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Check Formation on the Scales of Hatchery-Reared Lake Trout Prior to and Soon after Release into Lake Superior

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Abstract.—We investigated two assumptions about scales of hatchery-reared lake trout *Salvelinus namaycush* stocked as yearlings into Lake Superior: (1) only one check is formed during hatchery life and (2) a "stocking check" forms when the fish are released. We examined four scales from each of 176 fish prior to release from five hatcheries and 55 fish soon after release. Prior to release, 91% of the lake trout had only one check. This percentage was 81–100% for individual hatcheries. Evidence for a stocking check was observed only on fish whose scales had grown substantially between release and subsequent recapture. All measures of variability were less and check conspicuousness was greater for fish raised in hatcheries with seasonal cycles of temperature and photoperiod than for those reared with nearly constant water temperatures and darkness. We conclude that the assumption of only one check prior to stocking was not grossly violated when several scales from the same fish were interpreted and that there was some evidence for a "stocking check."

We investigated two assumptions generally made about scales from hatchery-reared lake trout *Salvelinus namaycush* released as yearlings (approximately 18 months old) into Lake Superior. The first assumption is that scales from these fish have exactly one check, considered the first annulus, at the time of release. The second assumption is that these scales will develop a check associated with stocking, often called the "stocking check." Confusion about or the invalidity of these assumptions may result in misinterpretation of scale features. These misinterpretations may lead to incorrect age assignments, although this is not an issue in Lake Superior because a 5-year rotational system of fin-clips is used to assign age to planted lake trout. A careful scale analysis, however, can provide more information than just age. For example, growth information can be extracted and related to other variables (Weisberg 1993; Cyterski and Spangler 1996) or used to assign age to fish that have ceased growing (Ogle et al. 1994, in press). Misinterpretation of scale features may lead to incorrect conclusions in studies involving growth of planted lake trout.

We identified "checks" on scales from planted lake trout that met the general (Casselman 1987) and specific criteria (Cable 1956) of "annuli," except that they may not have formed annually. We define a check as a break or change in spacing of the circuli that can be identified in all regions of the scale. In this we differ from Casselman (1987), who defined a check as any break or change in the spacing of the circuli. Casselman (1987) also stated that a check identified in all regions of the scale is often considered to be an annulus. Thus, what we call a check will be labeled an annulus by many researchers. We specifically do not use annulus because, as we will show, more than one check that has the characteristics of an annulus may form during the 18–20 months of hatchery and immediate posthatchery life of lake trout released into Lake Superior.

Aspects of the hatchery environment or husbandry techniques may cause checks to form. These aspects include rhythmic temperature patterns (DeBont 1967; Bigelow and White 1996), photoperiod (DeBont 1967; Hogman 1968), biomass or density (e.g., Refstie 1977), changes in feeding patterns (Van Oosten 1961; DeBont 1967; Bigelow and White 1996), or stress caused by handling (Coble 1970; Ottaway and Simkiss 1977). The occurrence and relative timing of these events will determine the appearance and number of checks that may form on scales. For example, two distinct checks may form on the scales of fish raised in a hatchery with low water temperatures during midwinter and decreased feeding regimes in early summer.

A stocking check has been reported by some (Casselman 1986), but not all, lake trout scale interpreters. This inconsistency may be due to variability in handling, release site, interpreter, or the number of checks formed during hatchery life. For example, if no check forms during hatchery life but a stocking check does form, the stocking check is usually assumed to have formed during hatchery life. Alternatively, if two checks form during hatchery life but no stocking check forms, the sec-

TABLE 1.—Characteristics of the environment and husbandry practices at study hatcheries and the samples of lake trout. Ages are approximated as the number of days from the midpoint of the range of hatch dates. Abbreviations for dates are e = early month (1–10), m = midmonth (11–20), and l = late month (21–31). Fin-clips used were adipose (Ad) plus left pectoral (AdLP), left pelvic (AdLV), right pectoral (AdRP), or right pelvic (AdRV).

Hatchery (abbreviation)	Water source	Hatch dates (Dec 1991–Feb 1992)	Transfer date (1992)	Clipping dates (Sep 1992–May 1993)	Fin clip	Sample Date (1993)	Sample Age (d)	Release Date (1993)	Release Age (d)
Hiawatha Forest (HF)	Surface	l Jan–e Feb[a]	9 Jul[a]	l Apr	AdLP	7 Jun	494	7 Jun	494
Iron River (IR)	Surface	l Jan–e Feb		e Mar	AdLV	27 May	483	7–8 Jun	494
Crystal Springs (CS)	Ground	l Dec–m Jan		e Apr–m May	AdRV	4 May	483	7–9 Jun	518
St. Paul (SP)	Ground	l Dec–m Jan[b]	4 Nov[b]	l Apr	AdRPLV, AdRP	22 Mar	440	7–9 Jun	518
Peterson (P)	Ground	m Dec–m Jan		l Sep–e Oct 92	Ad	3 May	488	17 May[c]	502

[a] Originated at Iron River.
[b] Originated at Crystal Springs.
[c] Released in northern Minnesota lakes, not Lake Superior.

ond check is usually assumed to be a stocking check. In both cases, an incorrect judgment is made and further analyses may be affected.

Our objective was to determine the number of checks on the scales of hatchery-reared lake trout prior to and soon after release into Lake Superior in 1993. In addition, we related the timing of check formation during hatchery life to attributes of hatcheries (e.g., temperature) or rearing (e.g., transfers and fin-clipping).

Methods

Hatchery characteristics.—Lake trout examined in this study were raised in five hatcheries as part of the 1992 year-class. Physical characteristics and husbandry practices that may have affected the number and position of checks on the scales differed among the hatcheries (Table 1). Seasonal variations in temperature were observed at Hiawatha Forest and Iron River, which have surface water sources, but not at Crystal Springs, St. Paul, or Peterson, which have groundwater sources (Figure 1). Fish from Crystal Springs, St. Paul, and Peterson were raised in complete darkness except for occasions when light was required for hatchery personnel to perform required tasks. Fish from Iron River and Hiawatha Forest were exposed to natural photoperiods. The density of fish at Crystal

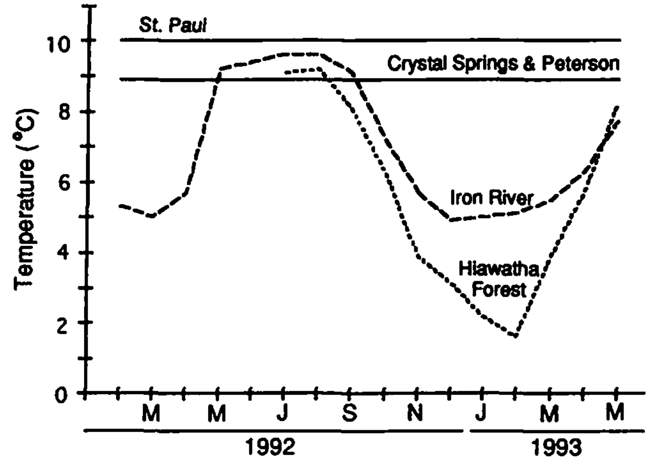

FIGURE 1.—Mean monthly temperatures in the five hatcheries.

Springs was reduced by 63% on 4 November 1992, and 16% of the fish were transferred to St. Paul. Approximately 70% of the fish in Iron River were transferred to Hiawatha Forest on 9 July 1992. Some fish were not fed during fin-clipping and for short periods (usually a day) during routine inventories. Hiawatha Forest fish were fed for only 7 d in February 1993 because of frozen raceways. All hatcheries used Isle Royale strain broodstock except Peterson, which used Gillis Lake broodstock.

Data collection.—Prerelease scale characteristics were identified for 176 fish removed from the hatcheries before lots were released (Table 1). Postrelease scale characteristics were identified from fish collected in bottom trawls and small-mesh experimental gill nets fished in the general area of the release site (near Two Harbors, Minnesota) on 15, 16, and 28 July 1993. All sampled fish were frozen after being removed from a hatchery or captured in Lake Superior. In the laboratory, the total length (TL) of each fish was measured to the nearest 1 mm and scales were removed from just above the lateral line below the posterior base of the dorsal fin. Approximately 20 scales from each fish were impressed in acetate. A subset of scales that were not regenerated, abraded, badly asymmetrical, or poorly pressed in the acetate were identified. Four scales from this subset were randomly selected, magnified 90×, and printed with a Minolta® RP405E microfiche reader.

The four selected scales were examined in random order for the existence and location of checks. A check was identified if one or more of the following characteristics were evident at approximately the same proportional distance from the scale focus around most of the scale: (1) circuli that "cut over" previously formed circuli, (2) a distinct change from narrow to wide intercirculus distance, (3) circuli that extended into the posterior field, and (4) thin, irregularly shaped circuli (Cable 1956; Casselman 1987). The circulus that cut over previous circuli or the first circulus after a distinct widening of the intercirculus distance defined the exact location of the check.

The position of each check was characterized by counting the number of circuli and measuring the distance from the focus to each check along a radius drawn at 45° to the ventral side of the main anterior–posterior axis (Figure 2). This radius was chosen because lake trout scales grow to an older age in the posteriolateral and posterior fields than in the other fields (Casselman 1990), but circuli form incompletely or irregularly in the posterior region of the scale. Only circuli that were within a 1-mm band on each side of the radius on the magnified scale were counted. Each check was given a "conspicuousness" score between 1 and 9 (least to most conspicuous) that subjectively scored the evidence for the four criteria of a check (J. Casselman, Ontario Ministry of Natural Resources, personal communications). The total number of circuli and the distance from the focus to the scale edge were recorded.

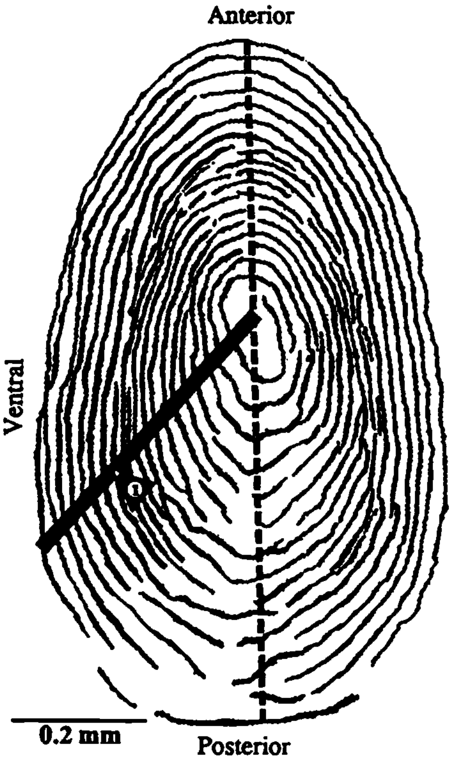

FIGURE 2.—Scale from an Iron River lake trout showing the main anterior–posterior axis (vertical dashed line) and the radius for making circulus counts and distance measurements (thick solid line). The width of the measurement radius corresponds to the band that a circulus must be within to be counted. One check, with a conspicuousness score of 8, is shown. This image is a digitally enhanced version of a scanned printout made from a scale impression.

After all scales had been examined individually, the four scales from a given fish were compared to determine a single number of checks for the fish. As an example of this determination, consider the case where three scales had one check and the fourth scale had no checks. If the fourth scale had a break in the circuli that was not considered a check, but the break was in approximately the same proportional position as the check on the other three scales, the fish was considered to have one check. However, if no breaks were observed on the fourth scale, a single number of checks could not be determined and the fish was removed from further analyses.

For fish with more than one check, the "primary check" was the one that most nearly matched the position of single checks on scales of other fish from the same hatchery. The other checks were considered "secondary" or "tertiary." This categorization was needed only so that checks that occurred at approximately the same position were considered the same. Thus, the primary check occurred on nearly all fish at approximately the same position, whereas the other checks occurred on only some fish and at a wide variety of positions. The circulus counts and radial measurements to each check were averaged across the four scales for further analyses.

Statistical analyses.—There was no evidence against normality (Shapiro–Wilk test; $P > 0.05$) for all measures (distances, number of circuli, and back-calculated total fish lengths), except for the distance and number of circuli to the scale edge of postrelease fish from the Iron River hatchery. Because these two measures were used only in tests that are robust to slight departures from normality (Montgomery 1991), none of the data were transformed.

For prerelease fish, likelihood ratio tests (LRTs), computed from parameters estimated with log-linear models (Agresti 1996), were used to test, among hatcheries, the odds of (1) observing the same number of checks on all four scales and (2) observing only one check when a single determination was made. One-way analyses of variance and post hoc multiple comparisons (Student–Newman–Keuls tests) were used to test for similarities and differences among hatcheries in (1) the distance to each check, (2) number of circuli to each check, and (3) the TL of prerelease fish. Among-hatchery differences in the distribution of conspicuousness scores for the primary check of prerelease fish were tested with a Kruskal–Wallis test (Sprent 1989).

Among-hatchery differences in within- and among-fish variation in distance to the primary check were examined with a random-effects analysis of covariance model (SAS Institute 1988) computed separately for each hatchery. In these models, distance to the primary check was the dependent variable, a unique fish identifier was the block (main) effect, and distance to the scale edge was a covariate effect. The within-fish variance was estimated by the mean square for error. The among-fish variance was estimated by taking the difference between the mean squares for block and error and dividing by k, a constant that differed among hatcheries and, because of the covariate, was slightly less than the number of scales sampled per fish (four). The inclusion of the covariate is a modification of Newman and Weisberg's (1987) approach.

Log-linear model LRTs were used to test, among hatcheries, the conditional odds (hatchery held constant; Agresti 1996) that additional checks had formed since the fish were released. To determine which check existed prior to release, the distance and number of circuli to each postrelease check were compared with those of each prerelease check with pooled-variance t-tests. Similarly, the measures were compared between each postrelease check and the prerelease scale edge to determine if the postrelease check formed near the time of release.

The timing of check formation in the hatcheries was estimated by comparing the back-calculated mean TL at check formation with the monthly mean TL of fish in a large random sample collected at the end of each month from each hatchery. The TL when each check formed was estimated with a linear form of the scale-proportional model for back-calculation (Francis 1990). A separate model was used for fish from each hatchery (parameter estimates were significantly different).

Results

Fish Growth in the Hatchery

Growth in the hatchery peaked or plateaued in the summer of 1992, was minimal during the winter, and then increased in the spring prior to stocking (Figure 3). The period of minimal growth was longer in Hiawatha Forest and Iron River than in the other three hatcheries. The monthly mean TL increment and mean temperature were positively correlated for Hiawatha Forest ($r = 0.89$, $P = 0.0003$) and Iron River ($r = 0.49$, $P = 0.0764$). In Crystal Springs, the minimum TL increment followed a decrease in density when fish were transferred to St. Paul (Figure 3). A similar decline was also observed for the fish transferred to St. Paul. The minimum TL increment for fish in the Peterson hatchery appeared unrelated to any variable or event that we monitored.

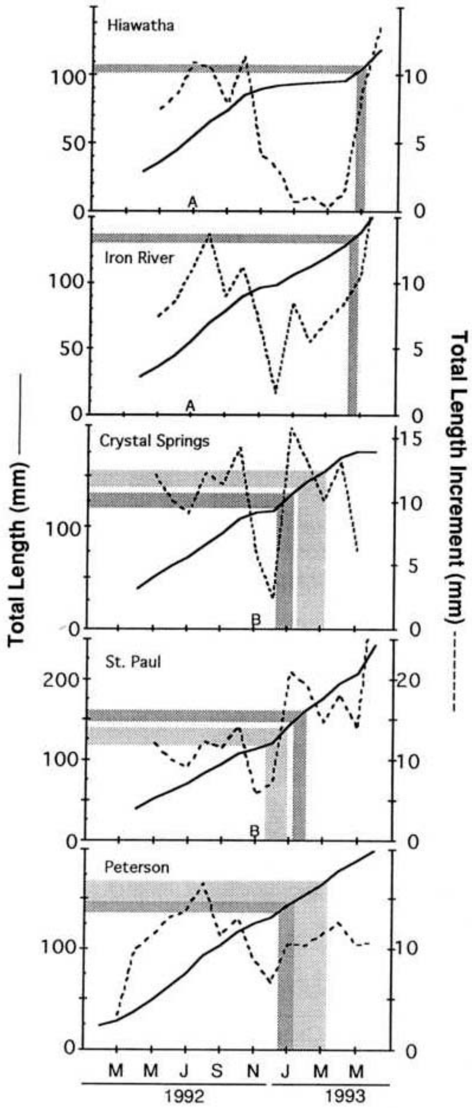

FIGURE 3.—Mean monthly total length (TL, solid line) and TL increment (dashed line) for fish from each hatchery. The dark shaded bar extending from the TL axis to the solid line in each panel is centered on the mean back-calculated TL at formation of the primary check on scales of prerelease fish. The width of the bar corresponds to the 95% confidence interval (CI) for the mean. The points where the CI bounds intersect the solid line are extended down to the time axis to estimate when the check formed. The lighter shaded bar in some panels follows the same conventions for the secondary scale check. The letter A represents when the fish were transferred from Iron River to Hiawatha Forest; B represents when fish were transferred from Crystal Springs to St. Paul. The time axis is scaled in bimonthly intervals from March 1992 to May 1993.

Prerelease Characteristics of the Scales

Of 176 prerelease fish, 77% had one check, 1% had no checks, and none had two checks on all four scales examined (Table 2). Of the remaining fish, 15% had either no or one check and 7% had one or two checks on at least one of the four scales. The odds of all four scales having the same number of checks were not different between Hiawatha Forest and Iron River (G^2 = 0.73, df = 1, P = 0.3927) or among Crystal Springs, St. Paul, and Peterson (G^2 = 3.29, df = 2, P = 0.1931), but were different between the two groups of hatcheries (G^2 = 16.3, df = 1, P = 0.0001). The odds of observing the same number of checks on all four scales from one fish were 4.9 times greater (95% confidence interval, CI: 2.1–11.5) for fish from Hiawatha Forest and Iron River than for fish from the other three hatcheries.

Of 173 fish for which a single number of checks was reconciled among all four scales, 91% had one check, 7% had two checks, and one had no checks (Table 3). The odds of having only one check were not different between Hiawatha Forest and Iron River (G^2 = 1.33, df = 1, P = 0.2494) or among Crystal Springs, St. Paul, and Peterson (G^2 = 1.45, df = 2, P = 0.4835), but were different between the two groups of hatcheries (G^2 = 9.76, df = 1, P = 0.0018). The odds of having only one check were 11.7 times greater (95% CI: 1.5–92.9) for fish from Hiawatha Forest and Iron River than for fish from the other three hatcheries.

Characteristics of the lake trout and their scales at the primary check and scale edge also differed among hatcheries (Table 4). For number of circuli, distance, and back-calculated TL at the primary check and for scale radius and TL at the scale edge, the hierarchy of significant differences among hatchery groups was (Peterson and St. Paul) > (Iron River and Crystal Springs) > Hiawatha Forest (all tests: df = 4, 170; $P < 0.0001$). However, for number of circuli to the edge of the scale, the hierarchy was Peterson > (St. Paul and Crystal Springs) > Iron River > Hiawatha Forest (df = 4, 170; $P < 0.0001$). The conspicuousness scores for the primary check differed among hatcheries (Kruskal–Wallis test; P = 0.0001). Scales from Hiawatha Forest were most "conspicuous" (mean, 7.2), those from Crystal Springs were least "conspicuous" (4.8), and scales from the other hatcheries were intermediate (approximately 6; post hoc Kruskal–Wallis analysis). For fish from all hatcheries, the primary check on the scales formed just

TABLE 2.—Percentages of prerelease lake trout, by hatchery, categorized by the number of checks observed on the four scales examined for each fish. Hatchery abbreviations are defined in Table 1.

Checks observed on the four scales	Hatchery HF ($N = 43$)	IR ($N = 40$)	CS ($N = 27$)	SP ($N = 27$)	P ($N = 39$)	Total ($N = 176$)
All four scales had the same number of checks						
All 0	0.0	0.0	0.0	0.0	2.6	0.6
All 1	93.0	87.5	51.9	74.1	66.7	76.7
All 2	0.0	0.0	0.0	0.0	0.0	0.0
All four scales did not have the same number of checks						
Some 0, some 1	7.0	12.5	25.9	11.1	20.5	14.8
Some 1, some 2	0.0	0.0	14.8	14.8	10.3	6.8
Some 0, some 2	0.0	0.0	0.0	0.0	0.0	0.0
some 0, 1, and 2	0.0	0.0	7.4	0.0	0.0	1.1

after the minimum TL increment occurred (Figure 3).

Within-fish and among-fish variation in distance to the primary check also differed among hatcheries. The within-fish coefficient of variation (CV = SD/mean) was substantially lower for fish from Hiawatha Forest (0.0010) and Iron River (0.0013) than for those from the other three hatcheries (0.0029–0.0041). The among-fish CV was lower for the Iron River (0.0009) and Hiawatha Forest fish (0.0014) and much greater for Crystal Springs fish (0.0112) than for the other two hatcheries (0.0020–0.0046). The ratio of within-fish to among-fish CV was 0.36 for fish from Crystal Springs, approximately 0.74 for Hiawatha Forest and Peterson fish, and approximately 1.44 for Iron River and St. Paul fish.

TABLE 3.—Percentages of pre- and postrelease lake trout, by hatchery, categorized by the single number of checks reconciled among four scales from a fish. "Mixed" means that a single number of checks could not be reconciled for the four scales. Hatchery abbreviations are defined in Table 1.

Checks	Hatchery HF	IR	CS	SP	P	Total
Prerelease fish[a]						
0	0.0	0.0	0.0	0.0	2.6	0.6
1	97.7	100.0	81.5	85.2	84.6	90.9
2	2.3	0.0	18.5	11.1	7.7	6.8
Mixed	0.0	0.0	0.0	3.7	5.1	1.7
Postrelease fish[b]						
1	100.0	66.7	84.6	30.0		74.5
2	0.0	13.3	15.4	70.0		20.0
3	0.0	20.0	0.0	0.0		5.5

[a] Sample sizes: HF = 43, IR = 40, CS = 27, SP = 27, P = 39, total = 176.

[b] Sample sizes: HF = 18, IR = 15, CS = 13, SP = 10, P = 0, total = 56.

Comparison of Pre- and Postrelease Characteristics

Mean TL was greater for postrelease than prerelease fish from three hatcheries ($P < 0.0007$) but not for Crystal Springs fish ($P = 0.1137$); no postrelease Peterson fish were captured. The change in TL between release and recapture was 41 mm for Iron River fish, 24 mm for St. Paul fish, and 7 mm for Hiawatha Forest fish.

The conditional odds (hatchery held constant) of having only one check differed between prerelease and postrelease fish from Iron River and St. Paul ($G^2 = 18.8$, df = 1, $P < 0.0001$), but not for Hiawatha Forest and Crystal Springs ($G^2 = 0.23$, df = 1, $P = 0.6320$; Table 3). Thus, the number of checks for pre- and postrelease fish from Hiawatha Forest and Crystal Springs did not differ. The conditional odds of having only one check was 13.5 times greater (95% CI: 3.8–48.4) for prerelease than for postrelease fish from Iron River and St. Paul.

Scales of fish from Iron River and St. Paul, but not from Crystal Springs and Hiawatha Forest, showed evidence of growth between the times of release and recapture. The number of circuli and distance to the scale edge were greater for postrelease than prerelease fish from Iron River and St. Paul (number of circuli: $P < 0.0001$; distance: $P \leq 0.0001$; Tables 4, 5). The distance to the scale edge did not differ ($P > 0.2$), but the number of circuli to the scale edge was slightly greater on postrelease fish from Crystal Springs ($P = 0.0520$) and Hiawatha Forest (0.0485).

The primary checks on pre- and postrelease lake trout generally corresponded. For each hatchery except Crystal Springs, either the distance or number of circuli to the primary check did not differ between pre- and postrelease fish (Table 6). For

TABLE 4.—Mean distances and numbers of circuli from the scale focus to the primary check, secondary check, and scale edge for prerelease lake trout, and mean total lengths of fish at the time of sampling and back-calculated to lengths at formation of the primary and secondary checks. Standard deviations are in parentheses. Along a row, means with a letter in common are not significantly different among hatcheries (Student–Newman–Keuls' test, $P > 0.05$). Hatchery abbreviations are defined in Table 1.

Scale feature	Hatchery				
	HF	IR	CS	SP	P
			Distance on radius (mm)		
Primary check	0.230 z	0.289 y	0.292 y	0.348 x	0.336 x
	(0.034)	(0.039)	(0.063)	(0.046)	(0.053)
Secondary check	0.231		0.357 z	0.233 y	0.413 z
			(0.027)	(0.031)	(0.035)
Scale edge	0.293 z	0.395 y	0.437 x	0.479 w	0.504 w
	(0.040)	(0.048)	(0.070)	(0.064)	(0.041)
			Number of circuli		
Primary check	10.9 z	13.5 y	13.4 y	15.5 x	15.5 x
	(1.6)	(1.7)	(3.0)	(2.1)	(2.5)
Secondary check	11.5		17.0 z	9.6 y	18.7 z
			(1.2)	(1.8)	(2.1)
Scale edge	13.9 z	18.1 y	20.7 x	21.6 x	23.6 w
	(1.5)	(2.1)	(2.6)	(2.8)	(2.3)
			Total fish length (mm)		
Primary check	105 z	133 y	126 y	154 x	141 x
	(9.2)	(10.0)	(19.7)	(16.9)	(14.3)
Secondary check	100		146 z	128 y	156 z
			(10.7)	(9.8)	(12.7)
Scale edge	112 z	149 y	163 x	175 w	175 w
	(9.9)	(12.3)	(23.3)	(22.8)	(20.0)

TABLE 5.—Mean distances and numbers of circuli from the scale focus to the primary, secondary, and tertiary checks and to the scale edge for post-release lake trout. Standard deviations are in parentheses. Hatchery abbreviations are defined in Table 1.

Scale feature	Hatchery			
	HF	IR	CS	SP
	Distance on radius (mm)			
Primary check	0.213 (0.022)	0.307 (0.054)	0.336 (0.063)	0.312 (0.060)
Secondary check		0.499 (0.097)	0.254 (0.016)	0.448 (0.057)
Tertiary check		0.646 (0.066)		
Scale edge	0.301 (0.024)	0.505 (0.138)	0.449 (0.058)	0.588 (0.085)
	Number of circuli			
Primary check	10.2 (1.2)	14.2 (2.4)	16.1 (2.7)	14.6 (2.8)
Secondary check		24.2 (5.7)	10.3 (1.1)	22.3 (3.5)
Tertiary check		35.3 (1.6)		
Scale edge	14.5 (1.1)	24.9 (8.8)	22.2 (2.4)	27.9 (3.4)

Crystal Springs, the distance and number of circuli to the primary check were greater for prerelease than for postrelease fish; however, neither the distance nor number of circuli differed between the secondary check on postrelease and the primary check on prerelease fish (Table 6). All other comparisons of distance or number of circuli to checks on postrelease fish differed from the same measure for secondary checks or the scale edge on prerelease fish, except that neither distance nor number of circuli differed between the secondary check on postrelease and the scale edge on prerelease fish from St. Paul.

Discussion

The assumption of a single check on the scales at the time of release does not appear to be grossly violated when a single determination of the number of checks is made from interpretations of several scales. Overall, 91% of the lake trout released into Lake Superior had only one check. Among fish raised in variable temperatures and photoperiods (Hiawatha Forest and Iron River) 98–100% had one check, but this percentage dropped to 82–85% among fish raised in constant temperatures and darkness (Crystal Springs, Peterson, and St.

TABLE 6.—Statistical significances (P-values) of comparisons between distance (upper value in paired lines) and number of circuli (lower value) from the scale focus to each check for postrelease fish and to each check and the scale edge for prerelease fish. Abbreviations are C1 = primary check, C2 = secondary check, C3 = tertiary check, HS = highly significant ($P < 0.003$), and VHS = very highly significant ($P < 0.0001$).

Post-release	Prerelease											
	Hiawatha Forest			Iron River			Crystal Springs			St. Paul		
	C1	C2	Edge	C1	C2	Edge	C1	C2	Edge	C1	C2	Edge
C1	0.03 0.06		VHS VHS	0.09 0.14		VHS VHS	0.02 0.01		VHS VHS	0.03 0.16		VHS VHS
C2				VHS VHS		HS VHS	0.21 0.08	HS HS	HS VHS	VHS VHS	VHS VHS	0.13 0.29
C3				VHS VHS		VHS VHS						

Paul). Overall, only 7% of the fish had two checks and 1% had no checks.

If only a single scale is considered, the assumption of a single check on the scales at the time of release may be violated for fish raised in constant temperatures and darkness. Four replicate scales all revealed one check for only 52–74% of the fish raised in constant temperatures and darkness, but for 88–93% of the fish raised in variable temperatures and photoperiod. Furthermore, the disagreement among the four scales was always the same for fish raised in variable temperatures and photoperiod (i.e., "some 0, some 1") but not for fish raised in the other hatcheries ("some 0, some 1" or "some 1, some 2"). The degree of violation of this assumption is reduced when several scales from the same fish are used to determine the number of checks.

Evidence for a stocking check was observed only on scales that had grown substantially between the times fish were released and recaptured in Lake Superior. Substantial scale growth was observed for fish from Crystal Springs and Hiawatha Forest, but not for fish from Iron River and St. Paul. Because of the short period between release and recapture, our data only suggest that stocking checks form on some fish. However, if the scales do not grow substantially before the winter cessation of growth, any stocking check that may form would be indistinguishable from the next annulus and it would appear as if a stocking check did not form.

The variability in position and appearance of checks was related to water temperature or photoperiod. Scales from fish exposed to seasonal fluctuations in temperature and photoperiod had the most consistent number of checks among the four scales examined and had the lowest within-fish and among-fish variability for distance to the primary check. In addition, checks were most conspicuous on fish from Hiawatha Forest. In contrast, scales from fish raised in nearly constant temperatures and darkness had less conspicuous and numerically less consistent checks and had higher within-fish and among-fish variability for distance to the primary check.

Other factors may be responsible for check formation on the scales of fish raised in nearly constant temperatures and darkness. Checks formed on the scales of fish from Crystal Springs and St. Paul after the densities of fish were reduced drastically. A check may form because the lower density results in increased growth (e.g., Refstie 1977) or because the move causes the fish stress (e.g., Coble 1970; Ottaway and Simkiss 1977). Fin-clipping may cause stress leading to check formation (Coble 1970; Ottaway and Simkiss 1977); however, our results do not provide any evidence for check formation during or soon after the period of fin-clipping. Finally, less conspicuous checks may form because of the effect of a factor or event at the individual level. This is suggested by the occurrence of secondary checks on only some fish.

Scales from hatchery-reared lake trout are not needed to assign age; however, valuable growth information can be obtained through careful interpretation of scale features. We have shown that most lake trout have one check on their scales when released into Lake Superior. We have not unequivocally determined whether or not a stocking check forms on all fish. Further examination for the occurrence of stocking checks is needed. Thus, a delineation between the periods of pre- and postrelease growth on a scale still cannot be made by simply counting the number of checks. Alternatively, perhaps characteristics of the scale could be found that could be used to delineate these two periods. Characteristics of the scale have already been used to differentiate between hatchery-reared and wild lake trout (Casselman 1986). It seems likely that those or similar characteristics could be used to distinguish between pre- and postrelease growth on the scales of hatchery-reared lake trout. If this distinction can be made, it would not be necessary to know how many checks appear on the scale at and soon after stocking.

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