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COMPARISON OF SCALES AND OTOLITHS FOR AGE DETERMINATION OF WHITEFISH *COREGONUS LAVARETUS*

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ABSTRACT

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Three techniques for determining the age of whitefish (*Coregonus lavaretus*) from Lake Tyrifjorden, Norway, were compared. The estimates of age obtained by reading scales were lower than those obtained by reading otoliths; the difference between the estimates increased linearly after the age 4—5 as estimated by reading otoliths. The reading of whole otoliths gave results almost the same as those obtained by reading burnt and cracked otoliths, but the estimates by the latter method were slightly higher than those by the former, and this difference increased with age.

INTRODUCTION

The use of burnt and cracked otoliths (Christensen, 1964) for age determination in *Coregonus* spp. provides a useful alternative to the more traditional methods that include the use of scales or whole otoliths (Bagenal, 1970; Aass, 1972; Ausen, 1976; Wilson and Pitcher, 1984). In stunted populations of salmonids in arctic ecosystems, age-estimates using unsectioned otoliths have been incorrect, especially in older individuals (Power, 1978; Beamish, 1979; Reimers, 1979), because of the growth pattern of the otoliths. When growth is retarded due to sexual maturation, the otoliths stop dorso-ventral growth and subsequent growth is lateral (Christensen, 1964).

Our study compared three techniques for age determination as applied to two populations of whitefish (*Coregonus lavaretus*) which were experiencing

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different levels of exploitation. Age was determined from scales, whole otoliths, and burnt and cracked otoliths.

METHODS

The whitefish were caught during the spawning period in the Rivers Sokna and Storelva, Lake Tyrifjorden, SE Norway, in 1977—78 and in 1980. The two populations do not inter-breed (Skurdal, 1982). In the River Sokna, the rate of exploitation is 17% (Ricker, 1975), whereas the exploitation of whitefish in the River Storelva is insignificant (Skurdal and Qvenild, 1982).

Fish in the River Storelva were caught with drifting gill nets (mesh sizes 29, 35 and 39 mm bar mesh). These sizes all catch whitefish larger than 29 cm with similar efficiency (Qvenild and Skurdal, 1981). Fish from the River Sokna were caught with two-winged hoop nets (mesh size 13 mm) and electroshock techniques. These methods are also equally efficient for catching all size-groups of spawning whitefish.

The overall length of the fish was measured to the nearest 0.5 cm. Scales and otoliths were collected for age determination. The scales were taken from an area along the lateral line between the dorsal and adipose fins. The scales were cleaned, dry-mounted between two glass slides and studied under a microscope. Both sacculus otoliths were removed, stored dry, and examined using two different methods:
(1) the otoliths were cleared in 96% ethanol (18—24 h) and read under a stereoscopic microscope using 96% ethanol as the refracting medium (Aass, 1972);
(2) one otolith of each pair was then burnt, broken through the centre line (Christensen, 1964), and read under a stereoscopic microscope using 1.2-propandiol as the refracting medium.

Survival rates were calculated from the age distributions (Robson and Chapman, 1961).

RESULTS

Scales vs. otoliths

In 1978, the age of 177 whitefish from the River Sokna was determined from scales, and from burnt and cracked otoliths (Table I). Scales gave ages between 2 and 6 years, whereas otoliths gave ages up to 11 years (χ^2-test, $P < 0.001$). Otoliths gave the higher age estimates in 47.5% of the cases, scales and otoliths gave identical estimates in 50.0% of the cases, and scales gave the higher estimate in 2.3% of the cases. The difference between the methods increased with increasing age (Fig. 1). The differences were small up to age 4 or 5 (burnt and cracked otoliths), and subsequently increased linearly (slope 0.93—0.99; $r = 0.88$—0.90; $P < 0.001$). This indicates that no annual zones are deposited in the scales after age 4—5.

TABLE I

Age distributions of whitefish (*Coregonus lavaretus*) in the Rivers Sokna and Storelva estimated using different ageing techniques (S = scales; W = whole otoliths cleared in 96% ethanol; B/C = burnt and cracked otoliths)

Locality	Year	Method	Age (years)														
			2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Sokna	1978	S	4	99	59	12	3										
		B/C	3	54	53	34	14	8	4	3	3	1					
Sokna	1980	W	2	281	123	119	71	34	11	4	1	1	0	1	0	1	
		B/C	2	281	121	113	72	34	13	4	3	2	2	0	1	1	
Storelva	1980	W		49	82	82	54	37	22	22	8	7	3	2	1		
		B/C		49	81	78	50	25	19	20	19	9	5	5	2	6	4

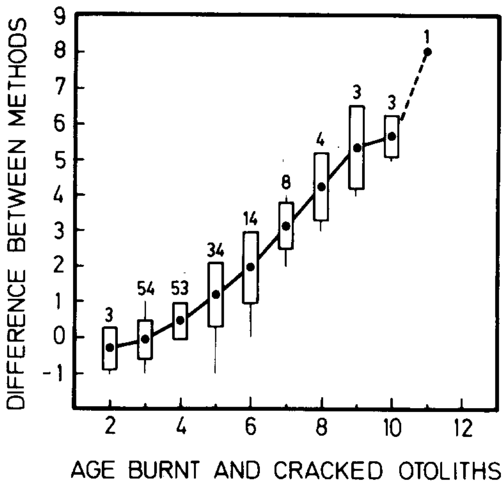

Fig. 1. Differences in estimated age (age using burnt and cracked otoliths and age using scales) of whitefish (*Coregonus lavaretus*) from the River Sokna, 1977 and 1980, as a function of the age estimates using burnt and cracked otoliths.

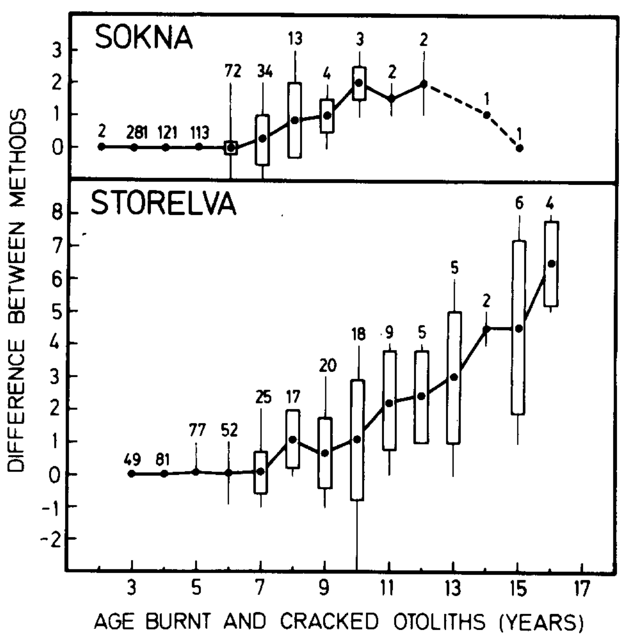

Fig. 2. Differences in estimated age (age using burnt and cracked otoliths and age using whole otoliths) of whitefish (*Coregonus lavaretus*) from the Rivers Sokna and Storelva, 1980, as a function of the age estimate using burnt and cracked otoliths.

TABLE II

Survival rate (± 95% confidence interval (CI)) of whitefish (*Coregonus lavaretus*) in the Rivers Storelva and Sokna, estimated from the age distributions obtained using two ageing techniques: (A) whole otoliths cleared in 96% ethanol; (B) burnt and cracked otoliths

Place	Method	S	CI
Storelva	A	0.640	0.039
	B	0.714	0.033
Sokna	A	0.560	0.026
	B	0.574	0.026

Burning and cracking vs. clearing in ethanol

In 1980, a total of 369 otolith pairs from the River Storelva and 649 otolith pairs from the River Sokna were read. The two methods yielded the same age estimates in most comparisons (79.1% for the Storelva and 95.5% for the Sokna). The age distributions obtained using the two methods were not statistically different (χ^2-test, P(Storelva) = 0.62, P(Sokna) = 0.95). When differences occurred, burning and cracking otoliths gave the higher age estimates. For the River Storelva, the difference between the methods increased linearly with increasing age from age 7 (burnt otoliths) onwards (slope 0.56; $r = 0.72$; $P < 0.01$). For the River Sokna, the increase was not significant (Fig. 2) (slope 0.007—0.01; $P > 0.05$).

Survival rates were estimated from the age distributions (Table II). For the River Sokna, the difference in estimated survival rates was only 1.4% (t-test, $P > 0.1$), whereas the difference for the Storelva was as high as 7.4% (t-test, $P < 0.001$). This shows that even small, statistically insignificant differences in age distribution may give significantly different survival estimates.

DISCUSSION

Ageing whitefish by means of scales may greatly underestimate their true age. Scales have also been found to be unsuitable for ageing populations of other salmonid species (Nordeng, 1961; Grande, 1964; Aass, 1972; Jonsson, 1976; Garnås, 1982). Figure 1 shows that the difference between age-estimates from scales and from burnt and cracked otoliths increases linearly, with a slope close to 1 after age 4—5. This indicates that no annual growth zones are formed in scales after this age. In samples of fish from Lake Tyrifjorden, the age of sexual maturity was found to be 2—6 years (Qvenild and Skurdal, 1984), which corresponds closely to the age when zone formation stops in the scales. Whitefish scales do not form annual zones when the somatic growth rate falls below a threshold of about 1.5 cm

(Hellner, 1980). Annual rings do continue to be formed in the scales when growth is rapid throughout life (Ausen, 1976; Wilson and Pitcher, 1984). In most whitefish populations, growth stops or is greatly retarded after sexual maturation. Thus, scale-reading may be a valuable method for determining age at sexual maturity.

No statistically significant difference in age distribution was obtained when the otoliths were cleared in 96% ethanol or burnt and cracked. When the two methods yielded different results, burning and cracking usually gave the higher value and the difference increased with increasing age. This resulted in a significant difference in the estimated survival rate in the River Storelva. The whitefish in the Storelva experience virtually no exploitation, whereas the whitefish in the Sokna experience an exploitation rate of 17% per year (Skurdal and Qvenild, 1982). Thus an increased exploitation rate reduces the bias in the estimation of survival rate from stock age composition data, but does not reduce the problem of estimating that age composition. Populations containing old and stunted individuals should be aged by using burnt and cracked otoliths, whereas populations experiencing even low exploitation rates may be aged successfully using whole otoliths cleared in ethanol. Our results emphasize the necessity to validate the age determination method used. One method obtaining an approximate estimate of the accuracy of a method is to compare age determinations using several techniques. If most readings are similar, there is an added degree of confidence in the determinations (Chilton and Beamish, 1982).

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