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ONEMA
Meetings

Diagnosing and restoring aquatic biodiversity

A symposium organised on conjunction with the International office for water in November 2012.

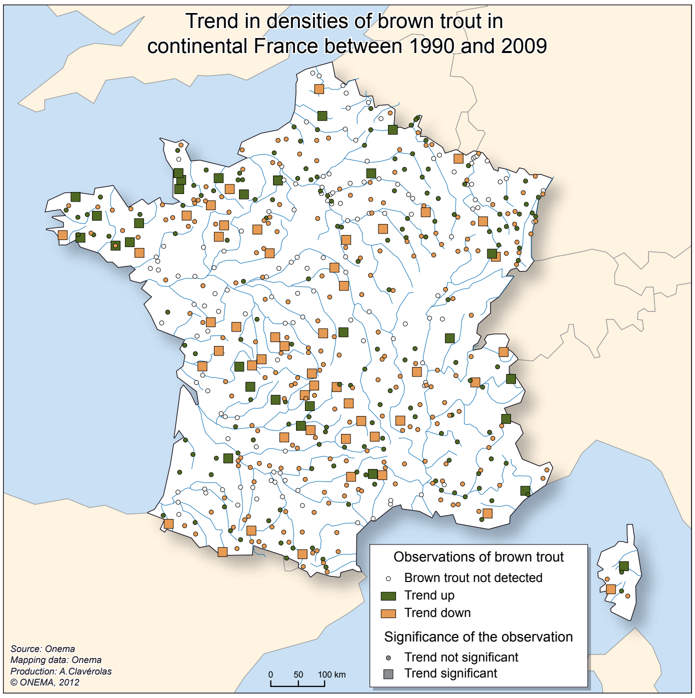
The national symposium on «The outlook for managing aquatic biodiversity in rivers and lakes» was an occasion to report on some 30 partnership-research projects in the field of aquatic biodiversity. The two days of discussions between scientists and managers brought together over 200 participants, including research labs, the Ecology ministry, local governments, companies, environmental-protection groups and NGOs. Following a status report on biodiversity in aquatic environments in France, the meeting went on to present a range of innovative tools for monitoring and restoring biodiversity in a context of global climate change.

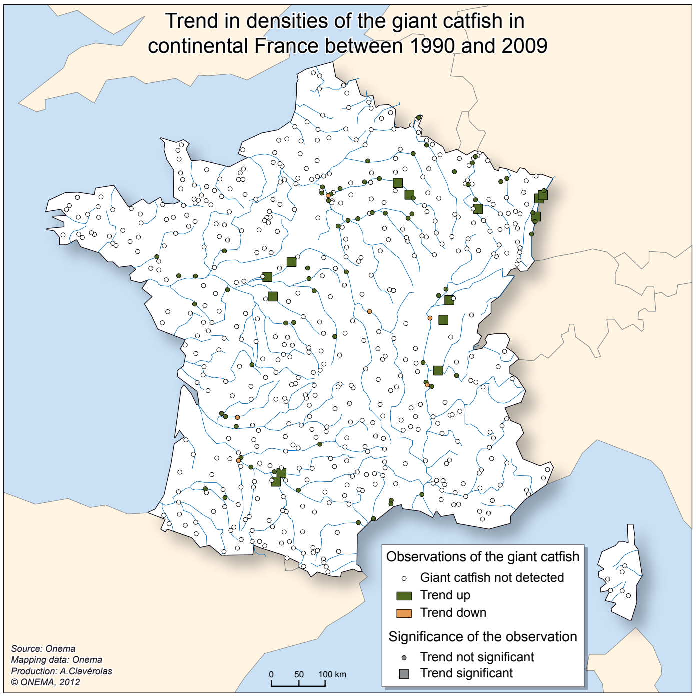
What is the current status of biodiversity in French rivers and lakes? To launch the meeting, the International union for the conservation of nature (IUCN) presented a status report (*F. Kirchner, IUCN France*). Of the 69 freshwater-fish species in continental France, 15 are threatened. Four species are critically endangered, namely the European eel, the European sturgeon, the Rhone apron and the Lez sculpin (Cottus petiti). One quarter of all crustacean species are also threatened. This alarming report was tempered in part by an analysis of temporal trends over the past two decades (*N. Poulet, Onema*). The analysis was based on the results from 590 measurement stations in the aquatic environment and fish database (BDMAP), a network spread over the entire country and from which at least eight years of monitoring data, using identical sampling methods, were available. According to the data, the number of fish species present on a given site (the species richness) increased by 1.4 on average between 1990 and 2009, and the distribution range of numerous species increased in size.

Brown trout, a declining species in continental France.

For three-quarters of the species, the average density also increased significantly, particularly for non-native species such as the giant Wels catfish and the asp. Only a dozen species would appear to have regressed, including eels, brown trout (see Figure 1 on next page), common bream and tench. The analysis could not present any significant trends for the rarest species (often the most vulnerable) or those, e.g. Atlantic salmon, for which the decline started in France before the studied period.

Interpretation of these trends remains a complex process. The efforts over the past 30 years to improve water quality, notably by reducing organic and phosphate pollution, certainly contributed to the observed improvements. In some cases, long data series available locally provided further information to improve the analysis. One example is the monitoring project for sea trout and salmon in the Bresle, a coastal river in Northern France, since 1984.





Examples of trend maps for densities of brown trout, in decline, and of the giant catfish, a species exhibiting a sharp increase.

The year-by-year results (average size, numbers, migratory rhythms and correlations with rainfall and temperature) reveal an overall reduction in the size of fish and improved freshwater survival rates during dry springs (*G. Euzenat, F. Fournel, Onema*).

Another example of useful local monitoring is the 40-year project in Lake Geneva where the waters have warmed significantly (1.5°C in 40 years). The changes in the annual dynamics of plankton are a major factor in explaining the trends observed in fish communities (*D. Gerdeaux, INRA*), notably the increase in the numbers of European whitefish caught. Given the temperature rise in the lake, it would appear inevitable that the artic char will have disappeared from the lake by 2070 if current trends continue.

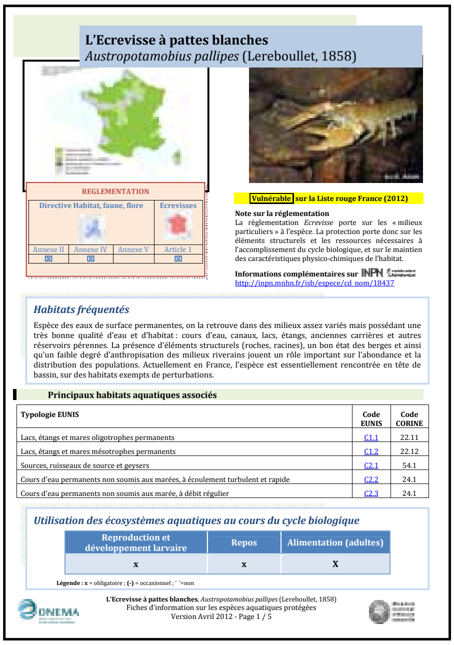
The European tree frog and its habitats are protected in France, but it is also a species «of community interest», listed in Annex IV of the Habitat directive.

An integrated approach to biodiversity

Though the results diverge widely for different species, the overall status report reflects the effects of European policies, starting with the 1979 Birds directive, which now increasingly take biodiversity into account. In addition to the 2000 Water framework directive (WFD), the policy designed to restore all water bodies in Europe to good ecological and chemical status, the 1992 Habitat directive constitutes an essential policy for management of aquatic biodiversity

Data sheets for protected species

The symposium was also the occasion to present (*C. Penil, Onema, D. Viry, National museum of natural history*) the issues involved and methods used for the aquatic-environment section of the second report for the Habitat directive to be published at the end of 2013 and which will assess the conservation status in France of 93 plant species, 199 animal species and 132 habitats in the Natura 2000 network. To assist local managers in protecting biodiversity, in 2011 the Ecology ministry, Onema and the National museum of natural history (MNHN) launched a series of data sheets summing up the knowledge acquired on 105 protected aquatic species, that should be of help in implementing the regulations governing protected species, e.g. Natura 2000 documents, Water-law forms, protected-species waivers, etc. For each species, the sheets indicate its status, biology, preferred habitats and the means to limit the impact of projects or activities on populations. The first 20 sheets were drafted in 2012.



L'Ecrevisse à pattes blanches
Austropotamobius pallipes (Lereboullet, 1858)

REGLEMENTATION

Directive Habitat, faune, flore			Ecrevisses
Annexe II	Annexe IV	Annexe V	Article 1
☒	☒		☒

Vulnérable sur la Liste rouge France (2012)

Note sur la réglementation
La règlementation *Ecrevisse* porte sur les « milieux particuliers » à l'espèce. La protection porte donc sur les éléments structurels et les ressources nécessaires à l'accomplissement du cycle biologique, et sur le maintien des caractéristiques physico-chimiques de l'habitat.

Informations complémentaires sur INPN
http://inpn.mnhn.fr/isb/espece/cd_nom/18437

Habitats fréquentés

Espèce des eaux de surface permanentes, on la retrouve dans des milieux assez variés mais possédant une très bonne qualité d'eau et d'habitat : cours d'eau, canaux, lacs, étangs, anciennes carrières et autres réservoirs pérennes. La présence d'éléments structurels (roches, racines), un bon état des berges et ainsi qu'un faible degré d'anthropisation des milieux riverains jouent un rôle important sur l'abondance et la distribution des populations. Actuellement en France, l'espèce est essentiellement rencontrée en tête de bassin, sur des habitats exempts de perturbations.

Principaux habitats aquatiques associés

Typologie EUNIS	Code EUNIS	Code CORINE
Lacs, étangs et mares oligotrophes permanents	C1.1	22.11
Lacs, étangs et mares mésotrophes permanents	C1.2	22.12
Sources, ruisseaux de source et geysers	C2.1	54.1
Cours d'eau permanents non soumis aux marées, à écoulement turbulent et rapide	C2.2	24.1
Cours d'eau permanents non soumis aux marée, à débit régulier	C2.3	24.1

Utilisation des écosystèmes aquatiques au cours du cycle biologique

Reproduction et développement larvaire	Repos	Alimentation (adultes)
x	x	X

Légende : **x** = obligatoire ; **(-)** = occasionnel ; ' '=non

L'Ecrevisse à pattes blanches, *Austropotamobius pallipes* (Lereboullet, 1858)
Fiches d'information sur les espèces aquatiques protégées
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An example of a data sheet on a species.

An increasing need for tools

To assess and understand the status of aquatic biodiversity, to implement the existing directives and procedures, scientists and managers have expressed a growing need for tools enabling an integrated approach to environments. Numerous research projects addressing this topic are currently underway. For example, on the international level, the IUCN has since 2008 been developing, in conjunction with its Red List, an ecosystem-assessment method based on various criteria, including ecosystem size, environmental degradation and disturbances to biological interactions (*A. Carré, IUCN*). To assist the assessment of the ecological status of water required by the WFD, ecosystem functional indicators are currently being developed in six joint projects that were launched in 2012 (*J.-M. Baudoin, Onema, G. Tixier, Metz University*). The goal is to take into account the complexity of biological communities and their interactions via a simple signal making routine monitoring a possibility. For example, one indicator measures the decomposition of organic matter in rivers and lakes using a standardised substance (cotton strips) placed on the bottom. This inexpensive tool is capable of precisely discriminating between various impacts and of informing on the response of the ecosystem once the disturbance has been eliminated. This is called a leading indicator.

Environmental DNA, an innovative method

Environmental DNA is an innovative method that can be used to draw up inventories. The DNA fragments present in a simple water sample collected in situ are sequenced, amplified and identified using a database containing the genetic IDs of a full 95 fish species. The database was developed by Onema and MNHN, among others. Studies comparing the new technique with standard electric-fishing methods, carried out according to the WFD protocol, were run on eight sites in 2012. The initial results are promising (*C. Miaud, École pratique des hautes études*) in that the ADN technique detected a total of 26 species, compared to 31 species captured by electric fishing. More or less serious discrepancies were noted between the sites and certain species were occasionally detected by only one technique. The environmental-ADN method is less expensive, impacts the environment less and, above all, can be used to inventory a number of aquatic communities (amphibians, aquatic mammals, invertebrates, etc.) using a single sample. However, it must still be improved. The development of integrated sensors would make it possible to detect low-density species and the analysis methods can also be refined, notably by setting interpretation thresholds. A further lacking of the environmental-ADN method is that it does not provide information on the size of populations, contrary to standard techniques such as electric fishing. However, in time, it should be possible to establish a reliable relationship between the ADN quantities detected and the corresponding biomass.

Molecular biology is a tool for the study of biodiversity that can be used by managers.

The impacts of climate change now and in the future

In a context of global change, the links between pressures and biodiversity lie at the heart of research and management issues. They were addressed by some 15 presentations during the symposium, during three sessions devoted to the impacts of climate change, habitat degradation and invasive species.

The ecosystems in natural, high-altitude lakes are impacted by climate change.

A study (*L. Comte, Toulouse University*) attempted to determine if climate change has already had visible effects on fish distribution ranges. A comparison (presence or absence of species) of over 9 000 sites during two periods, a «cold» (1980-1992) and a «hot» (2003-2009) period, revealed variable differences depending on the species.

Christel Fiorina,
Water and biodiversity department, Ecology ministry

This very dense symposium was an occasion to present new knowledge on every aspect of the subject. Sharing of knowledge is essential and the results will be fed into the Water information system for France (WIS-F) and the Nature and landscapes information system (SINP), among others. However, progress was also made in terms of quality. The restoration examples provide installation owners with concrete data for future projects. The economic approaches will be a great help in setting priorities and the initial studies presented on invasive plants are a step in the right direction. Current progress in biophysical assessment of ecosystems will soon be of use in determining the economic value of the services rendered by biodiversity.

The biodiversity of a river depends on maintaining its hydrological cycle.

Examples? Brown trout are disappearing from the edges of their distribution zone, whereas barbel are increasingly found along the edges of their zone. The common minnow has gained habitats throughout its distribution range. On the whole, the study suggests a trend among species to respond to climate change by following their ecological niche rather than adapting to the change, with many species moving to higher elevations. A large-scale modelling project (*E. Rochard, Irstea*) looked at possible changes in distribution ranges of migratory fish according to various climate scenarios established by the IPCC (Intergovernmental panel on climate change). The results, in the form of maps, show very different responses depending on the scenario and the species. The attention paid to fish populations, which are highly visible symbols of biodiversity and have been monitored for years, must of course not mask the crucial importance of other living communities in the operation of ecosystems. How will microbial processes react to temperature rises? Data was provided (*S. Boulêtreau, Toulouse University III*) by a comparative in situ study on biofilms (microbial communities adhering to a surface) on rocks in the riverbed of the Garonne River, under current conditions and a warmer context (+1.5°C on average) created by the Golfech nuclear plant. Clear differences appeared between bacterial communities. They showed highly diverse dependencies on thermal conditions, particularly the denitrifying species, i.e. those playing a key role in the nitrogen cycle. At this point in the research, there are more questions than answers. For example, what will be the consequences for nitrogen flows between biofilms and water bodies? And for the services rendered by the ecosystem?

Hydrology and habitats are factors in biodiversity

Independently of the climatic conditions, the pressures exerted on aquatic habitats by human activities (artificialisation, abstractions, hydroelectric installations, etc.) directly impact fauna and flora. As part of the hydromorphological section of the WFD, Onema studies the links between hydrological regimes and biodiversity. Following earlier work (*Naiman et al., 2002*), the presented results (*Ph. Baran, Onema, B. Bergerot, HEPIA Geneva*) confirm and clarify the need to reserve a certain quantity of water to ensure the ecological operation of rivers. Above and beyond the current concept of a «minimum biological discharge», an annual flow regime must be maintained to preserve biodiversity, ranging from seasonal high waters required for the reproduction of certain species to low-flow rates that modify the structure of populations.

Biofilm on a rock.

Onema has decided to proceed with an analysis on a larger scale in an attempt to link hydrological characteristics and biodiversity by combining the data from the fish inventories (BDMAP) and the HYDRO database (http://www.hydro.eaufrance.fr/). Throughout continental France, 127 measurement stations were selected for this study that will provide more in-depth knowledge on hydrological requirements in preparing operational restoration projects. That was already the goal in other projects, e.g. the Eels & Installations R&D programme (*L. Beaulaton, Onema*), a three-year partnership between Onema, scientists and hydroelectric companies comprising 18 research projects to optimise the design and management of installations in order to restore eel stocks (see the Onema Meetings document no. 15, April 2012).

In addition to hindering migratory fish, weirs, dams and other installations fragment rivers, degrade habitats and thus represent a major pressure on biodiversity as a whole. A study assessed the impacts of obstacles on populations of small fish using molecular-biology techniques (*S. Blanchet, CNRS*). In two river basins in South-western France, the team measured the genetic differentiation within gudgeon populations and common-minnow populations to quantify the habitat fragmentation caused by each obstacle. In addition to new biological information on the species and their sensitivity to hydromorphological disturbances, this approach produced concrete information making it possible to identify the most harmful installations and set priorities for management. For example, on the Viaur River, the height of obstacles is the decisive factor in genetic differentiation of populations.

Economic approaches to invasive species

The increase in invasive species in rivers and lakes is both a consequence and a part of global change. It also constitutes a growing disturbance for aquatic biodiversity. In France, the goal of the work group on «Biological invasions of aquatic environments», launched in 2008 by Onema and Irstea and comprising water managers, researchers and local governments, is to set guidelines for research on the problem and its management. Over the past five years, it drew up a list of the exotic animal and plant species now present in continental France and assisted in selecting a method to assess the risks created by these species for ecosystems (*A. Dutartre, Irstea*). The reports produced are accessible via a dedicated internet site (www.gt-ibma.eu), where visitors will find a good-practices guide, case studies, management-aid tools, etc.


© Alain Dutartre - Irstea

A river invaded by water cabbage (*Pistia stratiotes*).


© Nicolas Poulet – Onema

The Louisiana crayfish provokes profound disturbances in the operation of invaded ecosystems.

In response to increasing requests from managers, the work group intends to develop economic methods to evaluate the management costs incurred by the invasions. One of the first studies in this field in France was a research project (*A. Thomas, INRA*) that looked at water primrose. The management costs incurred by this aquatic plant were put into an equation linking the present quantity of biomass and the quantities that must be extracted to manage the various impacts (commercial and non-commercial) of the invasion. This method was applied to the wetlands of the Marais Poitevin region in Western France. The calculations produced an estimate of the «optimal» quantities of water primrose for the area corresponding to 87% of the current quantities. One of the major assumptions in the method is that the length of infested river is directly proportional to the quantity of the plant.

Another study on invasive plants adopted a more temporal approach. An identical group of researchers carried out in-depth floristic surveys on 32 sites in the riparian corridor of the Adour River, from the source to the mouth, in the years 1989, 1999 and 2009 (*E. Tabacchi, CNRS*). They noted changes in the river dynamics due to anthropogenic causes with major consequences for plant biodiversity. On one site for example, the number of species fell from 673 to 383 and the number of distinct habitats from 29 to 16.

Jean-Philippe Reygrobellet,
Board for the balanced management of the Gardon River

In the Gardon River basin, we have observed extremely rapid changes in ecosystems. The arrival of water primrose is the main problem that now represents 50% of our work on aquatic environments. However, it is difficult to fully understand the mechanisms impacting biodiversity. Could our management work not also have negative effects? Therein lies the great value of this type of symposium. The variety of the work presented puts managers in a position to see the links between the various aspects of the problems and to better interpret their observations in the field. To that end, the temporal approaches, for example the study on changes in the floristic compositions of the Adour River riparian corridor, strike me as being highly useful in understanding the dynamics at work in order to better plan our work.

Surprisingly, no significant changes were observed in the average species richness. The main change is a trend toward uniformity in compositions, with a decline in stress-tolerant species and in hydrophytes (i.e. plants submerged most of the time) and a clear increase in ruderal species (i.e. plants growing in abandoned or disturbed areas) and in introduced and/or invasive species. In a few years, this work should result in a quantified functional approach to the effects of these changes on ecosystem services.

The last session in the symposium examined examples of restoration projects and their effects. In one case, moving a water-treatment plant located on the banks of the Vistre River (Gard department) resulted in a rapid improvement in the composition of invertebrate communities (*V. Archaimbault, Irstea*). In another, work to remove tree stumps and trunks in the riverbed of a diked section of the Isère River in the Savoie department reactivated the migratory processes of sand bars (*J.-L. Peiry, Clermont University II*). And efforts to defragment rivers by eliminating obstacles or, if that is not possible, by creating fish passes in the framework of the European Life Apron projects (*P. Roche, Onema*) resulted in reaches of the Ardèche River being recolonised by the apron. In short, it is now clear that projects to restore biodiversity, if correctly implemented, can produce good results. ■

The presence of certain insect species whose larval stage is aquatic (here an adult mayfly) is a sign of environmental quality.

For more information:

The presentations may be found at:
http://www.seminairebiodiversite.oieau.fr/ and
http://www.onema.fr/Biodiversite-milieux-aquatiques-retour-sur-le-seminaire

A Meeting Recap will be available in 2013 at www.onema.fr, in the Publications section.

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