

FIGURE 6.  
SALMON IN HOLDING TANK PRIOR TO TAGGING

Parallel work is testing whether analysis of single nuclear polymorphisms (SNPs) might enable sufficient genetic resolution among areas of the S Esk catchment to allow the origins of spring salmon to be determined as the project continues. Currently, results of this work have been disappointing.

### What next?

The next stages of work will depend very much on results of the tracking. If spring fish originate from a localised part of the catchment, then investigation is required of the state of that habitat, how sufficient is the number of spawning salmon to provide eggs, and whether there are bottlenecks to production or constraints to fish passage. Concepts and tools for such investigations are well established and should be applied to prescribe management options.

If there is no clear geographic pattern to the distribution of spring salmon within the catchment, then management solutions to the decline may be more difficult to identify. In this case, it may be that spring-running fish are not as fit under current environmental conditions as later-running salmon and hence are being out-competed. Alternatively or additionally, the reduction in spring-running fish may be due to a shift in run timing for environmental reasons, probably at sea, rather than necessarily a reduction in the population strength per se. Why such effects would be observed on the S Esk but not elsewhere would then be a subject for consideration.

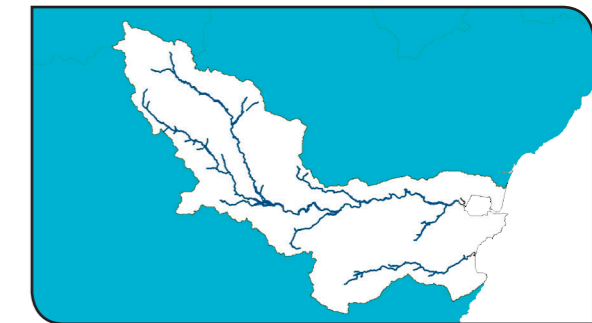
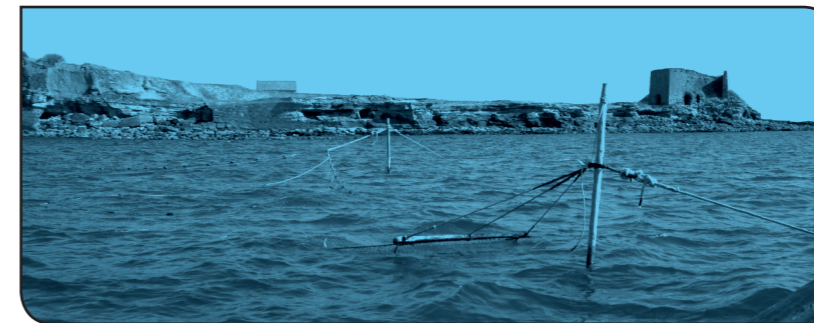
### Summary

- Reported rod catch of spring salmon has declined on the River S Esk.
- National and local constraints on net catches have not alleviated the problem.
- Reduction in killing of rod-caught salmon has not alleviated the problem.
- There has been no reported local investigation into whether there is a specific local problem impacting on spring salmon.
- Scottish Government has requested Marine Scotland Science to investigate the situation.
- As the first stage in their investigation, MSS have commenced a tracking project to determine which regions of the river spring salmon use to spawn.

### Further information

Details of the latest locations of the tracked salmon are provided on <http://www.gov.scot/Topics/marine/science/Research/Freshwater/southesk>

## SPRING SALMON IN THE RIVER SOUTH ESK



### Background

There has been considerable interest in changes in the salmon stocks in the River South Esk and associated management responses both by the local Salmon Fisheries Board and Scottish Government. This document summarises the underlying facts regarding the salmon stocks, fisheries, management responses and current investigations.

### Salmon catches

In the absence of a network of fish counters, much of the information regarding the strengths of salmon stocks is derived from catches. These comprise two main components- coastal and estuarine nets, and the rod-and-line fishery within the river.

#### Pre-fishery abundance

Using catch data and a series of assumptions, it is possible to estimate the numbers of salmon approaching the coast (pre-fishery abundance, PFA). PFA is a key indicator of stock status and assuming constant production of smolts (that is fish emigrating from the river prior to marine growth) indicates changes in survival of salmon at sea. However, because coastal nets harvest fish from more than one river, it is not a simple matter to derive PFA for individual rivers.

#### Rod catch and spawning escapement

Rod catch can be a useful indicator of spawning stock status. Assuming that a constant proportion of the salmon in the river is captured (that is, both effort and capture efficiency are constant) then changes in rod catch can indicate variations in the number of

fish in the river and the number available to spawn. Some adjustment may be required to account for variations in rod-catch associated with the numbers of salmon caught and released. The relationship between spawning stock and PFA depends on harvest by fisheries and other mortality near and in the river.

### General salmon rod catch trends in Scotland compared with the South Esk

Across Scotland, stocks of salmon (as inferred from catch data) have declined from a peak in the 1960s. The decline has been particularly acute with regard to returns of fish during spring months. However, over the last decade, the stocks, including the spring component, have generally stabilised or started to increase.

An exception among Scottish east coast salmon rivers to the general trends in rod catch is the spring component on the River S Esk. Here, in contrast to the region as a whole, reported salmon catches during spring have tended to decline progressively over recent years (Fig. 1). Hence, there is strong inference from the geographic patterns of rod catches that the decline in spring salmon in the S Esk is due to local factors.

### Management response to arrest the decline

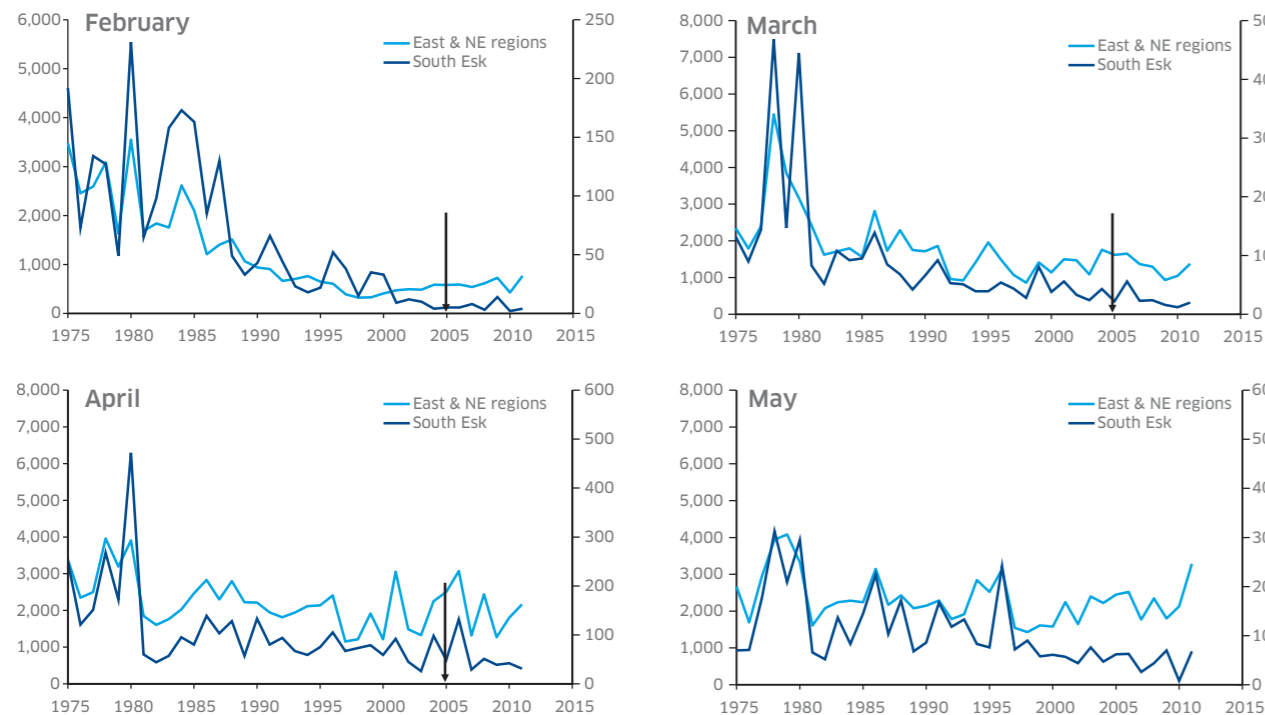
The most effective management response to declining stocks is to identify the cause of the decline and act to ameliorate the effects. If the main cause is over-

exploitation by fisheries, then the solution to the problem is readily apparent. Should other factors be primarily responsible, then reduction in fishing may nevertheless provide some temporary mitigation but is unlikely to provide a long term solution.

## Reduction in exploitation

On the River S Esk, a combination of nationally imposed regulations and local agreements resulted in cessation of the coastal net fishery on salmon during February-April from 2005. Despite these measures, there have been no marked changes in the patterns of declines in reported spring rod catches on the South Esk (Fig 1). However, because there is little information on the extent to which these mixed stock coastal fisheries exploit salmon from the S Esk compared to rivers further away, interpretation of these observations is confounded.

Rod-and line fishing on the S Esk has continued throughout spring months. There has been an increase in the release of salmon captured by rods, although killing of some fish continues. There is no information on the mortality due to the capture and release process and hence no measure of the current impact of the rod fishery.



**FIGURE 1**  
TRENDS IN CATCHES OF SALMON IN THE S ESK COMPARED TO OTHER SCOTTISH EAST COAST RIVERS IN SPRING MONTHS. THE ARROWS INDICATE WHEN COASTAL NETTING CEASED.

Due to the age structure of spring salmon stocks, any effect of these fishery changes would be expected to be seen from 2010 at the earliest.

Despite these measures, there has been no marked reduction in the trend of decline in spring salmon as inferred from the catch statistics.

## Cause of the decline

Despite the progressive decline in numbers of spring salmon, there has been no reported local investigation of the cause. Since reduction of netting and rod-and-line exploitation has not arrested the decline, it becomes progressively more evident that they were not the main underlying cause. In the absence of local information, Scottish Ministers instructed Marine Scotland Science to investigate whether there are identifiable specific local problems affecting the spring salmon stock.

## Investigating the decline

There are two fundamental factors that could result in reduction in the strength of a specific run-timing group of salmon. First, it is possible that there has been a change in run-timing independent of the overall

strength of the stock component. This could occur, for example, if changes in the marine environment resulted in longer migration routes causing a delay in return to the river. In such a case, a difference in catch trends between S Esk stocks and fish from neighbouring rivers would imply differences in their behaviour and distribution at sea.

An alternative, or additional, explanation is that different run-timing groups arise from distinctly different areas within the river catchment. In the Rivers Dee and Spey, for example, early-running fish tend to originate from upper tributaries and those that return in the autumn spawn lower down the catchments. Salmon tend to home to the area from which they originated and hence populations, or functionally similar groups of fish, can be maintained within a catchment. In the River Dee, the trends in the rod catch of spring fish are closely mirrored by catches of spawning salmon in traps in upper tributaries, consistent with a link between run-timing and specific geographic rearing areas. Hence, a locally weak spring stock may reflect emerging problems in the area of river in which they rear, or in access for spawners and smolts to and/or from that area.



**FIGURE 2**  
MINIATURE RADIO TRANSMITTER



**FIGURE 3**  
A RECEIVER STATION ON THE SOUTH ESK

## Where do spring fish spawn in the South Esk?

The first step in investigating the decline in spring salmon on the South Esk is to establish whether they originate from a localised part of the river catchment and, if so, which part. The genetics methods currently available (microsatellites) are not adequate to address this issue. Therefore, the necessary data are being obtained using radio transmitters (Figure 2) and a series of radio receivers (Figure 3). In the first phase of tracking movements of spring salmon, MSS has obtained fish from the coastal nets (Figures 4, 5 and 6) with a view to gaining insight into both the extent to which the fishery exploits fish from the S Esk and the spawning locations of those fish. Stomach tagging, whereby a transmitter is gently inserted into the stomach of the fish, has been the initial method of choice. This approach has the advantage of minimal handling and disruption to the fish, which is important with regard to welfare and conservation. The overall proportion of tagged salmon entering the S Esk can be expected to depend on the proportion of tagged fish heading for distant rivers, the occurrence of tag regurgitation (which can occur in fish that have yet to cease feeding as they approach fresh water), the proportion of the tags that fail, and the degree of mortality in the coastal zone.



**FIGURE 4.**  
FISHING COBLE USED IN THE INVESTIGATION



**FIGURE 5.**  
SALMON FISHING NET