



**SEVENTH FRAMEWORK PROGRAMME  
THEME 6: Environment (including Climate Change)**



**Adaptive strategies to Mitigate the Impacts of Climate Change on  
European Freshwater Ecosystems**

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Dissemination Level (add X to PU, PP, RE or CO)

PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

## **ABSTRACT**

'Freshwater Management in A changing World' a two day REFRESH dissemination even took place in London 6th and 7th November, 2013. On Day 1, at the Royal College of Physicians, 120 delegates attended a REFRESH Science Symposium where a number of REFRESH scientists presented results from the project to a mixed audience drawn from both the scientific and user communities (the latter including water companies, consultancies, water managers, environmental legislators, conservation bodies, NGOs etc). Several summary presentations provided syntheses of different aspects of the work programme, focusing on streams, lakes, riparian wetlands, integrated modelling and socio-economic analyses. Each of these was followed by a more detailed presentation highlighting a key area of the work programme. On Day 2 around 70 people attended the REFRESH UK Stakeholder Meeting where the focus was on the implications for management of climate and land use impacts on freshwater ecosystems (in particular, compliance with the Water Framework Directive). This was one of a series of four regional stakeholder workshops and the target audience included water managers, those tasked with revising the River Basin management Plans and conservation bodies interested in the management of freshwater ecosystems. A key component of this meeting was that a number of stakeholder with particular interest areas were given a platform to respond to the presentation from the REFRESH consortium having seen the these in advance. The stakeholder presenters subsequently participated in a panel discussion which included questions from the audience.

One of the stakeholder panellists, Tristan Hatton-Ellis from Natural Resources Wales, in consultation with REFRESH scientists, produced this policy briefing.

## Evidence and Advice Briefing

### Climate Change and Freshwaters: Results and advice from the EU REFRESH Project

Tristan Hatton-Ellis, Marine & Freshwater Ecosystems Group

Climate change is a major and ongoing stressor on our ecosystems. Although fluctuations in climate are natural, industrialization has resulted in increasing releases of greenhouse gases such as carbon dioxide and methane which have contributed to increasingly rapid change. This is predicted to continue throughout this century, resulting in warmer temperatures and increased frequency of extreme events such as floods and droughts. These changes are likely to have significant effects on our freshwater ecosystems and the services they provide.

The EU REFRESH project (<http://www.refresh.ucl.ac.uk/>) was set up to improve our understanding of these changes and help stakeholders to manage the environment more effectively. It includes partners from across Europe in order to understand the climate gradient, and includes a mixture of literature reviews, experimental work, catchment and subcatchment-scale environmental modelling and socio-economic analysis. The project is predominantly intended to support the aims of the Water Framework Directive and to a lesser extent the Habitats Directive.

Since climate change is a human induced pressure, REFRESH has not advocated the adjustment of WFD reference conditions to take account of it. Therefore, all ecological status values relate to current reference condition.

## Key Findings of the Project

### General

- The climate change signal is not likely to become distinguishable from other pressures (e.g. land use change) over the short term (i.e. up to at least the 2027 timeframe for achieving Good Ecological Status). This means that our classification tools and monitoring methods will continue to work normally.
- If we reach our GES targets by the deadline, freshwaters will be much more resilient to future climate change.
- Over the longer term climate change is predicted to cause a general deterioration in ecological status.

- Most of the recommended mitigation measures are already well known and supportable by other drivers (e.g. biodiversity, ecosystem services, reducing nutrient pressures). In general, they agree well with the ecosystem approach.
- As well as the direct effects such as increased temperature, changes to the rainfall regime and increased storminess, there will be indirect effects associated with climate change, such as changes in crops grown, nutrient availability and land use intensification. The effect of these indirect effects on freshwater ecosystems is likely to be greater than direct effects.

## Rivers and Streams

Temperature is a key factor affecting all aspects of the ecosystem including food web structure, species composition and species abundance. Many species indicative of Good and High status require cold water with high dissolved oxygen concentrations. Climate change is causing the loss of these species.

- A key threshold for many freshwater invertebrates and fish is a water temperature of 16°C, above which food web structure starts to change and cold water species are lost.
- Experiments where flow is depleted or removed entirely show that pools in dried up rivers do not offer refuges for these sensitive species.
- Providing more riparian shading and increasing habitat diversity are very effective restoration measures. 1km of shading can lower stream water temperatures for a further 1km downstream. Shading also is disproportionately effective during droughts, when temperature reductions of up to 10°C can be achieved compared to unshaded sections.
- Streamside corridors are also important for filtering nutrients and increasing infiltration, reducing flood peaks and increasing base flows so rivers are less drought sensitive.
- Using predictive approaches to ecology such as Bayesian modelling allows more flexible and innovative decision-making. Since sensitivity to pressures varies under different conditions, different combinations of measures may be used to achieve environmental targets. For example, sensitivity to high nutrients is increased if temperatures are warm and habitat is degraded, so restoring habitats and /or planting trees along the southern bank of a river may be more cost-effective than nutrient removal.
- Past management regimes that focussed on engineering and dredging watercourses have caused ecological damage and caused larger flood peaks and lower base flows. These effects will increase with climate change.
- Although the climate signal is important, catchment land use has and will continue to have a much stronger influence on ecological quality, at least in the short term (next 20-30 years).

## Lakes

Lowland lakes will become increasingly vulnerable to nutrient pressures as the climate warms. This is because most of the processes that are encouraged by high nutrient levels are also encouraged by warm temperatures (e.g. algal blooms, successful reproduction of coarse fish).

- In Wales an important process will be extreme rainfall events, which will result in greater inwash of nutrients into the lake. A high proportion of the nutrient load may be transferred during these events.
- In Wales coarse fish have a restricted natural range, although they have been widely stocked in lowland lakes.
- Some weaknesses in the Directive in relation to lakes assessment were highlighted, especially the lack of zooplankton as a quality element and the absence of a UK fish tool.

### **Socio-economic Analysis**

Cost-benefit analysis from different rivers around Europe indicates that the economic benefits of freshwater environmental improvements outweigh the costs. This conclusion was supported with high confidence in five out of six demonstration sites.

- However, costs and benefits are not equally shared across society. Whereas most of society benefits from freshwater environmental improvements, certain sectors such as agriculture tend to bear the costs.
- Analysis demonstrated that society placed a relatively high value on environmental improvements, though this decreases during times of economic hardship.

## **Operational and Policy Implications**

### **General**

The results and recommendations from REFESH generally align with other scientific studies (e.g. Pontbren) and strongly reinforce NRW's commitment to taking a catchment-based ecosystem approach.

- Ecosystem-based measures to mitigate the effects of climate on freshwaters will have other desirable effects such as contributing to Habitats Directive, Biodiversity, flood risk and water quality targets.
- Managing catchment land use (including ensuring best practice is followed) is the most effective way to reach targets and mitigate against climate change.
- As the climate changes, land managers may seek to change their farming systems. This will be both a challenge to NRW to ensure that land use changes do not further compromise ecosystem quality, but also an opportunity to ensure that best practice is integrated into these systems from the beginning and hence that the environment is more sustainably managed.
- NRW should work with UKTAG and European partners to investigate the feasibility of a WFD zooplankton tool, as this could add insights to lake management even if it is not used for classification.

### **Water Resources and Flood Risk Management**

Recent moves towards soft engineering and catchment based solutions should be encouraged and greatly expanded, as they are likely to be cheaper, more effective and less environmentally damaging than past approaches.

- The land drainage consenting process needs to be carefully examined to ensure it is fit for purpose in a changing climate.
- Incentives such as ecosystem services payments need to be used to encourage farmers to allow land to flood and / or to revert small streams to wetlands.
- Fisheries and biodiversity projects are likely to contribute towards reducing flood risk.

### **Freshwater Biodiversity, Water Quality and Ecological Status**

- The project results provide additional impetus for reaching our environmental objectives.
- Tree cover along streams should greatly increase, especially along small streams. This can also contribute significantly towards Welsh Government's woodland targets.
- Water Framework Directive Programmes of Measures should look beyond the immediate riparian corridor.
- Lake nutrient targets, especially for shallow high alkalinity types, lowland SSSIs and Habitats Directive sites, may need tightening.

### **Fisheries Policy**

Fish stocking policy needs to take into account the increasing sensitivity of lake and river ecosystems to climate change as the climate warms.

- In order to preserve ecosystem function and salmonid stocks, fewer stocking consents should be issued for coarse fish species and introductions of coarse fish to new systems should not be consented.
- Fisheries management plans may be needed for protected sites where coarse fish are likely to be a pressure.

### **Hydropower**

Although hydropower is itself a climate mitigation measure, depleted reaches of hydropower sections tend to simulate low flows and therefore worsen the impacts of climate change on rivers. In addition, structures associated with hydropower damage river habitat, also increasing vulnerability to climate change. Therefore, hydropower policy needs to ensure that these effects are minimised.

### **Overview**

Climate change is a major stressor for freshwater ecosystems and this will increase with time. This provides a major additional incentive to improve ecosystem resilience by reaching our existing policy and legislative targets. In rivers, by taking a catchment-based ecosystem approach, there is strong evidence that it will be possible to reach these targets, manage the environment more sustainably and mitigate much of the effects of climate change. In lakes, mitigation is more difficult and may need to take the form of tighter nutrient targets. In all freshwaters, introduction of coarse fish should be tightly controlled as these species are increasingly likely to displace our valuable salmonid populations as the climate warms.