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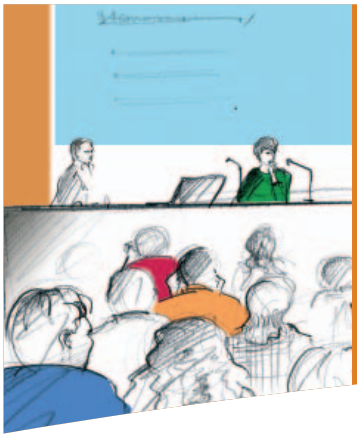


ONEMA
Meetings

Climate change, impacts on aquatic environments and consequences for management

A seminar organised on 29-30 June 2009, Paris.

Building, on a national scale, sustainable dialogue between scientists and water managers in order to address the recognised climate change, that is the objective of the seminar organised by Onema and the Management and Impacts of Climate Change (GICC) programme of the ministry in charge of ecology, on 29-30 June 2009 in Paris. This seminar, entitled «Climate change, impacts on aquatic environments and consequences for management», brought together more than 120 scientists, experts, managers, and representatives of NGOS and companies. This dossier provides an overview of the current knowledge that was presented, the points of view expressed, and the questions raised over these two days.

Steadfastly oriented toward dialogue between water managers and the scientific world, the seminar opened with a session entitled «State of the situation on operational needs». Representatives of stakeholders in water – farmers, service operators, natural park managers, fishermen – raised many questions as to changing their practices in order to best adapt to climate change. Many expectations of a technical or socio-economic nature, specific to each type of stakeholder, as well as recurring needs for scientific knowledge, came out of this session *(see the table on page 2).*

The managers freely expressed their needs for scientific elements on the impact of climate change. The sessions at the seminar made it possible to respond to their expectations at least in part and also to raise other questions.

Impacts of climate change on hydrology in metropolitan France

Since 1910, the average temperature in France has increased by about 1°C. The 1990s were the hottest in the 20th century and the current decade is keeping with the trend. It is now accepted – especially by the IPCC (Intergovernmental Panel on Climate Change) – that the main force driving this climate change is the increase in the concentration of greenhouse gases stemming from human activity. This relation forms the main hypothesis of the various greenhouse gas scenarios used by the IPCC[1] for its climate change projections. For a relatively optimistic scenario, the future change in the temperature on the surface of the planet will be about 3°C in France around 2100 (reference year: 2000) – which is an increase that is higher in absolute value than what the entire planet has experienced over the last 400,000 years.


Hervé Jacquot – Onema

[1] SRES (Special report on emission scenarios) report, 2007.

Elisabeth Jaskulké (Suez Medef)

"The priority: develop a methodology to resolve the usage and service conflicts in terms of water and town and country planning."

Climate change, part of a global change

In just a few decades, industry and intensive farming have taken substantial volumes of water and have caused much pollution, accelerated urbanisation has led to an artificialisation of the river banks and a degradation of natural environments, and the globalisation of transport systems has allowed exotic and sometimes invasive species to arrive in the ecosystems. The impact of these pressures on the environment is often combined with that of climate change.

In this context of multiple interactions, the primary challenge for the research conducted on adapting to climate change is to decrease the vulnerability of the ecosystems to global change. This notion of climate change as a component of a global change was largely agreed upon at the seminar.

Recall that global projections are based on climate models which tend to incorporate an increasing share of the extraordinarily complex phenomena that govern the climate. However, there is still a lot of uncertainty which has to be taken into account in policies based on these projections.

The influence of climate change on the rivers, in terms of temperature or flow, results in a complex set of interactions. The change however has already been noticed in many watercourses in France.

As such, the French Rhone *(Poirel, 2008)* has had an average temperature increase of 1 to 2°C over its entire course between 1978 and 2008. Over the middle course of the Loire river, the warming was from 1.5 to 2°C between 1977 and 2003 *(Moatar, -2006)*. Six climate scenarios with a doubling of the CO2 content *(3rd report from the IPCC)* were applied to the latter, in a model that takes the effect of air temperature and precipitation into account. Result: an average warming from 0.8 to 1.5°C is obtained for 2050, and this can go as high as +3°C for the hottest months. This result however needs to be put into perspective in light of the uncertainties concerning the scenario used and the limits of physical models.

A study *(Gosse et al, 2008)* tried to assess the share of the climate in the recent thermal changes in the Loire, by using the local « natural » temperature concept (T_{nat}, subjected only to the effects of the depth and of the local weather). It showed that 85% of the warming observed in the summer on the average Loire between 1980 and 2003 can be explained by the variations in the atmospheric conditions.

Needs expressed by stakeholders in water

Representative	Farming	Service operators	Natural park managers	Fishermen
Scientific knowledge	- Reliable scenarios on the scale of the catchment area - Prospective horizon 2020 - 2030 - Targeted research in agronomics	- Fine resolution flow predictions - Prospective horizon 2020 - 2030	- Understanding of the phenomena at work - Change in the distribution areas and in the behaviour of species	- Change in the distribution areas and in the behaviour of fish species - Impact of genetic mixing
Technical needs	- Data on the appearance of Water Attribution regulation areas (WARA) or the evolution in withdrawal allowance	- Development of alternative water resources (recovering rainwater, etc.) - Optimising the use of water for energy production	- Regular exchanges with researchers - Sustainable monitoring networks	- Harmonised legislation
Organisation	- Support tools for farmers - Advice and training		- Integration of climate change into a territorial charter	
Economic financing		- Method of financing for services and of water efficiency	- Economic and financial means	
Socio-politics	- Public decision-making tools - Public awareness	- Incorporating the value of water into GDP - Prioritising societal risks - Public awareness		

The remaining 15% include the non-modelled processes such as the upstream anthropogenic influence. Although certain French rivers are at their T_{nat} over a good part of the year (middle-course and downstream portions of the Loire, Moselle, Saône, Seine, etc.), this is less frequent for others (Garonne, Rhine and French Rhône), which requires taking the anthropogenic pressures other than the climate (planning, discharges, etc.) into consideration over a great distance. *(Gosse, Paris Seminar 2009)*.

What is the influence of climate change on river flow? Recent work *(Boé PhD thesis, 2007)* has made it possible to map the change in flows for the 2050 horizon *(see figure below).*

The results of the European project SESAME *(Ludwig, Paris Seminar 2009)* are predicting a decrease in river inflows into the Mediterranean regardless of the socio-economic scenario considered (Millennium Ecosystem Assessment[2]).

Some catchment areas, influenced for example by snow (mountain catchment areas) or by groundwater (such as the Seine watershed), require specific approaches.

As such, the GICC-Rhône project has taken interest in the Alpine basins of the Durance and of the Ubaye, with a coupled model run on six different IPCC scenarios. In every case, the results show higher winter flow rates, advanced nival floodwaters and lower summer flow rates *(Ducharne, Paris Seminar 2009).* For the Seine river, the RExHySS project (coordinated by A. Ducharne) is predicting a shift in the hydrogram around 2050 with delayed low-flow periods and floodwaters and a global decrease in flows[3]. In parallel, the annual recharge of ground water, simulated by a hydrological model according to the same scenarios, would record a substantial deficit around the year 2050.

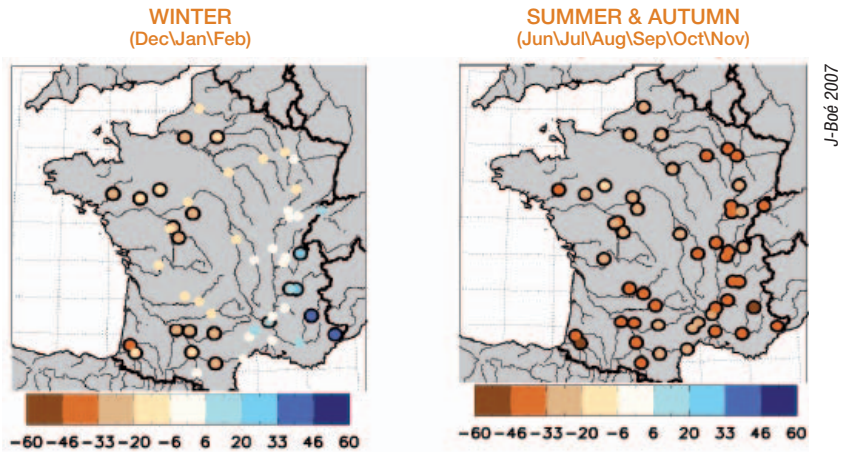
Generally, all of the recent research, although marked by the uncertainties linked to the scenarios taken into account and to the limits of the models used, show robust trends for a decrease in the low-flow periods and in water table levels.

The same applies to the reduction in the stocks of snow and ice. A dramatic drop in summer flow rates, which can go as far as interrupting the continuity in certain watercourses, is therefore expectable.

[2] http://www.maweb.org/en/index.aspx.

[3] Ducharne et al 2009 http://www.sisyphe.jussieu.fr/~agnes/rexhyss/documents_rapport.php.

Change in average flow rates



Multi-model relative change (in %), 2046/2065

Black dots with circles: agreement of 85% of the models on the sign

According to a rather pessimistic scenario of greenhouse gas emissions, marked declines in the average summer and autumn flow rates and a general net increase in the frequency and in the severity of the low-flow periods are to be expected.

Consequences for the aquatic environments

The predicted changes concerning the hydrology in France are already accompanied by modifications concerning aquatic ecosystems, reported in particular by the National French Fishing Federation *(see the box)*. As such, the survival of juvenile eels and shad has been a matter of concern for several years now. With shad, a brutal drop was recorded during the dry spell in 2003 and the French populations have since then stabilised to only a few thousand individuals each year *(Monnier, Paris Seminar 2009).*

Fishermen: first-hand witnesses

The National French Fishing Federation reports (Bernard Breton, Paris Seminar 2009) modifications observed in the distribution areas. As such, on the Seine downstream from Paris we are seeing strong development in the populations of certain fish (barb, nose fish, chub, dace), to the detriment of other species such as bream and roach. The federation also bears witness to increasingly severe low-flow periods, which requires a manual saving of fish populations on a regular basis. They share the concerns expressed about the future of species with a reduced thermal spectrum (greyling) and of migratory species, as well as on the long-term changes in exotic or invasive species.

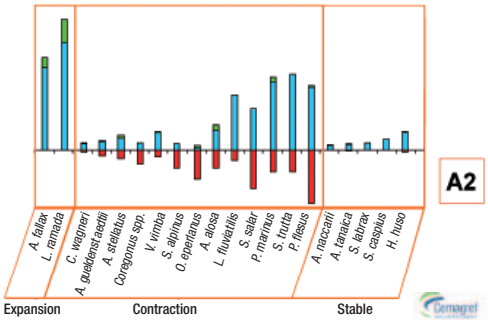
Although climate change is not the only cause of these changes, the temperature of the water is nevertheless a determining factor in the distribution of aquatic species, as shown by the marginal profiles of probability of a species' presence *(Pont, Paris Seminar 2009)*. As such, the consequences of global warming could be severe in the case of cold water species (such as Atlantic salmon, Arctic charr, common trout, etc.). The modifications in the distribution areas underwent a large-scale predictive study within the framework of the GICC programme. The change in the probabilities of presence of the various fish species throughout the entire hydrological network in France was simulated, using correlative bioclimatic models. In the case of trout, for a forced global warming of +0.54°C in the winter and +1.06°C in the summer, then +1.07°C in the winter and +2.12°C in the summer, potential losses of habitat are expected to reach respectively 16% and 33% - once again, notwithstanding uncertainties *(Pont, Paris Seminar 2009) (see figure below).*

For diadromous migratory fish, a predictive study on 22 European species *(Lassalle, 2008)* is calling for net contractions in the distribution areas around 2100 for 14 species, and a few rare gains. This study is based on the construction of distribution models, based on known areas of distribution, and according to the characteristics of the catchment areas, and then projected according to different climatic scenarios *(Rochard, Paris Seminar 2009) (see figure opposite).*

In parallel, there is a sharp acceleration in the arrival of so-called exotic species: numbering about ten species of naturalised allochtonous fish in 1950, there are now 23 in the freshwaters of France, for 46 autochtonous species *(Lévêque, Paris Seminar 2009)*. This acceleration can be an additional factor of the imbalance for aquatic environments, and certain species can proliferate. This must however be nuanced by recalling that after the glaciations (-20,000 years), the repopulating of the waters in Western Europe took place step by step starting from the Ponto-Caspian refuge. The recent arrivals in our waters of fish such as the walleye, catfish or asp can therefore be viewed as an extension of this natural mechanism.

Presence of migratory fish: projections in 2100

Using presence-absence models



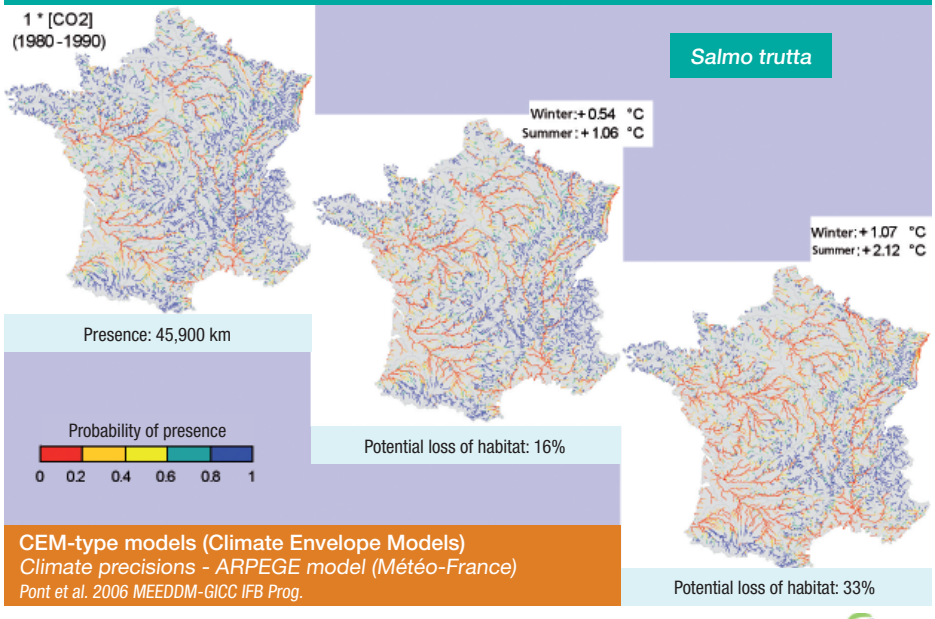
Where the species would still be present around 2100
Where the species would appear around 2100
Where the species would disappear around 2100

Lassalle et al., 2008
Climate Change Seminar 29-30 June 2009

David Monnier (North-east interregional delegation, Onema)

"The anthropogenic hydromorphological modifications of watercourses can amplify their warming under the effect of the climate: the surface of reservoirs in pond regions or the prevalence of dams are among the factors to be considered."

Loss of habitat: predictions for the entire French network (65,000 km, 8,467 sections)



Didier PONT - ONEMA Seminar – GICC programme (MEEDDM (Ministry of Ecology, Energy, Sustainable Development and the Sea)) 29-30 June 2009


Madeleine Carrouée – Onema

Moving toward taking climate change into account in public water policies

On a European scale, the European Water Framework Directive (WFD) of 23 October 2000 instituted the principles for a European water policy, getting its inspiration in particular from the French hydrographic basin approach. In particular, it calls for ensuring the non-degradation of the water quality and achieving good ecological status for all water bodies by 2015. It was transposed into French legislation by the Law of 21 April 2004, which plans among other things a revision of the guidelines for the planning and management of water bodies (SDAGE). Taking into account the impact of climate change on water and adaptation did not however occur in France until the Law on water and aquatic environments (LEMA) of 30 December 2006.

A milestone was reached with the creation, within the framework of the joint implementation strategy, of a working group in charge of producing «WFD and climate change» guidelines. It will be submitted for approval to the water directors of the European member states in November 2009[4]. This group will strive to anticipate the changes at the water body scale; understand the importance and the causes of the change on the reference sites; assess the direct and indirect influences of climate change on the pressures; specify the changes in the reference conditions and in the associated bio-indicators, and, finally, organise the monitoring of zones identified as the most vulnerable to climate change.
Moreover, in France, an inter-ministry group has been working since the beginning of 2007 on the ambitious theme «Impacts of climate change, adaptation and associated costs in France». In the perspective of the national adaptation plan of 2011, this work is based on two of the IPCC's greenhouse gas emissions scenarios and entails three prospective horizons: 2030, 2050 and 2100.

The reports from this group, which have been available since October 2009 on the website of the French national observatory on the effects of climate change (ONERC)[5], form a considerable amount of observation data, statistics, analyses and questions pertaining to decision-making on adaptation. Due to the recent character of the interest devoted to these questions, the problem of the costs of adaptation appears difficult to address today. This observation reflects the lack of a quantitative approach of the services provided by aquatic ecosystems, also reported by several managers at the seminar.

[4] The guide was adopted by the European water directors at the last meeting in Sweden on 30 November and 1 December 2009.

[5] http://www.onerc.gouv.fr.

Green and blue network: an advantage for adaptation

The concept of a green network, which came into existence in France in the 1980s, has taken a real ecological leap with the Grenelle laws, which provide for the creation of a green and blue network by the end of 2012 over the French territory. This project aims to restore and preserve ecological continuities – and especially for aquatic environment (blue network).

As such, it participates in facilitating genetic exchanges and the shift of the distribution areas of species, as well as restoring the functioning of ecosystems: a crucial vector for adaptation in the context of climate change.

Thomas Pelte
(Rhône-Mediterranean and Corsica water agency)

«Climate change reinforces the necessity in water and aquatic environments management to take a preventive rather than curative stance. This entails investing in data and knowledge, so as to enlighten deciders through prospective approaches and by putting the impacts of climate change into the general set of change factors over a territory. Moreover, balanced resource management is becoming a central concern for managers. They are striving to define the quantity objectives (regulatory minimal flows, withdrawal allowance, etc.) and achieve a good status for water and aquatic environments. As it is becoming rare, it is all the more so important that the resource be in good condition in order to satisfy the various uses."


Michel Bramard – Onema

The measures initiated bear witness however to a recent but powerful awakening as to the impacts of climate change concerning public policies. These must be supported by adapted research efforts, making it possible to increase the available knowledge.

This is the objective, in the short term, of many concrete efforts on the scale of France. As such, the purpose of the prospective workshop ADAGE (ADaptation to climate change of Farming and human-influenced Ecosystems)[6], launched in February 2009 by the French National Agency for Research, is to identify the research that is needed in order to support the adaptation of farming and of ecosystems that are managed by man, including aquatic environments, to climate change.

The Scientific Board animated by the French National Agency for Water and Aquatic Environments (ONEMA) is moreover setting up a working group on climate change, aimed at directing research to operational needs, especially based on the work presented at the Paris Seminar 2009. This work also benefitted from the GICC programme's scientific board, in preparing its 2010 call for research projects.

A consensus however seems to be emerging already: in order to encourage the resilience of the ecosystems and allow for continuity in the ecological services that they provide, the priority is to reduce as much as possible the local anthropogenic pressures that they are subjected to. Climate change must not be an excuse to delay action: on the contrary, it is a further reason to implement the objectives of the WFD.

[6] https://www1.clermont.inra.fr/adage/index.php?page=approche_systemique


Franck Cichy – Onema

Stéphane Marche
(Regional Natural Park of Camargue)

"The participation of local stakeholders is essential and it is crucial that a common diagnosis of the risks and challenges be shared. Social sciences have a pivotal role to play in this goal. As such, in Camargue, climate change has been incorporated into the 2011 – 2023 territorial project in concertation with the local stakeholders."

For more information…
www.onema.fr/seminaire-cc
www.gip-ecofor.org/gicc/

Meeting organisation:

«Climate change» representatives:

Nirmala Séon-Massin,
Research and development department,- Onema
nirmala.seon-massin@onema.fr

Daniel Martin, retired
Ministry in charge of sustainable development - Onema
maurice.imbard@developpement-durable.gouv.fr

Natacha Massu,
Gip Ecofor
natacha.massu@gip-ecofor.org

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