SECTION 1: THE ENVIRONMENT

A general description of the environment of the catchment is given in Chapter 1 of the Tweed Fisheries Manual

INPUT 1A: MONITOR THE RAINFALL AND RIVER FLOW PATTERNS OF THE TWEED AND EYE CATCHMENTS TO ASSESS THEIR EFFECTS ON FISH PRODUCTION

Background and rationales: The hydrology of the Tweed catchment was heavily modified by extensive land drainage in the first half of the 19th century. Many wetlands and lochs disappeared and this reduction in water storage is probably linked to the low flows now common during the fishing season. It would be useful to be able to assess just how much storage capacity has been lost and from where in the catchment as guide to any possible areas for restoration.

> **Parish of Kelso**: "*At one period, all the meadow-lands in the vicinity were filled with pools and marshes; and even in the memory of many persons still living, the beautiful meadow to the north-east of the town which is now used as a race-course, formed the favourite resort of a colony of Sea-mews and wild ducks .... The last of these morasses has now disappeared under the ameliorating processes of draining and tillage; and intermittent fever, which was for centuries the scourge of the district has departed with it.*"
>
> NEW STATISTICAL ACCOUNT 1845

Floods during the spawning seasons can impact on their success, as happened in 2016 after the storms and prolonged high water of the Winter of 2015/16 (*see Appendix 1A, Fig 1*) and it is important to be aware of such possible impacts if juvenile production within the catchment is to be correctly assessed. Data on such events and their effects needs to be collected and collated so that it can be worked out what sort and magnitude of events are likely to reduce numbers of returning adults and whether these might need extra protection (*see Appendix 1A Fig. 2 for another example of this sort of event - Spring Salmon catches after the October 31st flood of 1977 on the Ettrick).*

Policy 1A.1: Collect historical information on flows and drainage

An account of the history of floods, droughts and land drainage is given in Chapter 1 of this Manual

(a) Continue to collect and collate historic records of floods and droughts.

(b) Continue to collect and collate historic records of changes in land drainage and the original extent of wetlands in the Tweed catchment.

(*i*) Use landscape modelling techniques to map where wetlands should be in the Tweed catchment and assess their extent.

Maps and data of the current weather and river gauging stations in the Tweed catchment can be found at:
http://apps.sepa.org.uk/waterlevels/
and historic data can be found through the National River Flow Archive at:
https://nrfa.ceh.ac.uk/

Policy 1A.2: Collate data on present day flows and floods for analysis with electric-fishing and catch data to show any impacts on production

INPUT 1B: MONITOR WATER TEMPERATURES WITHIN THE TWEED AND EYE CATCHMENTS AND ASSESS THEIR IMPACTS ON FISH PRODUCTION AND POPULATION STRUCTURES

Background and rationales: As fish and the insects they feed on are cold-blooded animals, their activity and growth is related to the temperature of the water in which they live. This can therefore have major impacts on their life histories – for example, when the scales of Tweed salmon were first systematically read in 1929-30, it was found that less than 5% had been three-year-old smolts while when Smolts were netted in the early 1960s, the little surviving data shows that over 50% were three years old. In recent years, Smolt ages have returned to being more like those of 1929-30. The most likely explanation for this is temperature – the 1940s-60s were a period of long, cold, winters when the growing seasons for salmon in the catchment would have been much shorter than at present. The high proportion of three-year-old Smolts in the 1960s would therefore have been due to the large numbers of juveniles that took three years to reach smolting size (See Chapter **). However, very few two-year-old Parr (which will become three-year-old smolts) are now found in the catchment, showing that growth is generally faster – the higher number taking only one year to reach smolting size is another consequence of this. As climate change continues, it is likely that three-year-old smolts will disappear altogether. The effects of temperature on salmon fry and parr growth and age can be clearly seen if samples are taken regularly along a river downstream from its source: as altitude falls, average water temperatures increase and fry and parr become larger and so smolt and leave at an earlier age. An example of this from the Ettrick is given in Appendix 1B, Fig 1.

The effects of temperature on growth can be seen in other aspects of the fisheries – Fig 2 in Appendix 1B, for example, shows how the heaviest trout caught in the Galashiels Angling Association competitions tracks the average Summer temperature.

The European Freshwater Fish Directive of 2006 defined prime quality Salmon spawning areas as having temperatures during the spawning season that did not go over 10C. A pilot project measuring temperatures around the Ettrick and Yarrow in 2006 & 2007 found that the warming effect of St. Mary's Loch could keep the temperature in the Upper Yarrow above this temperature into the spawning season. Should temperatures generally increase, this area could cease to be classifiable as a prime spawning area.

Since shading by bankside trees can reduce water temperatures, areas at risk from increased water temperatures need to be identified so that remedial action (tree planting) can be considered. Already, temperatures in Summer can exceed those at which juvenile salmon feed best, as is shown in Appendix 1B, Fig 3 for the middle Ettrick. If such summers were to become more common with climate change, the length of the parr growing season would be reduced, though this could be compensated for by milder winters allowing growth to start earlier. It is therefore difficult to predict what the effects on juvenile salmon and smolt age might be. More shade in such areas would, however, limit extremes.

Policy 1B.1: Record the water temperatures at key points within the Tweed catchment

- **(a)** At fish counters where the integral temperature monitors on the VAKI counters are not adequate *(the Whiteadder counter, where the scanner is not fully submerged).*
- **(b)** Where there are wide, open, channels in nursery areas. Continue recording at the site on the middle Ettrick and possibly establish site on the lower Whiteadder additional to the fish counter.
- **(c)** Record temperatures generally across the Tweed catchment to give baseline information (*this is being carried out as part of policy 1C.1 below*).

Policy 1B.2: Identify areas where shading by trees could limit increases in water temperature in the future

This policy is being pursued through the national water temperature monitoring programme being run by Marine Scotland Science called "SRTMN" (the Scottish River Temperature Monitoring Network) see:

http://www.gov.scot/Topics/marine/Salmon-Trout-Coarse/Freshwater/Monitoring/temperature

The aims of this programme are:

1. to characterise spatial and temporal variability in river temperature regimes for salmon rivers across Scotland.

2. to improve understanding of hydrological, climatological and landscape controls on river temperature.

3. to develop large-scale spatial statistical models to predict current and future river temperatures.

4. to identify those rivers, and parts of rivers, that will be most susceptible to a changing climate.

5. to assess mitigation and adaptation strategies for high summer temperatures.

6. to assess long-term trends in river water temperature and drivers of change.

An output from this work will be the identification of the types of places (in terms of altitude, aspect etc.) where tree planting and shading will be able to affect water temperatures. The Tweed catchment is hosting 28 of these temperature recorders, which are downloaded every six months and a map of these is given as Fig 4 in Appendix 1B.

INPUT 1C: DETERMINE THE RELEVENT CHEMICAL PARAMETERS OF THE WATERS OF THE TWEED AND EYE CATCHMENTS AND CHECK ON WATER QUALITY

Background and rationales: Electro-fishing surveys have shown that there are areas of the catchment that consistently have lower salmon fry numbers than other parts as shown in Appendix 1C, Fig 1. This may be a natural feature, relating back to the chemical richness of the water or it may be due to some other, man-made, factor. If it is the first, then nothing can be done about it but if it is the second, then some management action could be possible. It is of key importance therefore to be able to distinguish the two possibilities, not only to be able to direct resources to where they can be of use, but also to make sure they are not wasted by attempting to change natural features.

Policy 1C.1: Map the chemical richness of the waters of the Tweed and Eye catchments in relation to fish abundances

(a) Take conductivity readings at all electric-fishing sites.

(b) Relate these to the abundances of trout and salmon fry found during electric-fishing surveys.

Policy 1C.2: Check for sub-lethal chemical impacts on Tweed smolts by subjecting samples of Salmon and Sea-trout smolts to a "*Saltwater challenge*" procedure

(a) Take samples of Salmon and Sea-trout smolts from the nets at Paxton and subject them to direct transfer in to full sea water (with appropriate controls).
(i) Do this for samples through the smolt season.
(ii) Make sure that the full range of smolt sizes is tested each time.

INPUT 1D: ANALYSE THE EFFECTS OF FLOWS ON FISH MIGRATION

Background and rationales: River flows affect both the ability of smolts to get out of the river to the sea and that of adults to get back to where they want to spawn. Work on the acoustic tracking of Sea-trout smolts found that that in the dry Spring of 2010, only 20% made it to the sea, while in the wetter Spring of 2011, 50% did. The more that is known about such connections, the more and better precautions can be taken and advice given.

Policy 1D.1: Record and analyse flows in relation to fish movements.

(a) Relate adult fish movements through the counters to flow patterns.

(i) This is of particular interest for the Whiteadder, where freshets are often released in response to low flows. Whether or not such releases affect fish movement is at present unknown.

Similar analyses can be carried with the Ettrick counter, upstream of which freshets are released from the Megget Reservoir.

(b) In future, it should be possible to gain additional information on how flows affect smolt migration downstream by acoustic tagging smolts on the Gala and tracking their migration downstream in both wet and dry seasons.

With the adult counter on the Gala as well, it should be possible to regularly PIT tag large numbers of smolts and see if water flows during the migration season relate to numbers of adults returning.

INPUT 1E: COLLECT AND COLLATE INFORMATION ON THE EFFECTS OF CLIMATE CHANGE IN THE TWEED CATCHMENT AND ON THE RIVER.

Background and rationale: Environmental variability is a constant, but the evidence of climate change is such that it can be expected that in the near future rainfall, flow and temperature averages and extremes will go beyond what has been known in recent times and the impacts of this on the fish need to be thought out and any mitigation possibilities explored.

(a) Collect and collate such evidences as and when they become available.