science summary

Environment Agency

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Factors affecting the recruitment of riverine coarse fish: Phase 3

Science Summary SC030214/SS1

The coarse fish populations of England and Wales have great social and economic importance. In many areas of the country there is concern about large-scale variations in the performance of the coarse fisheries within major river systems. These fisheries are under pressure from a range of factors but there are also marked fluctuations in abundance of fish related to natural environmental variations. The Environment Agency requires an understanding of natural variability not only to base its management decisions on sound science, but also to meet the EU Water Framework Directive requirement to determine ecological status and distinguish direct anthropogenic effects from natural variation and the effects of climate change. This project was undertaken to provide an understanding of the extent of natural fluctuations in abundance and the environmental factors affecting these.

Phase II of this project reported the relationships observed in rivers between the recruitment of new fish to the populations each year of the coarse fish species of main interest to anglers and environmental factors, especially temperature and river discharge. Recruitment was expressed as year class strengths (YCS). It was postulated that although water temperature may determine the potential YCS of coarse fish, in many cases it is river discharge that determines the actual YCS that are realised.

In Phase II, the status of coarse fish populations was assessed by estimating YCS according to the sizes and estimated ages of fish caught. These estimates are not very reliable. The YCS method does not allow for errors in the data, such as mistakes in the estimation of age from scale reading. It cannot cope with incomplete data or allow for data that are biased. Fish surveys are often biased towards larger fish, because smaller fish slip through nets and tend to shoal together. These problems made it difficult to accurately assess YCS.

In particular, the determinations of YCS and the subsequent analyses of relationships with environmental factors were severely compromised by the phenomenon of 'ageing drift', which appeared to be caused by changes between surveys in the accuracy of scale readings and thus assignment to particular year classes. Examples were found of characteristically strong year classes moving to both earlier and later years, as well as oscillating between surveys.

The aim of this Phase III of the 'Factors affecting the recruitment of riverine coarse fish' (FARRCoF) project was: to identify the extent to which ageing drift had adversely influenced the YCS outputs of Phase II; how such issues may be remedied in future studies; and why and how the FARRCoF project should proceed to the next phase.

The re-ageing of approximately 1200 scales from roach, dace and chub from the River Stour in Essex suggested that errors had indeed occurred in the original age determinations. These errors arose from the subjective interpretation of certain scale features, such as indistinct checks, and the growth season to which growth at the edge of the scale was ascribed. It was concluded that, without independent validation, such issues can never be eliminated from scale ageing and that their influence on existing YCS calculations was undesirable. As a result, it was recommended that a new method of assessing recruitment strength should be devised that can incorporate the subjectivity of scale ageing. During the course of this project, a statistical model was developed that can handle a certain level of uncertainty in the age data and provide an assessment of year class strengths.

This is the first time that fisheries scientists have applied statistical modelling techniques to the assessment of coarse fisheries. The Population Dynamic Model (PDM) uses data from fish surveys to estimate the fundamental population processes of reproduction, growth and survival of fish. It can be used to find out why populations are changing, or to predict how changes in the environment affect coarse fish. Because it can cope with uncertain or incomplete data, and track long-term changes, the model is considerably more useful and more reliable than previous methods for assessing populations of coarse fish. In future it should become a widely used fisheries management tool.

The PDM approach uses statistical techniques to estimate the fundamental population processes in a given fish population by combining survey data over many years. This creates a powerful analysis that is repeatedly validated against real data. The model comprises six interlinked sub-models, which deal separately with quantitative aspects of fish population dynamics, such as growth rate, survival of individual fish and cohort abundance. Where measurements are expected to be inaccurate, such as for age estimates, the model combines all the relevant information about each fish, including its size and the age structure of the population, to assess the likely true result. Similarly, where data are missing, such as for small fish, or years without surveys, the model makes a probabilistic estimate by looking at all the other information about the population. The uncertainties in the estimates produced by the model are explicit.

The fisheries scientists tested the PDM approach using 22 years of data for chub and dace in the River Stour, East Anglia. The PDM was able to rectify the scale reading errors and also shed light on why anglers have observed a declining dace catch in the Stour. By looking at how the age cohorts in different years move through the population, the problem was seen to be not low recruitment or poor growth, but survival of older fish. This level of understanding is extremely helpful for those deciding how to manage the fishery.

The PDM is very flexible. It can incorporate environmental variables, so it can be used to test the effects of pollutants or different physical environments on fish populations. It could also be linked to the spatial distribution of river fish, via Geographical Information Systems. One barrier to widespread uptake of the PDM for fisheries management is its mathematical complexity. Although statistical training of Environment Agency staff is in progress, in the meantime the model will need to be run by fisheries statisticians in the Environment Agency.

A continuing need was identified to understand and assess the factors affecting coarse fish recruitment in rivers. It was therefore suggested that the FARRCoF project should continue to further phases.

Gap analysis was used to identify those aspects of the Environment Agency's understanding of coarse fish recruitment that remain incomplete. It is recommended that these gaps in knowledge should be filled in future phases of the FARRCoF project. A number of discrete projects are proposed to assist in this process. These include research on:

- the key abiotic and biotic factors in the early life history of cohorts that impact upon subsequent recruitment strengths;
- the reproductive and life history traits that determine egg and larvae production, survival and subsequent recruitment;
- the effects of parasites on fish growth and mortality;
- the roles of habitat, discharge and floodplain management in regulating the carrying capacity of the fish stock, both in juvenile and adult life phases.

This summary relates to information from Science Project SCO30214, reported in detail in the following report:-

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