

## THE EFFECT OF SUBJECTIVE FISH SCALE AGEING ON GROWTH AND RECRUITMENT ANALYSES: A CASE STUDY FROM THE UK

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**Abstract.** Re-ageing of scales sampled in 1985 from the population of roach, *Rutilus rutilus* (L.), of the River Stour, England, revealed a high degree of subjectivity in their ageing, resulting from contrasting interpretations of similar scale features between practitioners. Compared with ages attained in 1985, re-ageing of the scales in 2004 only found agreement >80% at ages 1, 2, and 4 years. By age 9, agreement had dropped to 6%. The re-ageing revealed the presence of year classes that had previously been thought to have already died out and suggested their recruitment strength was associated with water temperatures in the first year of life of cohorts.

**Keywords:** fish, roach, *Rutilus rutilus*, scales, year class strengths, age misclassification

Determining the age and growth of fish from temperate waters from hard structures is a classical procedure in fisheries science, with scales usually used when a non-destructive process is required. The ability to accurately determine ages from scales is therefore crucial, especially as the data generated are the foundation for determining population growth rates, mortality rates, ages at maturity, recruitment patterns, and production (Ricker 1975, Bagenal and Tesch 1978, Campana 2001)—information integral to the formulation of many fisheries management strategies. Ageing fish from scales is prone to errors arising from the subjective interpretation of their features (Mann and Steinmetz 1985). Interpretation is made difficult when, for example, annuli overlay each other at the scale margin—a common feature of scales taken from older fish—and when false checks are produced during a growth year. These factors may ultimately result in an age misclassification (Beamish 1979, Campana 2001).

This paper reports on a case study regarding the effects of the subjectivity of scale ageing on subsequent growth and recruitment outputs. Research investigating the factors affecting the recruitment of roach, *Rutilus rutilus* (L.), in the River Stour, Essex, England, between 1969 and 1996 had revealed annually variable recruitment patterns and the infrequent recruitment of strong year classes

(Frear and Cowx 2003). However, slippage of strong year classes between samples was apparent. For example, in the 1985 sample, the 1975 year class was the dominant cohort, but in the 1988 sample, this switched to the 1976 year class, with the 1975 year class comparatively weak. As it was believed that this might have resulted from the initial scale ageing being erroneous (for example, a quality control procedure had not been used), work was initiated to review the original ageing.

The roach scales used in the case study were collected during stock assessment of the River Stour by electric fishing in June 1985. Following capture, fish had been identified, measured (fork length, mm), and scales removed from 625 roach, with these analysed on a projecting microscope to enable age determination. The scales were then placed in individual paper envelopes and held in an archive room at room temperature. Following retrieval of the scales from the archive, their re-ageing commenced in March 2004. The primary reader of the scales was selected on the basis of their vast experience of ageing scales in recent years. A quality control procedure was utilised by employing a secondary reader who checked 10% of the aged scales. Where disagreement was found, the scale was reviewed to enable consensus to be reached. On completion of the exercise, the parameters *K* (growth coeffi-

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cient) and  $L_{\infty}$  (maximum theoretical length) of the von Bertalanffy growth model (von Bertalanffy 1960) were determined for the original and revised ageing data (Bagenal and Tesch 1978). These values were then compared with those derived for 90 roach populations from other rivers in England, with these data available through a stock assessment programme completed in 2004 during which scales from roach were collected, analysed and growth outputs produced. Recruitment was measured using the year-class-strength method of Cowx and Frear (2004).

Results from the re-ageing exercise revealed only 69% agreement with the original ages (Table 1), with a significant decrease in agreement with age ( $r = -0.96$ ,  $v = 8$ ,  $P < 0.001$ ). Agreement was only above 80% at ages 1, 2, and 4 and reduced to 6% at age 9. Furthermore, there were roach now aged in the sample at ages between 11 and 13, when the oldest fish was previously aged at 10. The principal differences between the ages originated from the subjective interpretation of scale features that included false checks and growth close to the scale margin.

The effect of the re-ageing on the von Bertalanffy growth parameters of the roach population was to reveal the population had a lower maximum theoretical length but higher growth coefficient that had been shown previously, although values were within those expected for roach in English rivers (Fig. 1). The effect on the year class strength output was marked (Fig. 2). The recruitment strength of the 1972, 1973, and 1974 year classes was revealed, with the 1975, 1976, and 1979 year classes shown to be stronger than previously thought (Fig. 2). However, the weak year classes identified in the original ageing—the 1977, 1978, and 1982 year classes—remained weak after the re-analysis (Fig. 2). The original year class strength output had revealed there was no relation

between roach recruitment and water temperature in the first year of life of the cohort ( $r = 0.04$ ,  $v = 6$ ,  $P > 0.10$ ; Fig. 2). However, the re-analysis revealed a significant relation between recruitment and water temperature had actually existed ( $r = 0.74$ ,  $v = 6$ ,  $P < 0.05$ ; Fig. 2), similar to other riverine populations of *R. rutilus* in the UK (e.g., Mills and Mann 1985, Britton et al. 2004).

This case study demonstrates that consequences of subjective scale ageing include the production of incorrect age structures and recruitment patterns. This is important, given that assessment of the ecological status of fish fauna within the EU Water Framework Directive includes age structure evaluation (Anonymous 2000). The case study also revealed that ageing of fish from scales should always incorporate a rigorous quality control method, using at least one experienced worker. If used in conjunction with an ageing validation exercise, ageing accuracy would be further improved (Campana 2001). However, despite the availability of validation techniques, they may be overlooked in many stock assessment exercises due to time and budgetary constraints. Notwithstanding this, even the use of validation techniques may be unable to completely eliminate the subjective element of scale ageing and so new techniques to determine recruitment strength during stock assessment should be explored that can account for this subjectivity and produce more robust assessments.

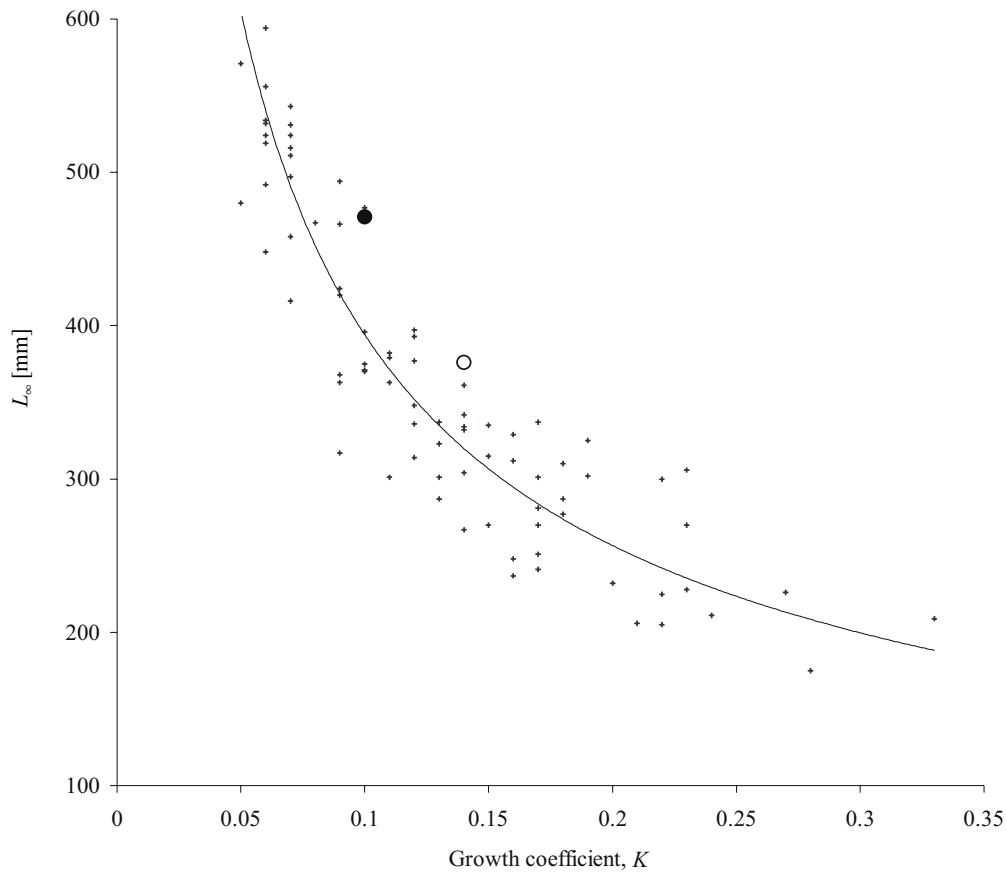
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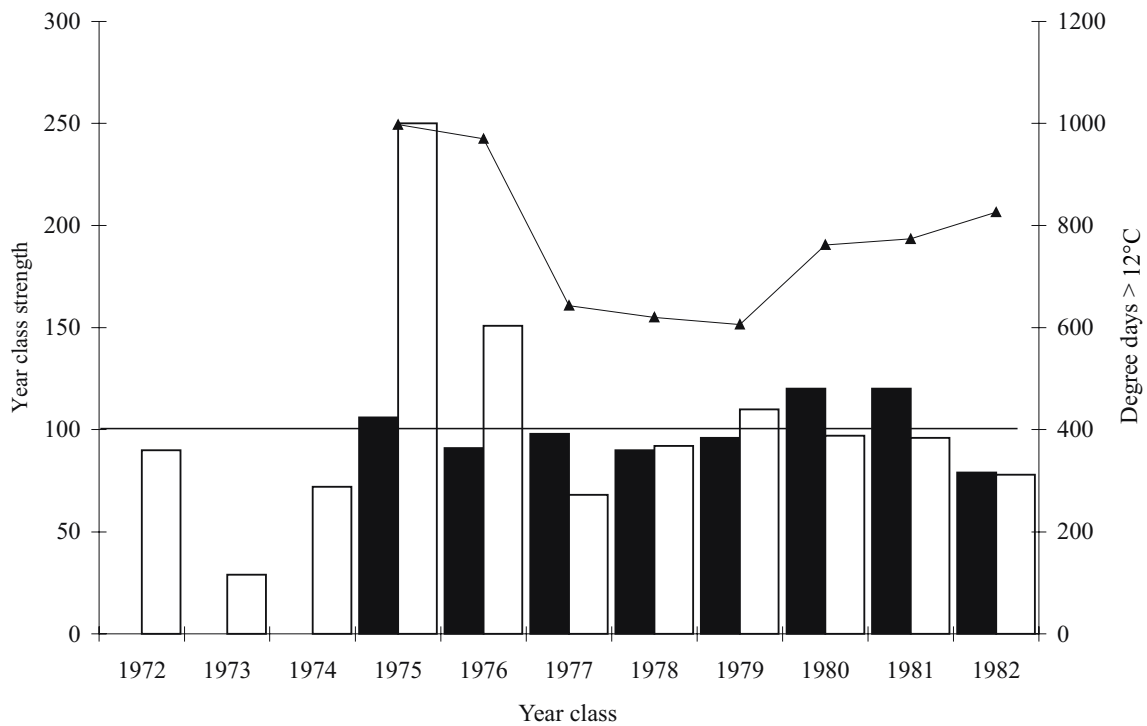
**Table 1**

Results of the scale ageing case study for roach from the River Stour, England, sampled in 1985

Age (years)	Number of fish per age class after the original ageing (1985)	Number of fish assigned their original age class in the re-ageing (2004)	Percentage agreement between the original and re-ageing	Number of fish per age class after re-ageing (2004)
1	13	12	92%	24
2	130	110	85%	115
3	120	92	77%	104
4	129	106	82%	134
5	91	58	64%	86
6	51	31	61%	62
7	34	15	44%	33
8	26	5	19%	16
9	17	1	6%	22
10	14	2	14%	22
11	0	—	—	4
12	0	—	—	1
13	0	—	—	2
Total	625	432	69%	625



**Fig. 1.** Relation between  $L_{\infty}$  and the growth coefficient  $K$  of the von Bertalanffy growth model for roach in rivers in England (+), with comparison to the parameters derived for River Stour roach in the original scale ageing (●) and the re-ageing exercise (○)



**Fig. 2.** Difference in the year class strengths output for roach in the River Stour, England, from the original ageing in 1985 (black columns) and the re-ageing completed in 2004 (white columns), with comparison to water temperature, expressed as the number of degree-days >12°C (▲). The horizontal black line delineates a strong year class from a weak year class

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