SALMON & TROUT ASSOCIATION
Game anglers for fish, people, the environment

Water Framework Directive Programme
Environment Agency
Rio House
Waterside Drive
Aztec West
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3rd April 2009

Dear Martin Booth,

Thank you for giving the Salmon & Trout Association the opportunity to respond generically to the consultation on the 'Draft River Basin Management Plans'. We would like to highlight that this is our preliminarily response to the consultation, and wish to reserve the right to update our response as further information becomes available in the consultation period.

The Salmon & Trout Association (S&TA), which was awarded charitable status due to our work concerning fish stock management and aquatic conservation, has over 80,000 individual and club members. We represent the public interest over issues relevant to the management and conservation of water, the aquatic environment and all its dependent species.

Overall, S&TA is concerned with the extremely low level of ambition in the first River Basin Management Plan (RBMP) cycle. We do not feel this demonstrates a commitment to a phased approach of achieving 'good ecological status' (GES) in all water bodies by 2027. A positive step to help demonstrate this would be to move the most effective and ambitious Scenario C measures to Scenario B, to ensure real progress is made in the cycle. As the Plans stand at present, we do not feel they form part of a credible strategy for WFD delivery over the next eighteen years.

We believe in order to achieve GES in all waterbodies by 2027, the issues of excessive water abstraction and excess fine sediment reaching our water courses must be particularly addressed. Without addressing these overarching issues, we feel little ecological benefit can be delivered through WFD. We urge the RBMPs, with the support of Government, to tackle these two fundamental issues threatening good ecological status.

Abstraction

River flows are a critical factor in the creation and maintenance of in-river morphology, riparian zones and floodplains, and create habitat for their fauna and flora. Flows help sustain water quality by flushing nutrients, containments and sediments (thus protecting spawning gravels) from the fluvial system. The magnitude, timing, frequency and duration of high and low flow events are critical to all elements of the river biota. Over-abstraction is still having a detrimental impact on our native aquatic species. Action is required now to create more natural running water systems in all our river catchments – not just those under protected status - in

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order to improve ecosystem health and provide resilience to climate change. Precautionary decisions must be made now to prevent future ecological damage, as comprehensive scientific evidence is available now to show the damage which may be caused by artificially low flows. This evidence can and should not be ignored (See *Annex A*).

The S&TA calls for:

- An urgent review of the CAMS process to: 1) to enforce the Precautionary Principle where limited data exist, and 2) take full account of the necessary dilution requirements needed to reduce the impact of consented discharges and diffuse pollution.
- The Government to quantify the effectiveness of the Restoring Sustainable Abstraction (RSA) Programme and revise on the basis of lessons learned.
- Action to make all existing licences time-limited, and to remove the requirement to provide compensation to the licence holder if the abstraction is causing environmental damage.
- Sufficient funding for monitoring, so that the impacts of abstraction can be separated from other stressors to provide clear evidence of the environmental damage caused by abstractions, and to fund research to distinguish human impacts on flow regimes from the effects of climate change.

Hydropower

In order to achieve the ecological objectives of WFD the impacts of hydropower schemes on water reaches must also be addressed. WFD must ensure sufficient water flow 1) over weirs connected with hydropower schemes so they do not impede migration corridors, and 2) to address the potential for depleted reaches of aquatic habitat between water abstraction and discharge sites.

Excess Fine Sediments

It is now accepted that excess fine sediment is an important cause of deterioration in water quality and aquatic biodiversity (See *Annex B*). Excess fine suspended sediment is a major threat to aquatic biodiversity, and a pressure which has been historically underestimated. Preventing further damage to river habitats and associated species caused by excess fine sediments requires catchment-scale, holistic management, involving the cooperation and regulation of all land users. Managing excess sediment requires sound understanding of the key sources and appropriate monitoring to gauge catchment compliance against revised and improved catchment-specific sediment targets. In order for sediment management to progress in England and Wales, better informed sediment targets, and replicable monitoring methods, are urgently required for compliance testing.

The S&TA calls for

- Urgent action by Defra to identify and use a suitable *methodology and* framework for establishing *local* sediment targets *that will enable good ecological status to be achieved in catchments* across England and Wales under WFD, taking better account of the impacts of sediment on ecology. This framework must be available at the latest for inclusion in the 2nd cycle of WFD delivery.
- Defra to monitor and quantify the efficacy of sediment mitigation options identified in the Inventory of Methods to Control Diffuse Water Pollution from Agriculture User Manual so that mitigation programmes such as the England Catchment Sensitive Farming Delivery Initiative can be accessed. If quantifiable

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improvements cannot be shown, further measures (compulsory if necessary) must be put in place, such as Water Protection zones (WPZ).

Transitional Waters

There is a greater need within the RBMPs to address issues within transitional waters, which we feel have been largely forgotten within the process. Intertidal habitats provide key feeding and nursery habitats for a wide variety of fish species, and we therefore urge for further action, research and protection for transitional waters.

Within this issue, we also feel that nitrates, the limiting nutrient in saline conditions, are being treated as somewhat inferior to phosphates, and should not become the 'forgotten' nutrient.

Monitoring and Research

We do not agree that regulatory action should only be taken if the EA is 95% confident the water body is at less than good status. We feel the balance of evidence approach would be more appropriate as the level of certainty required should be proportionate to the potential expenditure, or impacts on a specific sector. It is of paramount importance that the RBMPs establish monitoring networks to increase certainty and identify currently unknown causes of biological failure, to better inform the second cycle. Defra and the EA must also start investing now into research to better inform the second cycle of WFD. S&TA is already working with several different partners to help develop research to inform future measures for WFD delivery. These include;

- Sediment; S&TA, together with ADAS, were recently very pleased when Defra agreed to partner us on a project to assess the efficacy of bank side fencing schemes for reducing sediment pressures on salmonid spawning gravels. We are currently awaiting the results on this study, but feel post-project appraisals such as this are an important step forward in assessing how to successfully manage sediment pressures in the future.

- Brown trout; S&TA is helping to fund the sequencing of the transcriptome for the brown trout, which is currently not available. This will allow scientists for the first time to determine if and how the physiologies of brown trout are compromised as a result of exposure to chemicals. The research will have a significant effect on improving our ability to use native brown trout in high quality research studies in order to better understand the pressures they face from environmental stressors.

- Endocrine disrupting chemicals (EDCs); S&TA is a lead partner on a three year PhD project with Exeter University, which will use the new data collected from the brown trout transcriptome project, to investigate how certain EDCs affect the make-up and functioning of brown trout and to determine the relative ability of brown trout to cope with other stressors, such as rapid changes in temperature stimulating climate change, following long term exposure to EDCs. We feel EDCs are a very important pressure (See *Annex C*) which requires further action in the second cycle of WFD.

Existing stakeholder monitoring initiatives must be fully utilised in the WFD process in order to progress.

The Riverfly Partnership Anglers Monitoring Initiative

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The Anglers' Monitoring Initiative (AMI), led by the Riverfly Partnership (RP), offers particular opportunities to help determine the effectiveness of measures designed to produce good ecological status in water bodies through an established, regular monitoring programme. AMI also acts as a deterrent to incidental polluters, and produces long term data sets, both at catchment and national levels. AMI has the proven ability to specifically identify severe changes in water quality, should they occur, ensuring early remedial action by the EA. Importantly, AMI demonstrates partnership/community/stakeholder engagement to aid the identification of water quality problems, where these have not been precisely located or identified. Despite these extensive advantages, AMI is not recognised in the draft RBMPs. The EA is a member of the RP and provides significant funds towards operating the initiative. We therefore urge that the RP is included in all RBMPs. We support fully support the RP individual response to the draft RBMPs.

The RBMP Process

We feel the process is still lacking transparency, which makes it very difficult for stakeholders to understand how decisions have been made. In order to have true engagement in the consultation process, and in order to enable stakeholder co-delivery requires details of the process to be made clear.

It is clear that in most cases further information is needed about individual water bodies – including causes of failure, which measures have been considered for the water body, and why they have been considered to be either technically infeasible or disproportionately costly. Without this specific detail it is extremely difficult for us to meaningfully comment on these plans with regard to specific water bodies.

S&TA is still concerned about the lack of additional resources being made available to the Environment Agency (EA) to deliver WFD. The latest WFD related consultation on Water Protection Zones (WPZ) implies that the success of WPZ designation will depend on EA monitoring, analysis and modelling. We are concerned that with the EA's restricted resources, this will lead to limited WPZ actually being designated. The success of RBMP also requires a commitment to better resourcing for existing enforcement, ensuring that EA makes the most of its existing powers.

We support the proposal to establish a River Restoration Fund, accessible to approved charitable and voluntary bodies, as well the EA. We believe this fund, as well as providing a new source of finance for local projects, should also enable funds derived from polluter pays' cases to be directly reinvested into the affected water body.

The final RBMPs need also to illustrate how WFD will be integrated with Flood risk strategies, Water Company Water Resources Plans, and EA Strategies, such as Fisheries Action Plans, CAMS, Hydro-generation and development plans, to ensure holistic management and integrated resources. S&TA believes that it is only by coordinating all these initiatives into individual catchment based plans that full benefit can be gained and, vitally, most efficient use be made of limited resources.

Finally, we would like to stress our support for both Defra and the EA. We wish to work with both organisations at all levels, in particular through the Riverfly Partnership and in research projects to improve our understanding of issues related to WFD, and in monitoring through the AMI. Our aim is to maximise the benefits offered by WFD for the aquatic environment, all its dependent species and the general public over the coming years.

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Yours sincerely

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Annex A:

S&TA Briefing Paper; **The Impact of River and Groundwater Abstraction**

- River flows are a critical factor for the creation and maintenance of river and floodplain morphology and their associated fauna, flora and ecosystem services.
- Extensive and comprehensive evidence exists showing the damaging impacts of artificially low flow regimes on fish, invertebrates, plants and river morphology.
- Current management strategies are not enforcing the precautionary principle.
- Urgent action is required to remove damaging abstraction licences.

Water is essential for all life forms. It makes up approximately 60 to 70%, by weight of all humans and is vital for all. It is essential for photosynthesis and controls biodiversity distribution on the planet. Globally, water covers approximately 71% of the earth surface, yet 97% is saline water in the oceans. Of the 3% of freshwater, about 69% is trapped in icecaps, 30% in groundwater and only 1% is readily available in surface waters such as rivers and lakes (Gleick, 1996). The demand for freshwater to support both human and environmental needs can therefore result in conflicts.

River flow is the result of the conversion of rainfall into run-off, measured in units of volume / time and often referred to as discharge. This conversion from precipitation to run-off is hugely variable across different landscapes and climatic zones. The interaction of discharge/flow with the shape of a river channel results in variable water velocity patterns. Rivers do not have single, uniformed flows. Instead, river flows vary through time in response to changing rainfall, mediated by underlying geology: more porous rocks allow greater storage of water in aquifers (underground or groundwater reserves) and lead to smoother, more damped flow patterns through time. In-channel habitat, including seasonal structure such as submerged vegetation, can also give rise to significant variability of water velocity within a reach of river, which may be significant for maintaining habitat diversity and biodiversity including different life stages within individual species (for example fish eggs, fry, juveniles and adults).

The timing and intensity of high and low flow events can have important effects on aquatic biodiversity (Poff *et al*. 1997; Brown and Ford, 2002). Human activities, such as the direct removal of water from rivers and aquifers (abstraction), and impoundment (construction of dams for various purposes); have greatly modified the natural flow regimes of many rivers (Ward and Stanford, 1983, 1995; Poff *et al*., 1997). It is estimated, for example, that approximately 60% of the world's rivers have been diverted, and many of the rivers, including the Colorado, Murray and Yellow, no longer reach the sea (Naiman *et al*., 2002). In-channel and riparian habitat management may also simplify flow variability.

Human water management activities are threatening our freshwater systems (Giles *et al*., 1991; Wood and Petts, 1994). Abstraction (also called withdrawals in the US) is the permanent or temporary removal of water from rivers, canals, lakes, reservoirs or aquifers. Data from 2005 showed 57,757 megalitres of water per day was abstracted from surface and ground waters in England and Wales, of which approximately 52% was used in electricity production and 30% in public water supply. The remaining amount was utilised by agriculture, fish farming, mineral washing and other industries (Defra Abstraction Statistics, 2005). Although some of this water is returned to the river, it is often not in the same place as the discharge point, and the quality of returned water will often have declined.

The restoration and preservation of native stream biota requires the rehabilitation of natural flow regimes (Stanford *et al*., 1996; Poff *et al*., 1997). Yet, it is predicted that, by 2025, 40% of the world's population will be facing water poverty (Naiman *et al*., 2002). This is likely to be significantly affected by climate change. The challenge is how we balance these needs.

Potential Impacts of Water Abstraction

Hydrological variability within rivers and streams is widely recognised as one of the primary factors influencing the distribution of aquatic flora and fauna (Townsend *et al*., 1997). The biological communities living in flowing water conditions are adapted to natural flow regimes combined with natural channel morphology, for example via their body shape, metabolism and feeding behaviours (Statzner *et al*., 1988). Hence, unnaturally low flows and altered flow regimes caused by water abstraction can have damaging impacts on river systems and their associated biota (Wright and Berrie, 1987; Giles *et al*., 1991; Wood and Petts, 1994: McKay and King, 2006).

Over-abstraction of river systems can cause:

- *Hydrological and hydraulic changes.* Velocity is a significant factor affecting the distribution and assemblage of stream invertebrates (Statzner *et al*., 1988), by influencing their respiration, feeding biology and behavioural characteristics (Petts, 2008). A reduction in discharge alters the width, depths, velocity patterns and shear stresses within the river channel (Armitage and Petts, 1992). This can modify the distribution and availability of in-stream habitat, which can have detrimental effects on invertebrates and fish populations (Wood *et al*., 1999). Altered flow regimes have also been linked to invasion of non-native species (Baltz and Moyle, 1993; Brown and Moyle, 1997: Brown and Ford, 2002).
- *Temperature changes.* Artificially low flows may increase water temperatures by increasing the area of air-water interface per unit volume of water (Webb *et al*., 2003). Increases in water temperature will affect the river fauna and flora (Richardson *et al*., 1994). Temperature has a direct effect on metabolic processes, while increased temperature raises biochemical reaction rates and can cause wide fluctuations in dissolved oxygen levels. Temperatures over 22°C will have serious negative effects on salmonids (Elliott, 1994), with rising temperatures imposing increasing stress up to this level.
- *Water quality changes*. An artificial reduction in flow reduces dilution of effluent which is returned to rivers (Armitage and Petts, 1992), increasing the concentration of pollutants already within and newly entering the watercourse.
- *Sediment deposition.* Periodic high flows (spates or freshets) are important for maintaining in-stream habitats by flushing fine sediment out of the system (Reiser *et al*., 1989; Old and Acreman 2006). The highest flows also play a role in maintaining channel carrying capacity and structure. Similarly, artificially low flows can result in fine sediment being deposited in the channel. This can clog interstitial spaces in the substrate, thus reducing available fish spawning habitat (Carling and McCahon, 1987; Crisp, 1989) and invertebrate refugia (Wood and Armitage, 1999; Milan *et al*., 2000).
- *Shifts in invertebrate assemblages* (Armitage, *1987*)*.* For example, reduced abundance of filter-feeding invertebrates and a reduction of stoneflies and heptageniid mayflies, which favour clean stones and well-oxygenated water (Extence *et al*., 1999), and an increase in taxa associated with low velocity

including chironomids and molluscs (Jowett and Duncan, 1990). Some macroinvertebrates are able to survive short episodes of low flow, providing adequate refugia are available. However, prolonged artificially low flow conditions can lead to invertebrate mortality (Armitage and Petts, 1992) or replacement by more tolerant groups of invertebrate. The Salmon and Trout Association (S&TA) River Fly Life Abundance survey data from 2002 correlates low flow with decreasing fly abundance (Hayes, 2007).

- *Reduced growth of aquatic flora* (Franklin *et al*., 2008; Wilby *et al.*, 1998; Herne and Armitage, *1997).* Low flows can inhibit the growth of certain aquatic plants, such as *Ranunculus*. Reduced *Ranunculus* growth can have significant knock-on effects for invertebrates, fish and river structure.
- *Change in fish communities*, with species requiring higher oxygen concentrations (frequently salmonids) being replaced by more generalist species.
- *Disruption to migratory passages.* Low flows can impede the migration of salmonids and other migratory fishes and limit the distribution of spawning fish (Strevens, 1999; Environmental Agency, 2004; Old and Acreman, 2006). The upper reaches of river catchments are often very important for juvenile salmonid production; however, these areas may not be accessible to upstream migrating fish at low flows.
- *Reduced connectivity with floodplains and riparian margins.* Functioning floodplains have a major influence on in-channel processes, for example by providing inputs of nutrients and refugia and breeding habitat, essential to the life cycles of many riverine species (Bunn and Arthington, 2002).
- *Reduced fisheries production* which may jeopardise angling participation, resulting in the loss of social and economic benefits to local communities (Willis and Garrod, 1999) and onward investment in river management and conservation projects.

Measuring the Impact

These mechanisms of impact are reasonably well known and the science of Environmental Flows is developing rapidly (Acreman and Dunbar, 2004). However, it can still be very difficult to precisely diagnose the ecological impacts of low flows in any particular situation. There are several reasons for this, but particularly important are:

- The availability of sufficient hydrological data, both on historical flows and current water use extractions. (For many abstractions, only licensed volumes are known);
- The availability of sufficient ecological data, as variability in natural systems is often high even without human impacts. Furthermore, introductions and stocking can confound hydroecological relationships;
- The complexity of the environmental interrelationships and the presence of multiple stressors such as historical channel modification and water quality impacts. Rivers are commonly subject to, and will respond to and integrate, multiple stresses. Determining the impacts arising from an individual stressor (such as abstraction) alone can be difficult, and may also overlook synergistic effects (such as the impacts of pollution exacerbated by declining dilution).
- Where there is a requirement to seek proof of impact beyond all reasonable doubt before taking action (a common condition of many strands of statute law) runs the risk that protection will only be provided when the damage to the environment is already too serious, subject to strong vested

interests and possibly beyond redemption. Rejection of all evidence of impact with less than very high levels of statistical significance is inappropriate.

Some of the most acute problems with over-abstraction have been found in chalk stream systems, where naturally up to 95% of the flow is derived from underground aquifers (Owen, 1991). The catchments of chalk streams provide underground reservoirs of generally high quality groundwater which can be abstracted for public supply. Under natural conditions, classic chalk rivers have buffered flows due to groundwater interactions (Berrie, 1992), creating one of the most productive riverine habitats, particularly for salmonid fisheries ((Mann, 1971; Mantle and Mantle, 1992; Bowes *et al*., 2005). Low flow periods, which are artificially lower for longer, can change the physical and biological attributes of these waterbodies. Abstraction for public water supply and industry has dramatically reduced the flow in many chalk streams and, in some cases, completely dried up sections of these important rivers, particularly during dry summers when public demand is at its highest (National Rivers Authority, 1993). This also has an economic impact to local communities, resulting from the inability to fish, enjoy river views due to encroaching vegetation or undergo other recreational activities (Willis and Garrod, 1999).

Current Management

The Environmental Agency is responsible for regulating water systems and abstraction licenses in England and Wales. The duties of the Agency and its predecessor bodies date back to the Water Resources Act 1963, which required the regulation of water abstraction to balance the needs of water users with those of the environment. Historically, this was undertaken and updated on a piecemeal basis, informed by local precedents and "rules of thumb". An example of this is the use of "hands off flows", when abstraction had to cease or be significantly reduced if a specific low flow criteria was reached.

In May 1997, the Government held a Water Summit involving a range of key stakeholders to review the Water Resources Act abstraction licensing system. This resulted in the 1999 publication of 'Taking Water Responsibly', which announced changes to the water abstraction licensing system in England and Wales. The legislative changes were realised in the Water Act 2003, which included (Defra, 2008):

- Time limits for all new abstraction licences;
- The facility to revoke abstraction licences causing serious environmental damage without compensation;
- Greater flexibility to raise or lower licensing thresholds;
- Deregulation of small and environmentally-insignificant abstractions;
- Licensing extended to abstractors of significant quantities presently outside the licensing system; and
- Conversion of water company drought plans and water resource management plans to statutory status.

Non-legislative changes include;

Catchment Abstraction Management Strategies (CAMS)

CAMS were developed as a response to the requirements of 'Taking Water Responsibly' and to provide a consistent mechanism for managing water use through catchment planning and licensing. The Resource Assessment and Management (RAM) framework within CAMS provides information on water availability at a catchment scale (Dunbar *et al*., 2004). This assessment is based on the requirements of river ecosystems and other water users. CAMS were designed to provide the information necessary for the review of existing time-limited licences and for the assessment of new time-limited licenses.

The first formal cycle of CAMS commenced in 2001 and concluded in March 2008, after which there was a review of the first cycle of the CAMS process: the *Managing Water Abstraction Interim update* (Environment Agency, 2008). With the implementation of the Water Framework Directive, CAMS will no longer be produced on their own cyclical programme, but will feed into the WFD River Basin Planning process. Research undertaken to set abstraction limits to achieve 'Good Ecological Status' under WFD (Acreman *et al*., 2008a) has now been included within revisions to the RAM framework. Appropriate managed flow releases from reservoirs have been investigated (Acreman *et al*., 2008b) but it has proved difficult to define simple rules, as each reservoir and river system is unique. Site-specific studies are usually required.

Restoring Sustainable Abstraction (RSA) Programme

The RSA Programme was set up by the Environmental Agency in 1999 to identify sites which may be at risk from abstraction, and to prioritise how to resolve the conflicts in these areas. These included sites classified under the European Habitats Directive [and Birds] and designated as Sites of Specific Scientific Interest (SSSI). The RSA programme is a successor to the Alleviation of Low Flows (ALF) programme established during the 1990s to target 40 rivers believed to be suffering most because of artificially low flows. An ongoing review is taking place (Environment Agency, 2008) to identify environmental damage still occurring as a result of abstraction, focusing on sites designated under the Habitats and Birds Directives.

Since April 2004, all new abstraction licenses must incorporate a time limit, specifying start and expiry dates. The Environment Agency has the power, under existing legalisation, to vary or revoke abstraction licenses causing environmental damage. However, in many circumstances, such as permanent licences, this requires compensation to be paid to the licence holder. With most existing abstraction licenses being permanent (Environment Agency, 2005), the need for compensation is preventing progress to remove the damaging abstractions. For example, eight years of consultation on how to alleviate over-abstraction of the Rivers Brennand and Whitendale in the upper Ribble catchment, which results in important salmonid spawning and nursery areas being reduced to pools in the drier months, has ended in no changes to the current abstraction licences because no funds are available to compensate water companies for taking less water. Serious equity issues are raised by the support of private benefits (on the basis of over-abstraction) through costs incurred by the wider public (people's enjoyment of aquatic ecosystems and the many societal benefits they provide).

There is also concern over the effectiveness of the CAMS process in aquifer-fed catchments such as the Bourne Rivulet, where the Environment Agency is still allowing high levels of winter abstraction in the Test and Itchen CAMS. This is deemed acceptable because of high seasonal rainfall, but continuing abstraction during these winter months is jeopardising replenishment of the aquifer, with potential to impact the ecology of the Bourne Rivulet, especially in the spring and summer.

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Despite the conservation of aquatic biodiversity and ecosystem health being embedded in current policies, there seems to be little political will to prioritise it. Environmental protection tends to favour small-scale site protection or rehabilitation, poorly connected if at all to the ecological health of the wider catchment. However, structural river restoration will provide very little long-lasting environmental benefit if other key stressors on the system are not removed, including the integrity of the catchment as a whole. The conservation of running water systems requires the restoration of the underlying processes that support the biota. Restoring natural flow regimes is fundamental to improving aquatic habitats, and increasing biodiversity. Restoring flow regimes should not be considered in isolation, but linked with water quality and morphology targets. Restoring flow regimes should also be considered alongside climate change, in order the help manage anthropogenic demand and improve environmental resilience. This is essential not merely for the health of salmonid populations and ecosystems, but for the many and diverse benefits that people derive from catchments.

Action Required

The S&TA believes that WFD compliance will be compromised if further action is not taken to address damaging abstractions through altering their licenses. This could lead to the EU initiating legal infraction proceedings against the UK Government.

The S&TA calls for:

- An urgent review of the CAMS process to: 1) make allowances for inadequacies in historical flow data in assessing future flows and water availability; 2) take full account of the necessary dilution requirements needed to reduce the impact of consented discharges and diffuse pollution; and 3) to enforce the Precautionary Principle where limited data exist.
- The Government to quantify the effectiveness of the Restoring Sustainable Abstraction (RSA) Programme and revise on the basis of lessons learned.
- Action to make all existing licences time-limited, and to remove the requirement to provide compensation to the licence holder if the abstraction is causing environmental damage.
- Sufficient funding for monitoring, so that the impacts of abstraction can be separated from other stressors to provide clear evidence of the environmental damage caused by abstractions, and to fund research to distinguish human impacts on flow regimes from the effects of climate change.

Conclusions

River flows are a critical factor in the creation and maintenance of in-river morphology, riparian zones and floodplains, and create habitat for their fauna and flora. Flows help sustain water quality by flushing nutrients, containments and sediments (thus protecting spawning gravels) from the fluvial system. The magnitude, timing, frequency and duration of high and low flow events are critical to all elements of the river biota. Increasing human populations and escalating demand on freshwater resources, coupled with mounting concerns about environmental change, raise the need to protect, maintain and restore natural riverine flows. Over-abstraction can be destructive to resident river flora and fauna, including organisms with migratory lifecycles. It can also degrade the many benefits the people derive from river ecosystems.

Action is required now to create more natural running water systems in order to improve ecosystem health and provide resilience to climate change. Precautionary decisions must be made now to prevent future ecological damage, as comprehensive scientific evidence is available now to show the damage which may be caused by artificially low flow. This evidence can and should not be ignored.

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Annex B
S&TA Briefing Paper: The Effects of Excess Fine Sediment in Rivers.

- Excess fine sediment, derived from anthropogenic activities, is a very important cause of deterioration in water and habitat quality and aquatic biodiversity.
- The Water Framework Directive objective of 'good ecological status' cannot be achieved without addressing this pressure.
- Urgent action is required by Defra to identify and use a suitable framework for establishing revised sediment targets for catchment compliance across England and Wales.

Sediment loadings delivered to watercourses originate from a number of upstream primary and secondary sediment sources, including cultivated fields and bank erosion (Collins *et al*., 1997a,b,c). Erosion processes and sediment delivery form an integral part of aquatic systems, influencing their geomorphology, habitat distribution and water quality. Aquatic communities are adapted, and hence able to cope with, natural 'baseline' sediment inputs. Indeed, healthy freshwater ecosystems require sediment inputs to maintain habitat and nutrient fluxes.

However, at a global scale, suspended solid (SS) concentrations in many rivers have dramatically changed in recent years (Walling, 2006). Existing evidence suggests that natural sediment loadings have been substantially exceeded in many catchments in the UK, particularly since World War II (Evans, 2006).

The main anthropogenic activities increasing sediment supply to watercourses include:

- Changes in agricultural practices; for example, increased areas of arable cultivation, leading to greater areas of bare exposed soil susceptible to erosion by winter rainfall (Greig, *et al*., 2005), and mechanised farm practises which compact the soil and increase runoff and soil erosion (McMellin *et al*., 2002: Bilotta, *et al*., 2007). For instance, sediment fingerprinting research indicated 61% of the sediment load of the River Tweed in Scotland was derived from arable and pasture topsoils (Owen *et al*., 2000).
- Intensification of agricultural practices; for example, increasing stock density (Heaney *et al*., 2001) and multiple cropping on arable land.
- Increased bank erosion due to loss of natural hydrology.

Sediment in the water column can be measured in three main ways 1) turbidity; the optical (light scattering) property of the water, 2) total SS; direct measurement of particulate weight present in a volume of water and 3) water clarity; also an optical property of water. Deposited sediment can also be measured using sediment traps. Despite this, there is a distinct lack of SS monitoring data from around the UK, mainly due to cost implications but also a historic perception that other water quality parameters were of greater importance.

Effects of Excess Sediment on Fish and Aquatic Ecosystems
Excessive fine sediment, in suspension or deposited, can have damaging impacts on all life stages of fish, particularly salmonids. This has been made worse for salmonids by a shift in the timings of arable cultivation in the UK, from spring to autumn sown cereals, which now coincides with their egg incubation times (Collins and Walling, 2007; Collins *et al.,* 2008).

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The effect on ecosystems will, however, depend on several key factors, including: the concentration of fine sediment in suspension; the duration of exposure to fine sediment; and the sediment chemical composition and particle size (Bilotta and Brazier, 2008). This makes determining the impact of SS on fauna and flora difficult to generalise, quantify and compare. However, generic consequences of increased SS concentrations in the water column for fish can include:

Physiological effects (stressors on physical health)

- Mortality

The relationship between SS concentration and direct mortality is highly complex. The effect of sediment on fish will vary depending on life stage, time of year, size of fish, composition of sediment and the availability of off-channel habitat (Bash *et al*., 2001), as well as the exposure magnitude, duration and frequency (Servizi and Martens, 1992). For example, in a review of published critical SS concentration thresholds based on dose-response experiments examining impaired growth, reduced feeding and mortality, Berry *et al*. (2003) reported ranges of 27-80,000 mg l^{-1} for mollusca and 4-330,000 mg l^{-1} for various fish species. Such ranges in the severity of effect of SS concentration are a function of associated stressors including sediment particle size, species life history stage, temperature, the presence of sediment-associated contaminants and sediment load duration (Swietlik *et al*., 2003). Due to the complex interaction of such stressors, it is unlikely that a comprehensive list of genus-based critical SS concentration targets can be developed in the short-term (USEPA, 2003).

- Reduced reproduction and growth through the degradation of spawning habitat/redds and smothering of eggs and yolk-sac fry

Salmonid eggs (as well as many cyprinid fish and lamprey eggs) require a well-oxygenated environment during the embryonic development stage, so eggs are laid in permeable gravel beds with interstitial pore spaces which allow the passage of oxygenated water. Excess fine sediment in the water, when deposited, can clog these interstitial pores, obstructing the circulation of oxygenated water, which reduces egg survival (Carling, 1984; Magee *et al*., 1996). Salmonid egg mortality of between 98-100% has been recorded within spawning gravels experiencing high siltation loads (Turnpenny and Williams, 1980). The effect is particularly damaging when sediments contain a high organic component, as its subsequent decomposition also reduces oxygen from the water (Rubin, 1995). Excess deposited sediment can also reduce interstitial and hyporheic (region beneath streambed) flow velocities (Chapman, 1988; Acornley and Sear, 1999). This decreases the natural flushing process, which removes the harmful metabolic waste excreted by the embryos (Burkhalter and Kaya, 1975). SS can also be damaging to fish species, such as perch and roach, depositing eggs on macrophytes, as silt particles can adhere to the eggs and reduce oxygen and carbon dioxide exchange (Stuart, 1953).

Fine sediment can also exert sub-lethal effects on fish fry including: delaying emergence by trapping fry in interstitial pores (Phillips *et al*., 1975); and premature hatching of smaller and poorer quality fry, due to exposure to low dissolved oxygen concentrations (Alderdice *et al*., 1958: Mason, 1969). Researchers have found a relationship between fine sediment (less than 0.850 mm) and fry survival, with decreasing survival of up to 3.4% for each 1% increase in fine sediment (Cederholm *et al*., 1981).

- Gill irritation/trauma

Fish gills are delicate and easily damaged by abrasive sediment particles. Fish species have been found with increasing levels of deformities, eroded fins, lesions, tumours, gill flaring and 'coughing', all related to increasing SS in the water column (Berg, 1982; Schleiger, 2000).

- Alter blood physiology

Research has show increases in plasma glucose (Servizi and Martens, 1987), blood sugar levels (Servizi and Martens, 1992) and plasma cortisol (Redding *et al*., 1987) in fish species exposed to fine sediment. These are all indicators of stress, and can impact physiological systems, reduce growth and decrease immunological competence against other stressors, such as disease. Stress to salmonids can also affect the smoltication process, leading to decreased osmoregulatory ability, impaired migrations and a reduction in early marine survival (Wedemeyer and McLeay, 1981).

<u>Behavioural (changes in activity)</u>

- Impede movement

Migrating fish species, such as salmonids, are commonly known to migrate through high SS concentrations in estuaries. However, like other containments, exposure time is a key element in the impact of SS as well as concentration (Newcombe and MacDonald, 1991). This means high exposure rates to sediment loads can halt fish migration, particularly upstream. Fish are known to exhibit avoidance reactions and move away from the vicinity of adverse sediment conditions, if refuge conditions are present (Sigler *et al*., 1984; Bash *et al*., 2001).

- Alters foraging behaviour and reduces territoriality

Turbidity can reduce feeding rates, and affect prey selection and prey abundance. This is particularly significant for visual feeders, such as salmonids, where SS can reduce the effectiveness of them obtaining food (Berg, 1982). However, research also suggests the turbid-clear water interface may sometimes assist feeding, by offering concealment and protection within the turbid water (Scullion and Edwards, 1980).

Pulses of turbid water have also been shown to breakdown normal social organisation and territoriality, which can decrease feeding rates and may affect overall growth rates (Berg, 1982).

<u>Habitat effects (changes to spawning and nursery habitat):</u>

- Reduction in available spawning habitat

Excess fine sediment, when deposited within rivers, can clog potential spawning gravels, therefore reducing suitable spawning habitat.

- Reduced river bed habitat and shelter for fish fry and parr, leading to lower fry and parr density

The deposition of sediment on the river bed changes and degrades physical habitat for bottom dwelling fish and fry (Lisle and Lewis, 1992). The sediment fills in the spaces between substrate particles, creating a smoother riverbed (Diplas and Parker, 1992). This, not only reduces the available habitat complexity and availability, but also increases water velocity and the need for shelter from the water current (Richardson and Jowett, 2002).

Sedimentation also decreases habitat connectivity (Cohen, 1995) and heterogeneity (Boles, 1981).

Tropic effects:

- Changes in invertebrate communities in response to high and persistent sediment loads (which are well documented) can change food sources, particularly for juvenile salmonids

- Negatively impact invertebrate assemblages and abundances

This occurs through; scour damage, burial of heavy or immobile species, the clogging of gills or feeding structures, and a reduction in interstitial habitat and primary production (Newcombe and MacDonald, 1991).

Benthic invertebrate drift rates have shown to increase in SS concentration as little as 8mg/l (Rosenberg and Wiens, 1978) and population size has been shown to reduce by 77% when exposed to 62 mg/l of SS for 100 days (Wagener and LaPerriere, 1985). A 40% reduction in stream invertebrate species diversity has been recorded in response to prolonged SS concentrations of 133 mg/l over the period of a year (Nuttall and Bielby, 1973)

- Sedimentation can affect aquatic biota at both a population and community level, and result in homogenization; the replacement of regionally distinct faunas with a few invasive and disturbance tolerant species (Walters *et al*., 2003). This could be a serious threat to biodiversity, both now and in the future, by reducing species' resilience to climate change. Sedimentation can also increase the susceptibility of invasive species such as Canadian pondweed and the common carp, which potentially have major disruptive effects on aquatic ecosystems.

In addition to there direct impacts upon fish, suspended sediments, and the consequences of their fall-out in aquatic ecosystems also have a wide range of ecosystem-scale effects which, in turn, have impacts on fish populations. There include:

Transfer of pollutants:

- Fine sediment exerts an important control on the transfer and fate of a wide range of agricultural and industrial contaminants (Warren *et al*., 2003; Collins *et al*., 2005). Sediment therefore represents an important vector for contaminants such as phosphorus (Haygarth *et al*, 2005); heavy metals (Neal *et al*., 1999) and organic pollutants like sheep dip substances (Long *et al*., 1998). These associated pollutants can alter species assemblages by poisoning the water system, and accelerating eutrophication. The capacity of fine sediment to bind contaminants can also lead to an increase in the resident times of the pollutants in aquatic systems (Foster and Charlesworth, 1996), thereby increasing exposure times and the opportunity for pollutant remobilisation.

Reduced primary productivity:

- Suspended solids reduce water clarity and increase turbidity, exerting a negative effect upon primary production. Research suggests in subarctic Alaskan steams concentrations of SS as little as 8mg/l can reduce primary production by 3-13% (Lloyd, 1987), and above 2100 mg/l no primary production can occur (Van Nieuwenhuyse and LaPerriere, 1986).

Depressed oxygen levels in the water:

- Suspended solids can contribute towards raising the Biological Oxygen Demand (BOD; Petts *et al*., 2002), and hence lowered oxygen levels potentially to stressful or lethal levels for vulnerable species and life stages.

Costs of river management:

- Sedimentation increases dredging costs needed to remove sediment for navigation and flood defence purposes (Bates and Hooper, 1997), reduce reservoir capacity (White *et al*., 1996), and increase water treatment costs.

In summary, high concentrations of SS can also negatively impact fish assemblages by reducing; 1) the diversity of sensitive species, 2) overall population abundance, 3) the proportion of lithophilic (associated with a stony substrate) spawners, and 4) the proportion of omnivores (generalist feeders which consume both plant and animal matter) within the overall population. All of these factors can have impacts even at sublethal concentrations of suspended solids, cumulatively reducing the resilience of fish species and hence their resistance to environmental stresses including other forms of pollution, predators, disease and over-exploitation.

Current Management

The current UK standard for SS concentration is set by the EU Freshwater Fish Directive (FFD). The FFD stipulates that SS concentrations should not exceed a guideline annual mean of 25mg/l. This is only a 'guideline' standard which should be achieved where possible. No 'imperative' standards (standards which must be met) currently exist for SS in the UK. In August 2006, UKTAG made the decision to continue running with the guideline threshold in the FFD until this Directive is repealed in 2013.

For the purpose of sediment policy support, a recent modelling study investigated catchment compliance across England and Wales using the FFD guideline standard (Collins and Anthony, 2008a). The study provided the first national scale assessment of sediment sources for England and Wales under current environmental conditions (year 2000), suggesting that source contributions are in the order: agricultural sector (1929 kt = 76%) eroding channel banks (394 kt = 15%), diffuse urban sources (147 kt = 6%) and point source

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discharges (76 kt = 3%). A structured regression model was used to convert the predicted total sediment loadings into time-averaged suspended sediment concentrations at national scale. The findings suggested that approximately 83% of the total catchment area of England and Wales appears to require no further reductions in sediment loss to rivers from diffuse agricultural sources for the purpose of meeting 'Good Ecological Status' (GES) as defined by the Water Framework Directive (WFD). It is important to note, however, that the use of the FFD sediment threshold failed to identify catchments across England and Wales where the detrimental impacts of sediment are widely reported e.g. the chalk catchments of southern and eastern England. Chalk catchments are particularly vulnerable to sedimentation due to the lack of any significant flushing effect owing to their baseflow-dominated hydrology.

Collins *et al.* (2007) used the structured modelling methodology to predict the impact of projected structural evolution in agriculture (land use change) and the uptake of sediment mitigation methods due to programmes like the England Catchment Sensitive Farming Delivery Initiative (ECSFDI) on annual mean suspended sediment concentrations across England and Wales by 2015. This work suggested that structural and mitigation work could potentially reduce the national sediment loss from the agricultural sector by 9% by 2015.

There are, however, serious concerns regarding the use of a single global threshold concentration for suspended sediment. This is because of the large variability of effects caused by SS, the diversity of habitat and conditions within catchments, the existence of sub-threshold effects on both fish and their supporting ecosystems, and the failure of an annual mean to capture the highly episodic nature of sediment pressures which are focused during flood events.

Given the problems associated with using a global annual average sediment threshold, alternative sediment targets were recently proposed for England and Wales. The alternative sediment target scheme (Cooper *et al*., 2008) is based on nationally extrapolated suspended sediment yields and uses the lower quartile of the measured ranges for catchment types to represent potential targets and the upper quartiles as critical thresholds. These tentative targets are designed to be used in a nested manner and are intended to be used to help inform the identification of local thresholds. Collins and Anthony (2008b) recently used a structured modelling framework taking explicit account of sediment sources derived from different societal sectors to assess catchment compliance at national scale across England and Wales using these alternative sediment targets. This work successfully identified catchments where negative sediment impacts on fish are being reported.

However, the use of sediment yields to represent sediment targets is undermined by a number of problems. Since suspended sediment fluxes represent the aggregate of sediment delivery, their utility is best found in helping to define overall catchment response to environmental pressures as opposed to ecological impacts. Reliable coupling of sediment loadings to ecological impacts requires understanding of additional metrics such as sediment deposition and flushing and sediment grain size characteristics.

It important to highlight that all modelling data is based by common consensus on inadequate knowledge of all pathways and adequate monitoring data assumptions and therefore should not be used in isolation, but as part of an integrated modelling and monitoring approach, to help mange uncertainty and ground truth results. Anecdotal evidence from stakeholders on the impacts of fine sediments upon ecosystem can also provide important insight, and therefore should not be ignored.

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Action Required
The evidence here highlights the threats our aquatic fauna and flora face because of excess fine sediment pressures. The WFD objective of GES cannot be achieved without addressing this important pressure. Given the problems associated with using the FFD threshold or the alternative sediment yield based target scheme, urgent action is required to identify more meaningful revised sediment targets for England and Wales. Revised targets must take more explicit account of the impacts of sediment on aquatic ecology and should be developed in a catchment-specific manner (Collins and McGonigle, 2008). A generic measurement of SS is not reliable; therefore we feel SS management should focus on the river basin scale to ensure source control, taking more account of observed impacts rather than modelled inputs.

The S&TA calls for:

- Urgent action by Defra to identify and use a suitable framework for establishing revised sediment targets for catchment compliance across England and Wales, taking better account of the impacts of sediment on ecology. This requires a combined modelling and monitoring approach, for which proportionate investment is required to redress historic oversight of the importance of suspended sediment.
- Defra to monitor and quantify the efficacy of sediment mitigation options identified in the Inventory of Methods to Control Diffuse Water Pollution from Agriculture (DWPA) User Manual (Cuttle *et al*., 2007) so that mitigation programmes like ECSFDI can be accessed. If quantifiable improvements cannot be shown, further measures (compulsory if necessary) must be put in place, such as water protection zones (WPZ).

Conclusions
Natural sediment pressures within river systems vary dramatically depending on catchment topography, geology, vegetation, local climate and land use (Hicks and Griffiths, 1992). It is now accepted that excess sediment is a very important cause of deterioration in water quality and aquatic biodiversity (Collins *et al*., 2008).

The WFD requires the management of watercourses and their catchments to support high quality and representative biological communities (i.e. GES). In order to achieve this, all major threats to these communities must be monitored and managed effectively as part of a WFD ‘Programme of Measures’. Excess fine suspended sediment is a major threat that has been historically underestimated, and therefore must be managed within a framework addressing the multiple pressures influencing water quality and ecological status.

Preventing further damage to river habitats and associated species requires catchment-scale, holistic management, involving the cooperation and regulation of all land users. Managing excess SS requires prevention and restoration measures, all of which require sound understanding of the key sources (Collins and Walling, 2004) and appropriate monitoring to gauge catchment compliance against revised and improved catchment-specific sediment targets. In order for sediment management to progress in England and Wales, better informed sediment targets, and replicable monitoring methods are urgently required for compliance testing.

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Annex C
S&TA Briefing Paper: The Effect of Endocrine Disruptors on Fish

- Research shows Endocrine Disrupting Chemicals (EDCs) are causing abnormalities in sexual development, thus reducing fecundity in many plants and animals, including fish species.
- Current management strategies are not enforcing the precautionary principle.
- Urgent action is required to reduce EDCs reaching and bioaccumulating in aquatic ecosystems.

Endocrine Disrupting Chemicals (EDCs) are substances which interfere with endocrine systems and hormonal activities. EDC are threatening biodiversity on a large scale, with currently over 200 plant and animal species known or suspected to be affected by EDCs (Miyamoto and Burger, 2003). Aquatic organisms are at enormous risk from EDCs, which enter watercourses through both diffuse and point source pollution. There is a wide range of known EDCs, these include natural (e.g. oestrogen) and synthetic hormones (such as ethynylestradiol; found in contraceptive pills), industrial chemicals (such as alkylphenols, bisphenol A and ethoxylates), pesticides (tributyl tin. TBT), fungicides and herbicides (including atrazine, diazinon and permethrin) and some chemicals in domestic products (including some surfactants).

The Salmon &Trout Association (S&TA) believes that the precautionary principle should be implemented now to reduce the quantity of these substances reaching our watercourses, before potentially serious and irreversible damage becomes evident.

Impacts
EDCs have been shown to cause most damage to fish at larval or development stages, by causing abnormalities in sexual development, behaviour and fertility (Gross-Sorokin *et al*., 2006). Early life stages of other organisms are also generally more vulnerable than adults. The adverse alterations reported in the sexual development of exposed fish include:

- Gonadal intersex (gonads contain eggs and sperm developing simultaneously);
- Feminisation of reproductive ducts;
- Reduced gonad (testis and ovary) growth rate and size;
- Reduced gamete quality; and
- Increased levels of vitellogenin (egg-yolk protein), indicative of exposure to feminizing chemicals.

The molecular pathways causing these effects are poorly understood, in all probability diverse, and the wide range of effects caused by EDC exposure makes them difficult to assess and monitor. As well as causing intersex and feminisation, EDCs have been shown to affect courtship and territorial behaviour in three-spined stickleback (*Gasterosteus aculeatus*: Bell, 2001). Research on Atlantic salmon (*Salmo salar*) has also shown oestrogenic compounds can significantly inhibit the development of smolt physiology (Madsen *et al*., 1997). EDC can also differ in the species they affect; for example, steroidal oestrogens can have a potent effect on fish but little endocrine effect on invertebrates such as copepods (Sumpter and Johnson, 2005). Inter-species susceptibilities are poorly understood, with potential for significant vulnerability in species important for ecosystem stability and functioning.

Research from the UK clearly shows an association between the incidence of fish feminisation and their exposure to effluent discharges (Centre for Ecology and Hydrology (CEH), 2002; Jobling *et al*., 1998). Data from fish populations also correlates the severity of intersex with the proportion of oestrogenic effluent (Jobling *et al*., 2006). However, diffuse urban and rural pollution is also known to contribute to endocrine-disrupting effects.

Research on wild roach (*Rutilus rutilus*) in the UK indicates that more severely feminized fish are found in the older year classes, suggesting the condition is progressive (Environment Agency, 2004). These delayed effects mean exposure during early life stages could result in irreversible changes which remain undetected until the offspring reaches maturity (Lyons, 2006: Jobling *et al*., 2006). Other studies indicate that some EDCs have the ability to bioaccumulate and can be passed on to offspring, resulting in transgenerational effects. For example, laboratory experiments on the Pacific oyster (*Crassostrea gigas*) have shown that exposure to the industrial chemical nonylphenol results in poor survival rates in subsequent generations (Nice *et al*., 2003).

The occurrence of intersex individuals in fish populations is affecting their reproductive success and possibly their population stability. Studies assessing gamete quality of wild intersex roach have found moderately to severely feminised male fish have reduced sperm quality and quantity (on average 50% less), and were less able to release their milt compared with 'normal' males (Jobling *et al*., 2002). Elevated levels of vitellogenin in male fish have also been shown to disrupt kidney function (Herman and Kincaid, 1988), and result in calcium loss and lipid diversion from the scales, which can make the fish more susceptible to disease (Carragher and Sumpter, 1991).

EDCs are a widespread problem, now known to affect freshwater, estuarine and even marine fish. Research from the Tyne, Mersey and Solway estuaries have shown signs of feminisation in male flounder (*Platichthys flesus*) (Allen *et al*., 1999; Kleinkauf *et al*., 2004). A study by CEFAS (2006) found cod (*Gadus morhua*) sampled from both the North and Irish Sea had elevated concentrations of vitellogenin, which correlated to the size their diet changed from mainly nektonic (free-swimming) to benthic organisms. This worryingly suggests cod are accumulating EDCs through their food-chain as the benthic organisms live in sediments which typically contain far higher concentrations of oestrogenic compounds than seawater (Scott *et al*., 2006).

A synthetic oestrogen, ethinyloestradiol (EE2), commonly used in the conceptive pill, is causing particular concern due to its widespread occurrence, high potency and persistent nature (Santos *et al*., 2007). Concentrations in UK freshwater systems have been shown to reach 3.4 ng l^{-1} (Williams *et al*., 2003). This is very worrying as laboratory experiments have shown EE2 exposure in zebrafish (*Danio rerio*) of 1.67ng l^{-1} increases vitellogenin synthesis (Fenske *et al*., 2001), and 3 ng l^{-1} exposure reduces reproductive development in males (Fenske *et al*., 2005). A recent study by Santos *et al*., (2007) demonstrated that current environmental concentrations of EE2 decreased the quality and quantity of gametes produced by both male and female zebrafish.

Oestrogen contamination of drinking water has also been attributed to reproductive disorders and reduced sperm counts in humans (Sharpe and Skakkebaek, 1993).

Actions being taken

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In 2004, the Environment Agency concluded that the effects of endocrine disruption on fish were sufficient to develop a risk management strategy for biologically active effluents that discharge into the aquatic environment. The Endocrine Disruption Demonstration Programme was established to assess the effectiveness and costs associated with removing steroid hormones at sewage treatment works (STW). This programme will run from 2005-2010 (Environment Agency, 2004).

The well-documented endocrine disruptor TBT, which leaches into aquatic systems from boat anti-fouling paint, was shown to cause intersex in dog whelks, oysters and mussels. It now faces a European ban for most applications, coming into force on the 1st January 2008.

The S&TA helped lobby for ban of cypermethrin, a pyrethroid insecticide used in sheep dipping, which was shown to cause endocrine disruption in fish, including salmon (*Salmo salar*) and brown trout (*Salmo trutta*) (Jaensson *et al*., 2007), and fatal impacts on aquatic invertebrates. The lobbying resulted in a temporary suspension on the sale of cypermethrin in February 2006. Further action is still awaited from the Government as to whether the ban will become permanent or if the destructive chemical will be reintroduced. In our view, evidence of both toxic effects and risks from endocrine disruption would make any reintroduction unwise and indefensible, and certainly in direct contravention of the Precautionary Principle.

The Environment Agency has funded the development of a model which predicts the concentrations of three steroid oestrogens, oestradiol (E2), oestrone (E1) and EE2, and their associated risk of causing endocrine disruption in fish in 10,313 river reaches in England and Wales (William *et al.,* 2008). The model calculated that 39% of river reaches were 'at risk' from causing endocrine disruption effects in fish. The regions at greatest risk were Thames, Midlands and Anglian regions, with 67%, 55% and 50% respectively of river reaches in the area predicted to be 'at risk' (William *et al.,* 2008).

Call for Further Action

The S&TA feel the severity of the problem of EDCs requires urgent attention. We feel precautionary action should be implemented now to reduce the exposure to EDCs in the aquatic environment before it is too late. We feel sufficient evidence exists to demand:

- Universal threshold levels for total endocrine loads and specific oestrogen threshold standards in STW discharges by 2012.
- Immediate action to reduce natural and synthetic steroid oestrogens in priority STW discharges in 'at risk' areas.
- Reduction in the use of other manufactured chemicals with endocrine activity and replacement with safer alternatives. Priority must be given to the prevention of the release, rather than end-of-pipe solutions.
- The development of new assays and screening methods for the identification of endocrine disrupters relevant to humans and wildlife.
- Research to be adequately funded, prioritised and co-ordinated. All species in decline to be investigated for potential effects of endocrine disruptors, and all relevant data to be made publicly available wherever possible.
- Reassessment of current toxicity tests and chemical standards, as current assessments are dominated by single-chemical exposure studies. The environmental reality is that these chemicals occur mixed with other in effluents and in rivers, and are therefore likely to instigate additive effects. Precautionary limits/standards should therefore be set to take this into account.

- Phasing out of persistent chemicals known to accumulate in the environment.
- Investigations into population level impacts caused by EDC exposure, including population declines and loss of genetic diversity.
- Further research into the other effects of EDC exposure as, beside reproductive disruption, these chemicals have the potential to affect other biological functions also under hormonal control such as growth, development, metabolism, immune response and metamorphosis (in amphibian species).

Conclusion

The full extent of endocrine disruption and its effects on the environment are not fully understood. However, there is a consensus amongst experts that they are far more widespread than currently confirmed by experimentation.

The future of commercial and recreational, marine and freshwater fish populations could be threatened by the effects of EDC exposure. There is also significant potential to perturb whole ecosystems, from which many societal benefits arise. The S&TA strongly believes that this issue needs addressing now to help safeguard our native fish populations, and to enable us to be confident of attaining the Water Framework Directive (WFD) requirement of 'good ecological status' in all of our waterbodies by 2015.

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