Kiyi Age & Size Results

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11 November, 2015

# Methods

The June tows were cross-contour with a mean beginning depth of 26 m (range: 13-40), ending depth of 106 m (range: 68-144), and distance covered of 1.50 km (range: 1.47-1.53). The tows in July followed a depth contour, had a mean average depth of 186 m (range: 134-255), and a mean distance covered of 0.86 km (range: 0.76-0.91).

# Results

A total of 983 Kiyi were sampled in 2014. These fish were between 108 and 266 mm TL with a mean (SD) TL of 197 (19.3) mm. The length distribution of Kiyi from the Northern Ontario region differed significantly from the length distributions of Kiyi captured from all other regions (p<0.045), which did not differ (p>0.091). The Northern Ontario region had fewer longer fish, which resulted in a significantly shorter mean TL (p<0.017; Figure 2). In the subsample of 335 fish, four were juveniles and 60.1% of non-juvenile fish were female.

The examination of length frequencies from 2001 through 2014 revealed distinct modes near 80-100 mm in 2004, 2006, and 2010 (Figure 3). These modes corresponded to age-1 fish as Kiyi hatch at approximately 20 mm in early spring (CITATION). Thus, these cohorts corresponded to ages 11, 9, and 5, respectively, in 2014. There was little evidence for the 2005 cohort in 2007 which suggests few age-9 fish may exist in 2014.

Ages were estimated by two readers from 288 thin-sectioned otoliths. Of these otoliths, 22 (7.6%) were deemed unreadable (cracked or cloudy image) and were removed from further consideration. Ages estimated from the two readers perfectly agreed for 72.6% of the otoliths, agreed within one year for 97.0% of the otoliths, had a between-reader ACV of 2.8, and showed no significant systematic bias (p=0.445; Figure 4). However, the mean estimated age for the second reader was slightly greater when the first reader estimated an age of 5 (95% CI: 5.1-5.4; p<0.001) and slightly lower when the first reader estimated an age of 12 (95% CI: 11.1-11.8; p=0.0). Mean scale age for each otolith age was less than the otolith age for all observed otolith ages with adequate sample sizes (p<0.039; Figure 5).

Kiyi for which a consensus otolith age estimate was obtained were used to generate ALKs. Four Kiyi less than 140 mm TL (all of the juvenile fish) were excluded from all ALK analyses because of sample size considerations. An additional seven fish that were estimated to be age-13 or older were also removed from the analysis that compared ALKs among regions because of sample size considerations. Age-length keys did not differ significantly between sexes within any region (p>0.109) or among regions when sexes were pooled (p=0.104). Despite this finding, to minimize the loss of any regional differences in the relationship between age and length, region-specific observed age-length keys were generated and used to assign ages by region to the 979 sampled Kiyi that were longer than 140 mm.

The age distribution was bimodal in each region (Figure 6) with an upper mode centered at age-11 in all five regions and a lower mode that consisted of nearly equal numbers of age-5 and age-6 fish in all regions except for Eastern Michigan where there were nearly twice as many age-5 as age-6 fish. The age distribution, after age-4 and 5 fish were pooled and age-11 and older fish were pooled within each region for sample size reasons, differed significantly among regions (p<0.001). Variability around the age-11 mode and the relative frequency of intermediate aged (ages 7-9) fish appeared to explain much of the difference in age distribution among regions.

The slopes of the weight-length relationships did not differ between sexes (), among regions (), or due to the interaction between sex and region (). The intercepts, however, differed between the sexes () and among the regions (), but not due to the interaction of sex and region (). Post hoc contrasts found that the the intercept for females was greater than for males for fish from Eastern Michigan (), but there were no differences between sexes for any other region (p>). Post hoc contrasts showed that the intercepts did not significantly differ among regions for male Kiyi (), but that the intercept for females from Eastern Michigan and Southern Ontario did not signficantly differ (), but were significantly greater than for females from all other regions (p<) except for when Southern Ontario was compared to the Western Arm (). The intercepts for females from the Western Arm, Northern Michigan, and Northern Ontario did not significantly differ (p>).

# Results for tables

## Length and Age Characteristics

## 1-Way ANOVA results for mean TL

## region n nvalid mean sd min Q1 median Q3 max percZero siglets  
## 1 West 153 153 195.9 18.2 142 184 196 210 232 0 b  
## 2 NoMich 69 69 197.9 19.1 152 185 200 211 240 0 bc  
## 3 NoOnt 355 355 190.3 16.8 126 179 190 204 239 0 a  
## 4 SoOnt 65 65 202.0 22.3 126 187 204 218 253 0 bc  
## 5 EastMich 341 341 202.6 19.7 108 190 203 214 266 0 c

## Weight-Length Relationships

## Results from Individual Regressions

## sex region n r2 b log(a) adj.log(a) predW  
## 1 female Western Arm 40 0.945 2.935 -5.035 -5.329 48.665  
## 2 female Northern Michigan 31 0.915 3.058 -5.326 -5.339 47.529  
## 3 female Northern Ontario 49 0.956 2.962 -5.110 -5.341 47.324  
## 4 female Southern Ontario 26 0.924 3.233 -5.700 -5.309 50.953  
## 5 female Eastern Michigan 53 0.958 3.151 -5.501 -5.298 52.175  
## 6 male Western Arm 29 0.907 2.677 -4.458 -5.336 47.885  
## 7 male Northern Michigan 17 0.926 3.432 -6.197 -5.361 45.139  
## 8 male Northern Ontario 37 0.945 3.083 -5.391 -5.347 46.669  
## 9 male Southern Ontario 18 0.915 3.304 -5.879 -5.328 48.709  
## 10 male Eastern Michigan 31 0.929 3.154 -5.543 -5.336 47.875

## Results from Multiple Comparisons of Intercepts

## Between Sexes, Within Each Region

## comp Contrast.1 Pvalue.1 adj.p sig  
## 1 male v. female, West -0.0070 0.4407 1.0000 FALSE  
## 2 male v. female, NoMich -0.0224 0.0470 0.7053 FALSE  
## 3 male v. female, NoOnt -0.0060 0.4564 1.0000 FALSE  
## 4 male v. female, SoOnt -0.0196 0.0876 1.0000 FALSE  
## 5 male v. female, EastMich -0.0374 0.0000 0.0003 TRUE

## Between Regions for FEMALES

## comp Contrast.1 Pvalue.1 adj.p sig  
## 1 female, West v. NoMich 0.0103 0.2504 1.0000 FALSE  
## 2 female, West v. NoOnt 0.0121 0.1271 1.0000 FALSE  
## 3 female, West v. SoOnt -0.0200 0.0341 0.5458 FALSE  
## 4 female, West v. EastMich -0.0303 0.0001 0.0028 TRUE  
## 5 female, NoMich v. NoOnt 0.0019 0.8263 1.0000 FALSE  
## 6 female, NoMich v. SoOnt -0.0302 0.0025 0.0493 TRUE  
## 7 female, NoMich v. EastMich -0.0405 0.0000 0.0001 TRUE  
## 8 female, NoOnt v. SoOnt -0.0321 0.0004 0.0092 TRUE  
## 9 female, NoOnt v. EastMich -0.0424 0.0000 0.0000 TRUE  
## 10 female, SoOnt v. EastMich -0.0103 0.2492 1.0000 FALSE

## Between Regions for MALES

## comp Contrast.1 Pvalue.1 adj.p sig  
## 1 male, West v. NoMich 0.0257 0.0248 0.4247 FALSE  
## 2 male, West v. NoOnt 0.0112 0.2272 1.0000 FALSE  
## 3 male, West v. SoOnt -0.0074 0.5078 1.0000 FALSE  
## 4 male, West v. EastMich 0.0001 0.9922 1.0000 FALSE  
## 5 male, NoMich v. NoOnt -0.0145 0.1854 1.0000 FALSE  
## 6 male, NoMich v. SoOnt -0.0331 0.0091 0.1723 FALSE  
## 7 male, NoMich v. EastMich -0.0256 0.0236 0.4247 FALSE  
## 8 male, NoOnt v. SoOnt -0.0186 0.0834 1.0000 FALSE  
## 9 male, NoOnt v. EastMich -0.0111 0.2226 1.0000 FALSE  
## 10 male, SoOnt v. EastMich 0.0075 0.4971 1.0000 FALSE