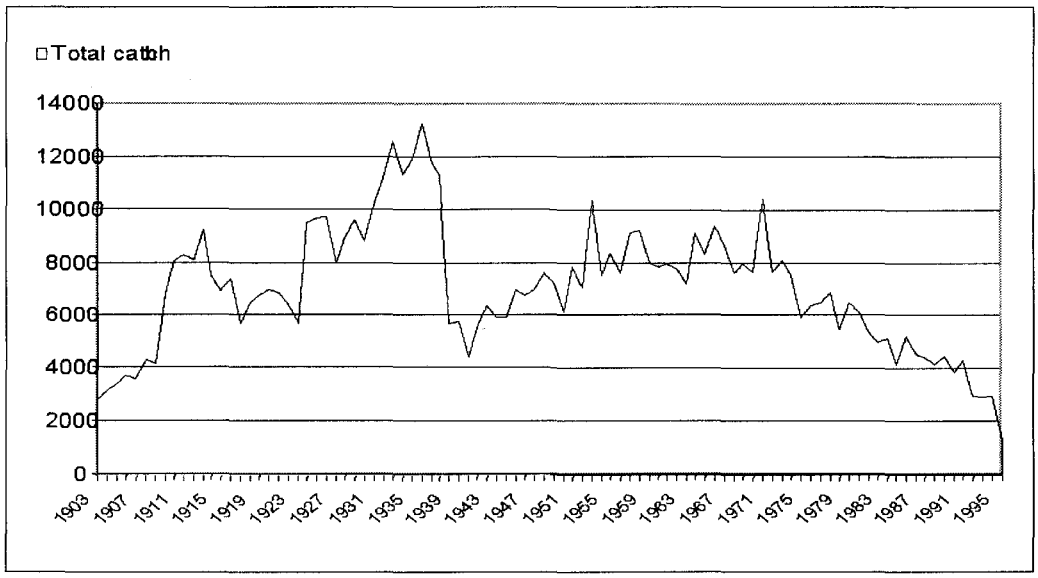

Fig. 3. Trends of Catches of European eel *Anguilla anguilla* in Europe (all stages). Data from ICES Statistics STATLANT (1999).

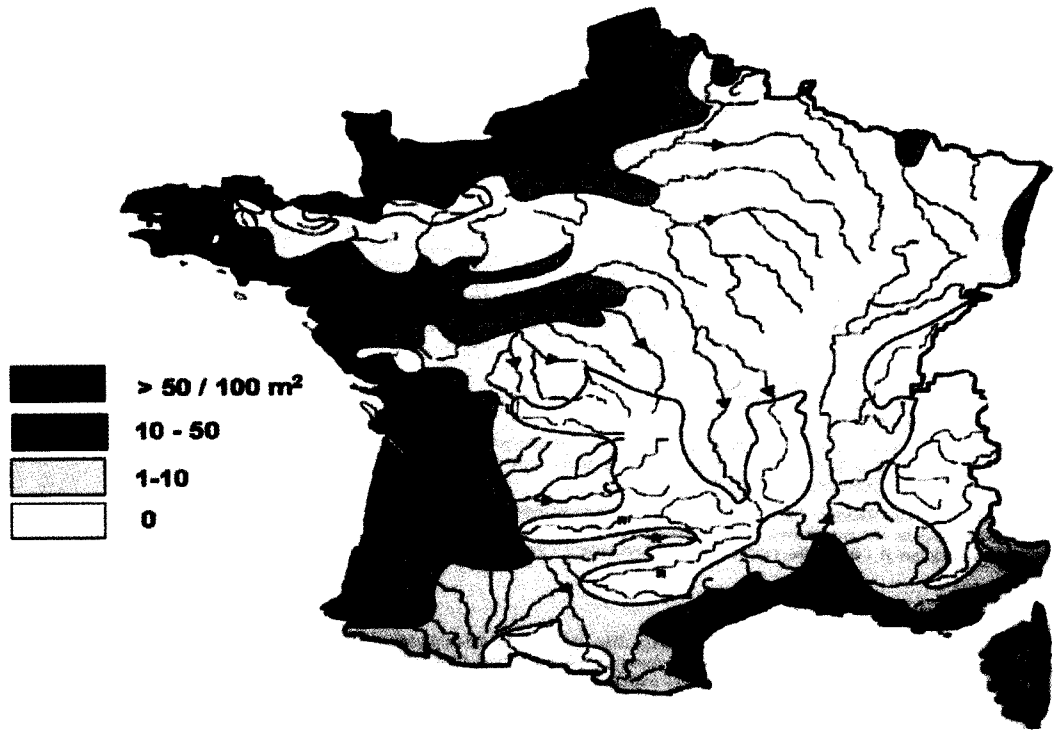

Fig. 4. Densities of eels (yellow stage) in French river systems from annual electrofishing surveys. Adapted from Chancerel[16].

Beyond the status of a valuable resource, the eel was also promoted in France as an ecological integrator. Indeed, the apparent long stay in all aquatic habitats and the wide range of food items it consumed gives this species the potential to become a recording species for mid-term change in water quality (pollutants) and management (damming).

Among the final recommendations of the French National Group on Eel, one was to set up a collaborative and national research and management program to address all these issues in the following years. A bottom line was defined and approved to make incentives for researchers and managers to carry out some programs aimed at improving the situation of eels and eel users.

Along with many meetings and discussions, some important features were approved as a background for a new approach: (i) once considered a freshwater species because of the length of time spent growing in freshwaters, the eel must be first considered a marine species. The marine phase cannot be skipped while eels can live all their life in seawaters; (ii) spawning occurs in international waters, thus cooperation is needed at this level. Furthermore, all impacts (fisheries, habitat management) occur within EEZ and continental waters of European countries and some other countries around the Mediterranean sea; (iii) eels can be marketed dead or alive, which is not so common for a fishery. Moreover, there is much confusion in statistical reporting because all exploited stages are not split into

different categories across the different markets worldwide.

The questions raised by French eel workers about the possible causes for the eel decline are embedded in the European approach. Without neglecting possible large-scale reasons like oceanic changes[13-20], we assumed that continental causes (migration obstructions: physical or chemical, habitat losses, overfishing, pollutant and/or parasite long-term impact) might be largely responsible for this general degradation. In addition to specific research programs on biological and ecological features (in particular on age validation, which suggested that the growth of eels seems to be much better than generally admitted in the literature[21-24], the French policy promotes restoration engineering. This is based on some case studies[25-26] in various river systems and some of them at watershed scale [27]. This scale must be considered as the only relevant scale for appropriate management[12]. So far, there is no evidence of any stock-recruitment relationship. Hence, once an upstream run of glass eels enters an estuary of a watershed, the general idea is to promote an optimal management to allow an optimal escapement target for potential spawners [28]. But this idea must be adopted on every watershed at a European scale to improve the species status.

European authorities involved in environment and fisheries are now more and more looking at the declining eel population. Several reports have been prepared [7-29] and in 1999, the Advisory Committee for Fisheries Management for the European Union proposed some drastic guidelines to reverse this trend.

However, European countries do not agree on all the rules in terms of management and fisheries. Most Northern countries (Sweden, Denmark, Norway, Netherlands) consider that eels should not be exploited before the large yellow and /or silver stage. Meanwhile, Southern countries (France, Spain, Portugal, Morocco) as well as the U.K and Ireland argue that glass eels can be exploited too but with different fishing gears. Thus, some huge controversies remain while, apparently, the eel stocks keep declining.

Cooperative research and management programs at the watershed scale: the baseline of French strategy for eel restoration

In addition to a European wide monitoring plan to verify the declining trend of incoming glass eels, France started funding several programs to restore eel populations at the watershed scale and to involve all other fish populations. The eel should not be disconnected from the whole fish community [30]. These restoration programs require a logical framework as follows: (i) depleted stocks must be first assessed, which needs a comparison of past time series if available and the current status within waters (the key question is to know what was the most likely biomass in the aquatic habitat under assessment); (ii) then, if a serious depletion is found, possible causes must be screened (obstructions, habitat suitability and/or loss, fishing pressure, others); (iii) at last, restoration programs can be defined to fix most of these problems (efficient eel-ladders, habitat protection and restoration, fishery control, restocking).

In terms of population dynamics, several river watersheds including their related estuaries have been selected as case studies to address management purposes. The key issue is to understand how glass eel runs can generate potential spawning runs some years later i. e. to find out what the main features of the stock – recruitment relationship are from a single recruit cohort within a watershed. Some monitoring stations in France have been selected for research and monitoring. Most of these combined research programs are now depending on two organizations: on the one hand, the National Scientific Working Group on Eel (GRISAM) sponsored by three Ministries (Environment, Research, Agriculture and Fisheries); on the other hand,

Regional Management Committees for Migratory Fish (COGEPOMI) at watershed scales in which most stakeholders have representatives.

Among the approved programs are re-opening migratory routes on various rivers by using eel-ladders, assessment of stock-recruitment from glass-eel to silver eel stages: on the Fremur River on by a very low proportion of a glass-eel cohort produces silver eels[31] (Fig. 5), and modeling of population dynamics.

The Vilaine River case constitutes a good example of such a program that combines research and management.

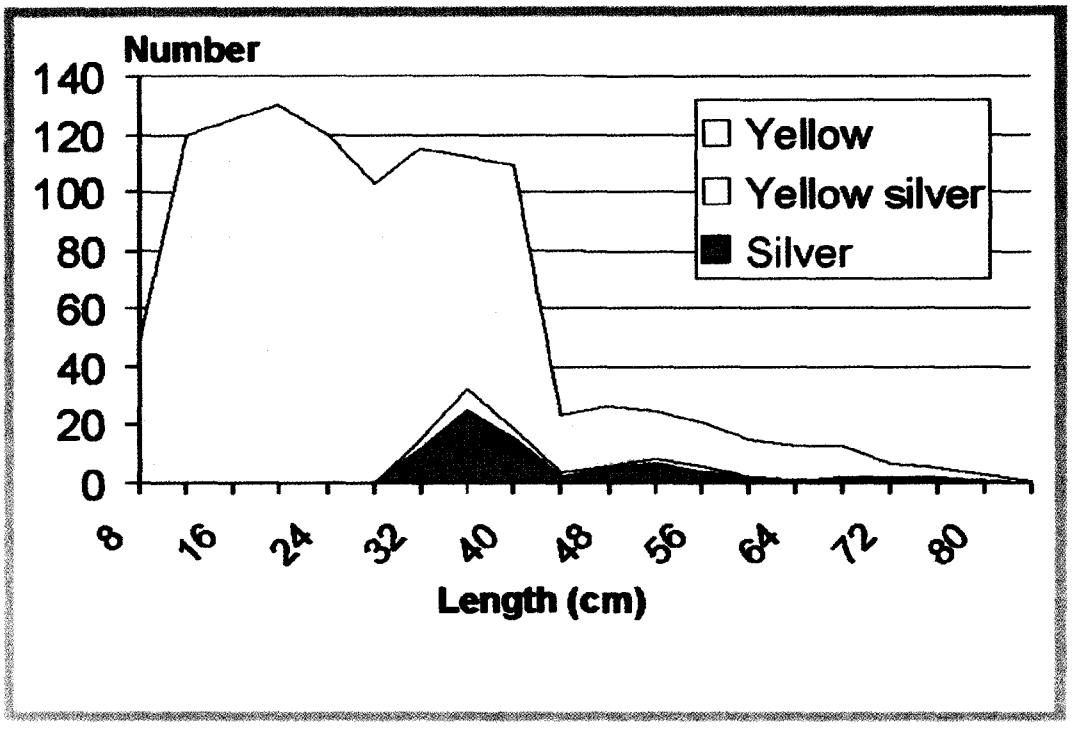

Fig. 5. An example of yellow and silver eels produced (in number) on several years from a single cohort of glass eel within a small watershed in Brittany (Western France). Results obtained with a PIT tagging experiment (Adapted from Feunteun et al.[31]).

The Vilaine river watershed encompasses an area of about 10,000 km^2 in Brittany (Western France). The eel represents an emblematic species for this region and has supported a fishery for several decades[32-33]. This is one of the most threatened glass eel fisheries as the upstream runs have been blocked by a dam located in the estuary since the late 1960s (fig. 6). Catch and CPUE data time-series of glass eel in this fishery highlight a significant decline over the last has been thirty years. However, since 1997, a specific eel-ladder device (Fig. 7) is working to facilitate eel upstream migration. The early and common hypothesis was that

fishing mortality was the main cause of this decline. The fish ladder was built to provide the upstream parts of the watershed some chance to be colonized by eels. But the impact of the re-opening of this watershed required some monitoring. Research programs were initiated to evaluate how many recruits could go upstream and grow in an eel depleted watershed. The results of research that considers the different behaviors of glass-eel runs in tidal waters are described in the literature[34-35-36-37]. These results are now available to evaluate the different fates of incoming glass eels[38]. During fishing seasons (usually from October to late March), almost all available glass eels are caught by fishing boats using tow-nets. Hence, the river recruitment is only made from later runs, out of in the fishing season. But, these runs are only capable of using the eel ladder when the water temperature reaches a 12°C threshold[39]. However, even when the temperature is above this value, many glass eels will stay within the estuary, possibly for their whole life.

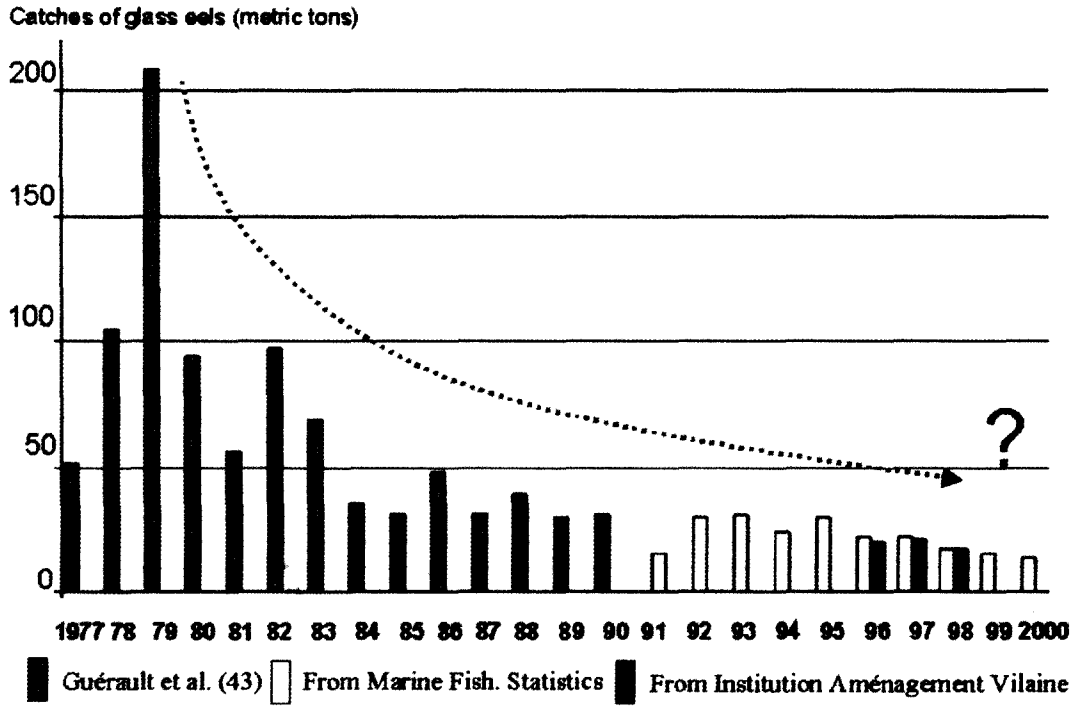

Fig. 6. Trends of glass eel catches arriving into the estuary of the Vilaine River from 1977 to 2000. Data from three different sources.

The dynamics of the migration were studied by using dye-marking experiments[38]. Ageing validation studies were also carried out as because many discrepancies were found when only using otolith reading. The number of annuli exhibited by eels' otoliths is so different depending on their stay in

estuarine or freshwaters that high ageing errors are possible[23]. Based on this validated data and a related length-age key, the growth of a new cohort can be tracked as the young eels colonize the river upstream of the dam. The progress of colonization is assessed by electrofishing surveys and trapping along the main river and some tributaries. From a depleted situation back in 1981(figure 8 A), the more recent surveys show significant improvement situation (Fig. 8 B-C) due to the re-opening strategy[33]. But in accordance with Tsukamoto[40], an important but unknown fraction of a glass eel run might stay and live their entire continental life within estuarine or even marine coastal waters without entering freshwaters. This assumption should be carefully examined as it raises the problem of the potential spawning biomass for the single Atlantic stock. Does this potential depend more on the "marine" than on "freshwater" eel?

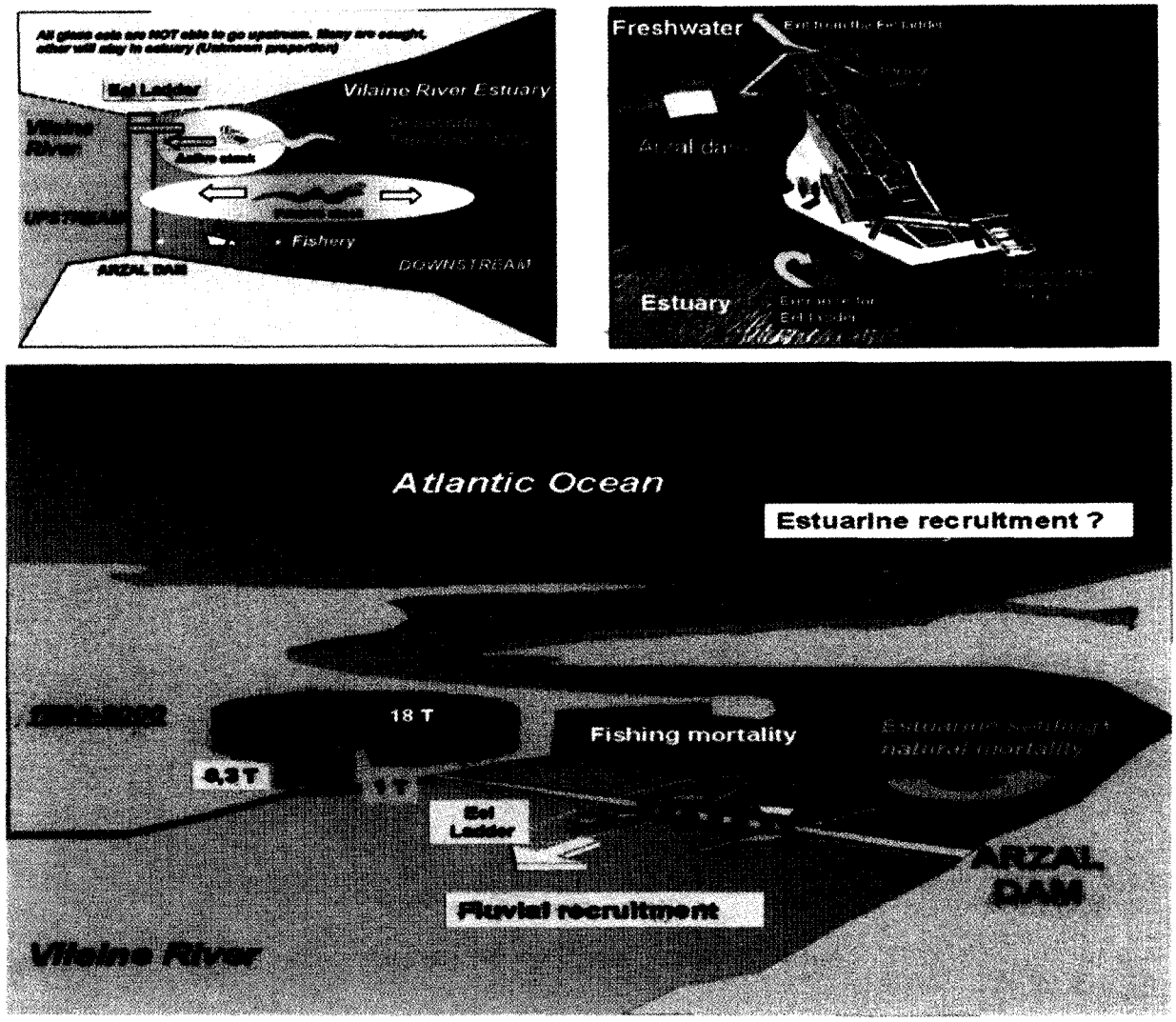

Fig. 7. A general illustration of the Vilaine River estuary where a management strategy has been developed by using data from the commercial fishery and by monitoring the upstream migration of glass eels and yound eels through an eel ladder. Details of the eel ladder and some information on the location of data sampling are also given on the above small figures.

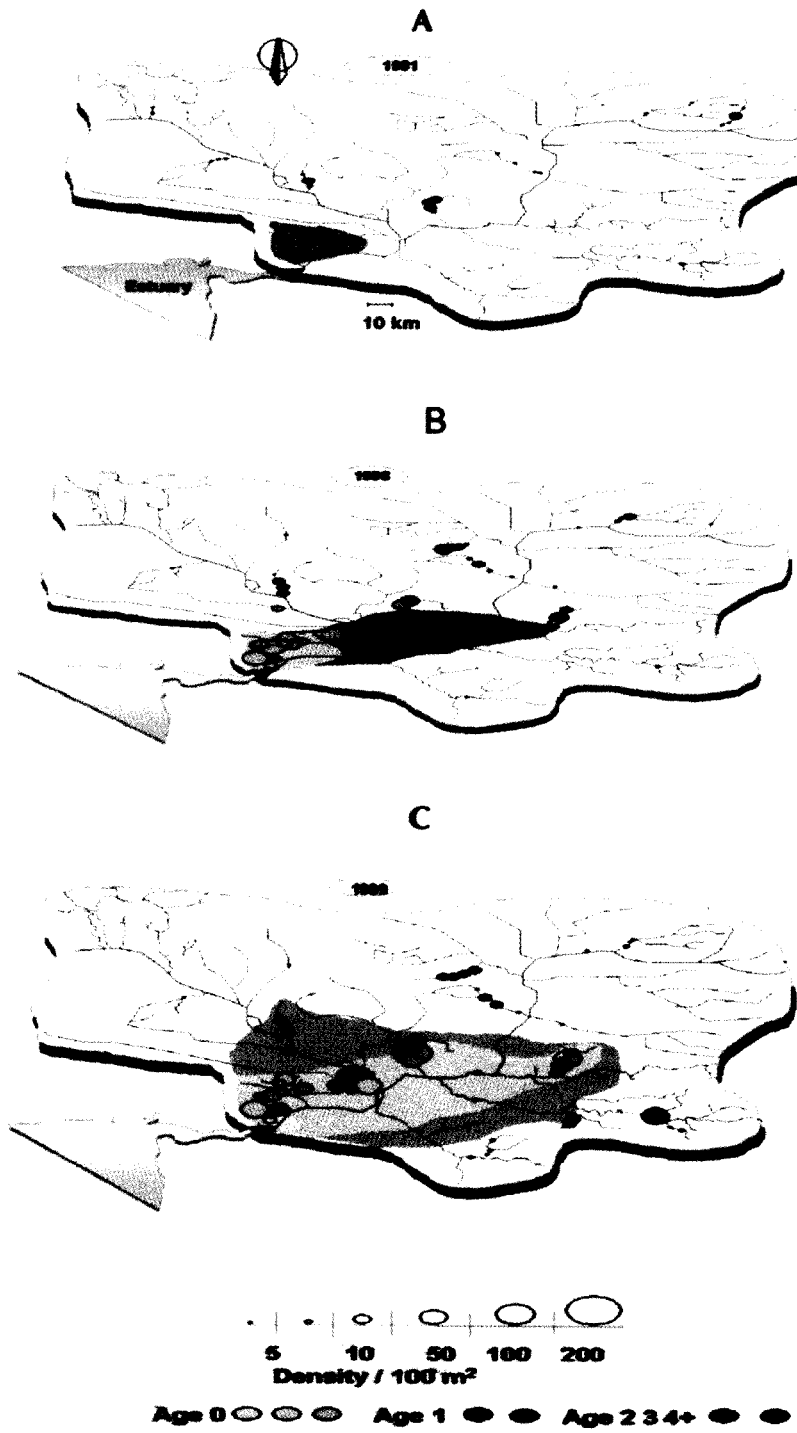

Fig. 8. Multi-annual evolution of the colonization by glass eels of the watershed of the Vilaine River (Western France). A. Situation before (1981) and B-C after re-opening (1998-1999) the migration route by using a eel ladder at Arzal Dam (electrofishing surveys). The size of ◯ illustrate the different densities of eels. The colours correspond to different ages.

Conclusions and perspectives: towards the sustainability of eel resources

Looking at several case studies scattered over the whole territory, some results are promising. It seems possible to improve the stock efficiency from arriving glass eels at local scales (small watersheds) without having to consider the possible impact of estuarine or coastal stocks. Therefore, the French strategy moves towards an appropriate restoration management at a relevant scale: the watershed (including estuaries and coastal lagoons). However, this strategy will not be efficient if it is not embedded within a European and north Atlantic framework. Indeed, according to the dynamic fractal distribution of the species as suggested by Dekker[41] and the possible oceanic influences on the change at the species level we need to enlarge the current vision to reach any sustainability of the eel resources. As the decline in recruitment continues, we still face huge uncertainties on oceanic influences on the whole stocks as suggested by many authors[13-20].

There is no clue about the required Minimal Biological Acceptable Level yet at a European scale This M. B. A. L. should support the long-term sustainability of the eel as an exploited species. But other wide ranging issues also challenge the sustainability of this species. Spreading parasitic infestations and impact of pollutants still might jeopardize the ability of eels to return safely to the spawning grounds by altering the swimbladder functions and maturation processes.

However, the most important threat may lie in the ever increasing demand from the aquaculture industry which is under pressure from an increasing world market demand. Thus, any current European management attempts (among which are the very drastic recommendations of the Advisory Committee of Fisheries Management) should be widened to a world scale, in particular in Asia where wild eel stocks have declined for decades. We just realize now that all eel producing and consuming countries in the world are connected within a very complex system. All countries must develop relevant knowledge and skills in science and management as well as in aquaculture. But there is not a single country able to solve this typical dilemma of the eel as a common resource pool. Basically, this problem refers to the "assurance issue" of a common resource[42] : any country (and stakeholder) which agrees to change its way of management (for instance by increasing the annual spawning escapement targets for the eel stock living on their territory) wants to be sure that all the others will behave likewise. The final outcome of this shift must be a collective win-win game. This is not the case yet. All the eel producing and consuming countries must deal with the uncertainty of the causes of the decline in all eel species combined with the uncertainty of expected results from national restoration programs applied to an international species.

We suggest that the "world eel system" may be shaped like a hyper-system which is made of several interactive subsystems: (i) the wild and natural production geographically identified by oceanic and eco-regional features; (ii) the aquaculture production still located in eco-regions and plugged into the former system but spreading beyond the natural boundaries through exchanges of young eels for on-growing; (iii) the consumption market which is no longer restricted to a specific country or region. This very instable worldwide system can be the main trigger and pressure on the sustainability of all eel species. Today, there is no regulatory tool capable of solving this sustainability issue on this scale unless a cooperative program is proposed with involvement of the world eel business. It is time to share experience and promote solutions through a "New Deal on Eel" which would embraces not only commodities flows but would also include the knowledge and goals of all stakeholders.

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