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Age Determination of Manitoban Walleyes Using Otoliths, Dorsal Spines, and Scales

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Abstract

Otolith sections were used to determine ages of walleyes (*Stizostedion vitreum*) collected from four Manitoban lakes. To verify the presence of annuli on otolith sections, ages determined from otoliths were compared to ages derived from dorsal spine sections and scales; mean body lengths back-calculated from 252 otolith sections were compared to mean observed lengths; and otolith sections from known-age walleyes were aged.

Otolith sections not only can provide accurate age estimates and back-calculated length estimates for young walleye populations but also they are easier to age, and consequently are more accurate for determining ages of older walleyes than are scales and dorsal spines.

Thin sections of otoliths have been used by Beamish (1979), Campbell and Babaluk (1979), and Erickson (1979), for determining ages of various fish populations including walleyes (*Stizostedion vitreum*). Most of the otolith annuli were distinct when the section technique was used in the above studies. Age estimates from otolith sections were considered more accurate than scale estimates for older walleyes.

Otolith sections were used in this study for determining ages of walleyes collected from four Manitoban lakes—Lake Winnipeg, Chitek Lake, Eardley Lake, and Obukowin Lake. The objectives of this study were to compare ages determined from otolith sections to ages determined from scales and dorsal spine sections, verify whether or not otolith sections provide an accurate method of age determination for walleyes, and validate the presence of annuli on otolith sections of walleyes of known age. Back-calculated lengths from 252 otoliths from Lake Winnipeg walleyes were compared to mean observed lengths. Furthermore, otolith sections from known-age walleyes were aged.

Methods

During the summer of 1978, 264 walleyes were collected from Eardley Lake and 172 walleyes were collected from Obukowin Lake (Fig. 1). Both lakes are located in the Precambrian Shield, contain lightly exploited walleye populations, and are oligotrophic (Hagenson and O'Connor 1979, 1981).

One hundred walleyes (known-age 3+) were collected from Chitek Lake (Fig. 1) in August 1980. Chitek Lake is a sedimentary lake of 8,288 hectares with a mean depth of 2.4 m. Walleyes had never been netted in Chitek Lake prior to 1977 when 2.4 million walleye fry were stocked by the Provincial Fisheries Branch in the spring of 1977.

In June 1981, 252 walleyes were collected from the south basin of Lake Winnipeg (Fig. 1) which has an area of 2,780 km² and an average depth of 9.7 m (Brunskill et al. 1980). This basin is sedimentary and walleyes are heavily exploited by the commercial fisheries (Lysack 1980, 1981; Brunskill et al. 1980).

The fish were collected with gangs of experimental gill nets of mesh sizes that ranged from 38 to 140 mm, stretched measure. Walleyes also were collected from commercial catches in southern Lake Winnipeg. Otoliths, dorsal spines, and scales were collected from each fish with the exception of the Chitek Lake sample where dorsal spines were not collected. Scales were removed above the lateral line below the anterior edge of the dorsal fin, and scale annuli were identified according to the methods of Carlander (1961). Otoliths and dorsal spines were prepared, and sectioned according to the methods of Erickson (1979). A microfiche reader was used to view otolith and dorsal spine sections at 72× and scales at 48×. Two experienced readers from the Provincial Fisheries Branch aged all structures. Any structure yielding differences in ages was re-read simultaneously by both readers and omitted from further analysis if the age disagreement persisted.

Otolith annuli were measured according to Beamish (1979). Back-calculated lengths were

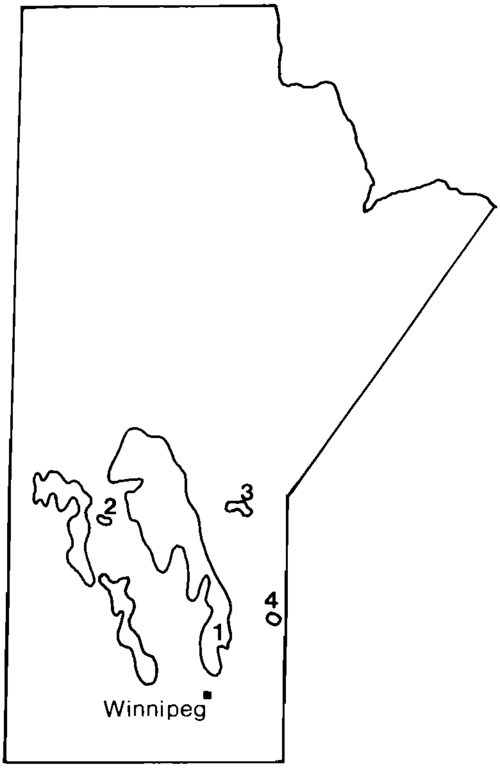

Figure 1. Location of study lakes in Manitoba: 1—Lake Winnipeg, 2—Chitek Lake, 3—Eardley Lake, and 4—Obukowin Lake.

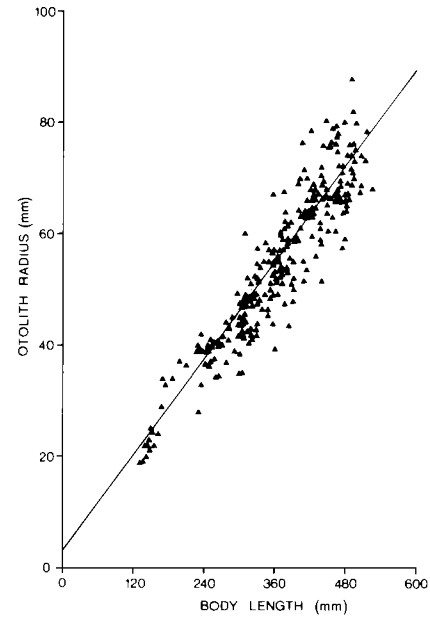

Figure 2. Relationship of otolith radius and body length for 252 walleyes sampled from southern Lake Winnipeg. At least 10 fish per age class are represented.

estimated by the first method described by Ricker (1968, page 110). A least-squares regression analysis of otolith radii and body lengths of 252 walleyes from southern Lake Winnipeg resulted in the following equation:

$$Y = 3.53 + 0.142X$$

where

Y = otolith radius (mm),
X = fork length (mm).

This relationship was highly significant ($F = 1{,}385$; $df = 1$ and 251; $r = 0.92$). The correlation coefficient (0.94) of a log-log transformed plot was not higher than that of the untransformed plot shown in Fig. 2.

Because the body size : otolith size relationship intercepted the abscissa extremely close to the origin and a full log transformation did not significantly improve the correlation coefficient, it was assumed that this size relationship was linear and intercepted the axes at the origin. Therefore, back-calculated lengths were calculated according to the following equation:

$$\frac{l_n}{l} = \frac{O_n}{O}$$

where

l_n = back-calculated length of fish at annulus n,
l = present length of fish, (1) (Ricker 1968)
O_n = radius of annulus n,
O = present otolith radius.

Results

Lake Winnipeg

The ageing structures collected from southern Lake Winnipeg walleyes had well-defined annuli. The mean ages determined from otoliths were similar to the mean ages derived from dorsal spines and scales (Tables 1 and 2). The southern Lake Winnipeg walleye sample consisted mainly of age classes 1–9 and the percent agreements between readers for all ageing structures were high (Table 3). Observed mean lengths of 1- and

Table 1. Comparison of dorsal spine ages and mean otolith ages (with two standard deviations) of walleyes collected from lakes Winnipeg, Eardley, and Obukowin.

Lake	Dorsal spine age (years)	Mean otolith age (years)	Standard deviations	Sample size
Winnipeg	1	1.0		13
	2	2.0		30
	3	3.0	2.3, 3.8	52
	4	4.0	3.5, 4.8	41
	5	5.0	4.4, 5.6	25
	6	6.1	5.6, 6.6	15
	7	7.0	6.6, 7.4	43
	8	8.0		5
	9	8.9	8.8, 9.2	28
Eardley	1	1.0		2
	2	2.0		7
	3	3.0		10
	4	4.0		14
	5	5.2	4.2, 6.2	25
	6	6.1	5.6, 6.5	36
	7	7.2	5.9, 8.4	11
	8	9.5	6.0, 12.9	47
	9	12.0	8.2, 15.9	15
	10	13.4	8.6, 18.2	8
	11	14.4	10.6, 18.3	43
	12	15.8	12.2, 19.3	31
	13	16.4	13.4, 19.4	15
Obukowin	1	1.0		1
	2	2.0		2
	3	3.0		5
	4	4.0		9
	5	5.3	4.2, 6.4	24
	6	7.5	4.3, 10.7	27
	7	9.4	5.2, 13.6	20
	8	11.5	6.6, 16.4	8
	9	13.0	8.8, 17.2	24
	10	13.8	9.2, 18.4	16
	11	15.1	11.6, 18.6	20
	12	16.4	12.8, 20.0	7
	13	17.0	13.4, 20.7	7
	14	17.5	16.1, 18.9	2

Table 2. Comparison of scale ages and mean otolith ages (with two standard deviations) of walleyes collected from lakes Winnipeg, Eardley, and Obukowin.

Lake	Scale age (years)	Mean otolith age (years)	Standard deviations	Sample size
Winnipeg	1	1.1	.5, 1.6	13
	2	2.1	1.6, 2.6	31
	3	3.1	2.5, 3.6	54
	4	4.1	3.2, 4.9	44
	5	5.2	4.2, 6.2	27
	6	6.4	5.4, 7.4	18
	7	7.3	5.8, 8.8	40
	8	8.4	7.0, 9.8	10
	9	8.9	8.5, 9.4	15
Eardley	1	1.0		2
	2	2.1	1.4, 2.9	7
	3	3.2	2.4, 4.0	10
	4	4.2	3.4, 5.0	15
	5	5.8	4.4, 7.3	50
	6	9.1	4.3, 14.8	83
	7	13.5	9.2, 17.9	50
	8	14.5	10.2, 18.8	24
	9	16.4	11.8, 21.1	23
Obukowin	1	1.0		1
	2	2.0		2
	3	3.2	2.3, 3.9	5
	4	4.3	2.9, 5.7	10
	5	6.1	3.8, 8.4	51
	6	12.4	7.5, 17.3	72
	7	15.3	12.9, 17.6	18
	8	16.5	12.7, 20.3	13

2-year-old walleyes were less than the corresponding back-calculated mean lengths at those ages but the observed mean lengths of fish 3 years old and older were greater than the corresponding back-calculated mean lengths. However, the differences between observed and back-calculated mean lengths at any age were not significantly different (Fig. 3).

Chitek Lake

Both otolith and scale annuli were distinct and age comparisons and percent agreements between readers were similar (Table 3). Age determinations from otoliths taken from 96 walleyes showed they were 3+; 90 walleyes were aged 3+ according to the scales from the total of 100 known-age fish 3+ years old. Figure 4 shows a photograph of a known-age 3+ walleye from Chitek Lake which validates the presence of three annuli on the otolith section.

Eardley and Obukowin Lakes

Walleye otolith sections from Eardley and Obukowin lakes had well-defined annuli (Fig. 5a). Ageing difficulties were encountered with scales (Fig. 5b) and, to a lesser degree, with dorsal spines (Fig. 5c). Annuli were crowded at the edge of the scales on the majority of walleyes older than 5 or 6. Similar ageing difficulties, although not as frequent as with scales, were encountered with the dorsal spine sections.

The otoliths showed that the walleye age composition in both lakes contained many old (10+ to 21+ years) individuals (Tables 1 and 2). Mean

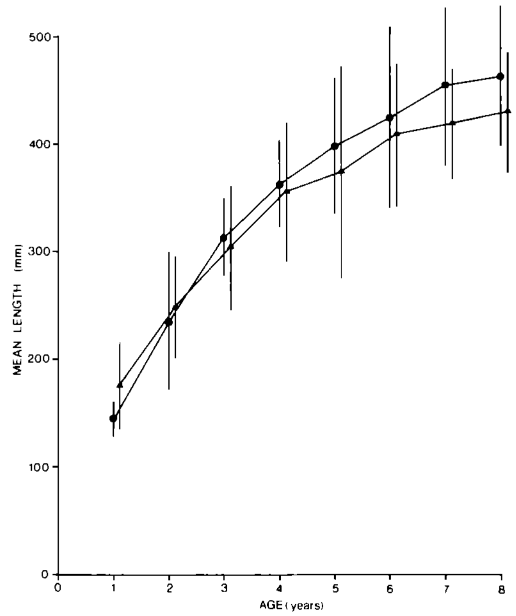

Figure 3. Observed (●) and back-calculated (▲) lengths of Lake Winnipeg walleyes. Vertical bars represent ±2 standard deviations about the means.

ages derived from otolith sections were significantly older than ages determined from scales of fish older than age 6+ for Eardley Lake walleye and beyond age 5+ for Obukowin Lake walleyes (Table 2). Also, mean ages derived from otolith sections were significantly older than ages observed on dorsal spines for walleyes older than age 11+ in Eardley Lake and 10+ for Obukowin Lake walleyes (Table 1). Percent agreements between readers were significantly higher for otolith-section ages than for both dorsal-spine and scale ages (Table 3).

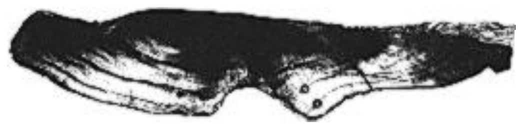

Figure 4. Example of an otolith section from a known-age 3+ walleye collected from Chitek Lake. Annuli are indicated by dots.

Discussion

Ages derived from otolith sections were similar to ages derived from dorsal spines and scales for Lake Winnipeg walleyes. The majority of these fish were captured in their growing years before individual asymptotic sizes had been attained. Many of the walleyes collected were large but young and showed evidence of fast individual growth. This young age composition and fast growth of southern Lake Winnipeg walleyes has been attributed mainly to the heavy exploitation by the commercial fisheries (Lysack 1980, 1981). As a result, all annuli were well-spaced and distinct on all ageing structures; ages derived from otolith sections were similar to ages derived from dorsal spine sections and scales. Because the otolith annuli were distinct, there were no significant differences between the observed and back-calculated mean lengths at all ages (Fig. 3).

Likewise, both otolith sections and scales were useful for determining ages of known-age walleyes collected from Chitek Lake. The marks

Table 3. Percent frequencies of agreement and disagreement for walleye ages determined by two readers using otolith sections, dorsal spine sections, and scales.

Lake	Structure	Percent agreement	Percent disagreement (±1 year)	Percent disagreement (±2 year)	Percent disagreement (±3 year)
Winnipeg	Otolith	89.0	11.0		
	Dorsal spine	80.0	15.8	4.2	
	Scale	78.8	16.7	5.3	
Chitek	Otolith	93.0	7.0		
	Scale	90.0	10.0		
Eardley	Otolith	76.1	20.9	3.0	
	Dorsal spine	55.4	29.5	10.8	4.3
	Scale	53.3	27.4	15.4	3.9
Obukowin	Otolith	77.6	17.4	5.0	
	Dorsal spine	59.4	24.3	12.1	4.2
	Scale	51.6	25.4	14.1	3.9

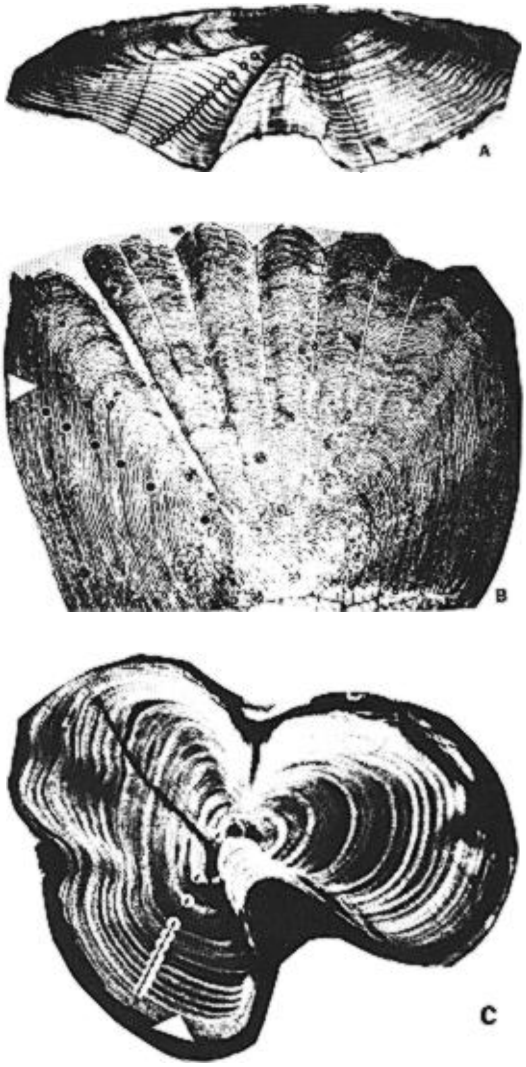

Figure 5. Example of an otolith section (A), a scale (B), and a dorsal spine section (C) from a walleye sampled from Eardley Lake. Visible annuli are indicated by dots. Merged annuli on the scale and dorsal spine are indicated by a triangle.

identified as annuli on the otolith section were valid (Fig. 4). Annuli were distinct on both structures because of the fast growth and young age of the walleyes examined. Marks interpreted as annuli on the known-age otolith sections were similar to marks believed to be annuli on otolith sections from the other three walleye populations examined.

Ageing results from Eardley and Obukowin walleyes showed similar characteristics. Several old individuals (10+ to 22+) were prevalent in the age composition of both populations according to the otolith sections (Table 1, 2). Walleyes from these lakes have a slower growth rate and a smaller asymptotic size than walleyes from southern Lake Winnipeg (Hagenson and O'Connor 1979, 1981; Lysack 1980, 1981). Because scale growth is similar to body growth, it follows that the outer annuli on walleye scales from Eardley and Obukowin lakes should be crowded. Otolith sections were considered superior for determining ages of older walleyes as annular crowding at the edge of the otolith sections was not as pronounced as it was on scales and dorsal spines (Fig. 5). Annuli also were not crowded together on any of the ageing structures of the younger (1+ to 6+) walleyes collected from Eardley and Obukowin lakes because young fish grow faster than old ones. As a result, otolith section ages were similar to scale and dorsal spine ages for younger walleyes.

The presence of annuli on walleye otolith sections was validated by known-age results from Chitek Lake (Fig. 4). Otolith sections provide fishery managers with an accurate means of age estimation for young walleyes, and are less difficult to age and consequently more accurate for determining ages of older walleyes than scales and dorsal spine sections.

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