Estimating the Size and Age of Smallmouth Bass (*Micropterus dolomieu*) and Yellow Perch (*Perca flavescens)* Consumed by Double-Crested Cormorants (*Phalacrocorax auritus*) in the Eastern Basin of Lake Ontario, 1998

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The health of the smallmouth bass (*Micropterus dolomieu*) population in the eastern basin of Lake Ontario is the focus of intense public scrutiny and resource agency study. The relative abundance of the smallmouth bass population is currently near the lowest level observed, caused partly by increased mortality at younger ages (Chrisman and Eckert 1998). Related to the decline in numbers of smallmouth bass, the catch per angler hour in the 1998 eastern basin fishery was at its lowest level recorded in three decades (McCullough and Einhouse 1998).

Yellow perch stocks in the eastern basin declined in the early 1980s, probably in response to alewife predation on young-of-year fish and intense commercial fishing (Eckert 1998b). In recent years, yellow perch reproductive success has improved, producing more young-of-year, but fewer yellow perch are surviving to older ages compared to the earlier years (Eckert 1998b).

In the late 1970s, double-crested cormorants (*Phalacrocorax auritus*) began to re-populate Little Galloo Island in the eastern basin of Lake Ontario; peaking at over 8,000 nesting pairs in 1996, but declining to 5,839 in 1998 (NYSDEC 1998). Based on an examination of pellets (regurgitated, undigested fish remains) during the 1990s, annual estimates of fish consumption by double-crested cormorants in eastern Lake Ontario ranged from approximately 200,000 to 1.25 million smallmouth bass, annually (Ross and Johnson 1995, in press). Yellow perch (*Perca flavescens*) were a far more important component in the diet, with double-crested cormorants consuming 9 and 14 million yellow perch annually from 1993 to 1996, the second most abundant prey item after alewives (*Alosa pseudoharengus*, Ross and Johnson 1995, in press).

Although the consumption of substantial numbers of smallmouth bass and yellow perch by double-crested cormorants was well documented in the eastern basin of Lake Ontario, little is known about the sizes and ages of fish consumed. Studies done on Oneida Lake showed that smallmouth bass eaten by double-crested cormorants were primarily (55%) young-of-year smallmouth bass, not older ages or larger sizes (C. M. Adams, unpublished data). If this were the case for Lake Ontario, the reported consumption of 200,000 to 1.25 million smallmouth bass would be less of an impact on the smallmouth bass population than if older ages were targeted (Adams et al 1998).

The purpose of this study is evaluate the size and age structure of the smallmouth bass and yellow perch that were consumed by double-crested cormorants in 1998. The age composition of fish consumed by double-crested cormorants is crucial to modeling the effect of bird predation on smallmouth bass and yellow perch stocks in the eastern basin of Lake Ontario. Three separate approaches were used to provide this information: 1) smallmouth bass and yellow perch were collected from the stomachs of double-crested cormorants, 2) smallmouth bass were recovered from the regurgitate of double-crested cormorant chicks, and 3) smallmouth bass and yellow perch otoliths retrieved from

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pellets expelled by double-crested cormorants were used to predict size and age.

Methods

Between May 6 and July 15, 1998, ninety-eight double-crested cormorants were shot by NYSDEC law enforcement staff for use in quantitative diet studies. Because the main focus of the these studies was to describe the sizes and ages of smallmouth bass eaten by double-crested cormorants, most birds were taken on bass grounds. No birds were collected over deep water, where bass are not likely to occur; nor were they taken near Little Galloo Island, the largest breeding colony in the eastern basin of Lake Ontario. Most birds were shot at mid-afternoon and were immediately tagged to indicate time and location, and were then stored on ice. Twenty-nine double-crested cormorants were processed the same day, within a few hours of collecting; the remainder were examined the following morning (approximately 17 hours after they were shot). Prior to removing the stomach, each bird was weighed on an autopsy scale to the nearest 5 grams, and again after the stomach was removed. Fish recovered from the stomachs were identified to species and measured to the nearest mm of total length. Scale and otolith samples were taken when available. After removing fish from the stomach, the stomach was flushed, strained and the fine material stored for later analysis.

One feature of double-crested cormorant chick behavior facilitated the collection of smallmouth bass for diet study. During the period when chicks are flightless and being fed by adult birds, they regurgitate any food that may be present in their stomachs, if they are approached or threatened. During routine visits to Little Galloo Island, any smallmouth bass that were regurgitated by chicks were saved for more detailed examination. From June 5 to July 23, 83 smallmouth bass were collected from Little Galloo Island, and an additional 35 were taken from Pigeon Island, Ontario on July 16 and 24. For those smallmouth bass that were relatively undigested (n=35), total length and caudal peduncle height were measured to the nearest mm. Otoliths and scale samples were taken and stored dry in vials and envelopes, respectively. For those smallmouth bass that lacked a tail (n=31), a scale sample was removed and the otolith extracted. For headless bass (n=47), the caudal peduncle height was measured and a scale sample taken.

Smallmouth bass and yellow perch otoliths were recovered from double-crested cormorant pellets collected from April 30 to September 23, 1998 from Little Galloo Island (Johnson et al 1998). Smallmouth bass otoliths recovered from double-crested cormorant pellets are often damaged by the digestive process. The degradation of the otoliths was recorded on an erosion index scale (Adams et al 1998), where the least eroded are Level 1 and most eroded are Level 5. Only minimally damaged otoliths, Levels 1 and 2, were used to estimate total length (n = 110). The maximum length of the smallmouth bass otoliths was taken along the longitudinal axis. Yellow perch otoliths are relatively uncomplicated, i.e., no rostrum and no filigreed edging that typifies smallmouth bass otoliths; 925 yellow perch otoliths were measured. Measurements for both species were made with a *Manostat* Fiberglas Dial Caliper. Otoliths were not compressed, since they can bend and break with only very slight pressure, and otolith length was recorded to the nearest 0.1 mm.

We used a total length-to-otolith length relationship to predict the total lengths of smallmouth bass from bass otoliths collected from pellets, and we also used this relationship to predict the length of those smallmouth bass without a tail that were regurgitated by chicks. The relationship between total length and otolith length of smallmouth bass was calculated from 80 smallmouth bass collected from gillnets in the eastern basin of Lake Ontario during July and August, 1998 (Eckert 1998a). The resulting relation (Figure 3) was then used to estimate total length of smallmouth from otolith length:

$$Y = 44.00X - 50.98$$

$$R^2 = 0.905$$

where:

Y = total length and X = otolith length

Because only one smallmouth bass otolith was recovered from many of the pellet samples, we tested to see if there was a significant difference in size of right and left otoliths. Three separate length measurements were made for each otolith (6 measurements per pair) for 101 smallmouth bass collected with gillnets and chick regurgitate. A one-way ANOVA using the least significant difference (LSD) method to compare means showed there were no differences among the six samples ($P>0.05$). For each fish, a difference in otolith length was calculated by subtracting the average for the three right otolith measurements from the average for the left otolith. The mean difference was small (0.047 mm) and non-significant (One Sample T-test, $P>0.05$). These results indicate that either otolith can be used to predict length, and furthermore, no improvement is likely to be made in the total length-to-otolith length relation by segregating the otoliths.

We used a total length-to-caudal peduncle height relationship to predict total lengths from headless smallmouth bass recovered from chick regurgitate samples. Total length and caudal peduncle height measurements were taken from 114 smallmouth bass collected from gillnets in the eastern basin in 1998 (Figure 2). The predictive relationship was:

$$Y = 8.55X + 31.94$$
$$R^2 = 0.984$$

where:

Y = total length and X = caudal peduncle height.

The total length of yellow perch was predicted using a total length-to-otolith length relationship described for yellow perch in Oneida Lake (C. M. Adams, personal communication), where the predictive relationship was:

$$Y = 37.17X + 29.40$$
$$R^2 = 0.977$$

where:

Y = total length and X = otolith length

Estimated total lengths of smallmouth bass were then used to estimate age composition by using an age-length key calculated from fish collected by NYSDEC in the eastern basin of Lake Ontario in August 1998 (Eckert 1998a). Otolith estimates of total lengths were arranged into 25 mm size groupings and apportioned according to the distribution of ages within each size group.

A One-Way ANOVA using the least significant difference method to compare sample means was used to test for statistical differences in size distributions. In those cases where size variances were unequal (Bartlett’s Test), a Kruskal-Wallis One-Way ANOVA was used to compare mean ranks, a Chi-Square test was used to determine if age distributions were homogeneous, and trends in size were tested using linear regression analysis comparing the slope to zero.

Results

Double-crested Cormorant Stomach Data: Of the 98 double-crested cormorants collected for stomach analysis, 9 were immature, 31 were females, 56 were males, and 2 were unknown. Males were significantly heavier than females, 2,164 and 1,976 g, respectively ($P<0.05$). Weight of immature birds was intermediate, averaging 2,107 g, and they were not significantly different from either males or females ($P>0.05$). Approximately one-third (34.4%) of the stomachs were empty. The difference in weight after the stomach was removed, i.e., the weight of an empty stomach, was 80 g. For those birds with fish in their stomachs, the average weight of the contents, excluding the stomach weight itself, was 116 g. Stomach contents of larger double-crested cormorants were significantly heavier than smaller birds ($P<0.05$). For example, the weight of stomach and contents for a 2,200 g double-crested cormorant was 82% greater than that for a 1,800 g bird. There was no relationship, however, between date collected and average weight of stomachs and contents (ANOVA, P>0.05).

Twelve species of fish were recovered from the stomachs. Alewife were the most abundant (47.6%) followed by yellow perch (20.2%), and sculpin (*Cottus sp.*,15.0%, Table 1). One bird greatly influenced the occurrence of sculpins, however. Forty sculpins were found in four double-crested cormorants, but one bird contained 30 sculpins. Smallmouth bass represented 3.0% of all identified fish remains and were the fifth most abundant species found in the stomachs.

The size distribution of fish found in double-crested cormorant stomachs ranged from a 48 mm (1.8 in) darter (*Etheostoma sp.*) to a 300 mm (11.8 in) brown bullhead (*Ictalurus nebulosa*). Figure 3 represents the size distribution for those prey with sample sizes greater than 5. Total length of alewives ranged from 123 to 182 mm and averaged 154 mm (4.8-7.2, 6.1 in), yellow perch ranged from 95 to 185 mm and averaged 141 mm (3.7-7.3,5.6 in), and smallmouth bass ranged from 57 to 208 mm and averaged 148 mm (2.2-8.2, 5.8 in). Yellow perch ages ranged from 2 to 4 years and averaged 3.3 years (n=18, Table 2). Smallmouth bass averaged 2.7 years and ranged from 1 to 4 years (n=6).

<u>Chick Regurgitate Data:</u> Smallmouth bass recovered from double-crested cormorant chick regurgitate were used to help validate the total length-to-otolith relationship. We plotted the total length and otolith length for 26 smallmouth bass collected from double-crested cormorant chick regurgitate on the total length-to-otolith length relationship described using gillnetted fish (the crosses in Figure 1). We made a similar comparison for 28 smallmouth bass collected from chick regurgitate with both total length and caudal peduncle height measurements (crosses in Figure 2). Moreover, a more rigorous examination was made of 24 smallmouth bass recovered from chick regurgitate where total length, otolith length and caudal peduncle height were available for each fish. Actual total length for each fish was compared with estimates of total length from otolith length and caudal peduncle height. Among the three groups there was no significant difference in total length (ANOVA, P>0.05). For incomplete samples of smallmouth bass, (head-less and tail-less fish), total length was then estimated using the appropriate regression. In those instances where both otolith and caudal peduncle estimates of total length were available, an average was used to describe total length. The resulting length frequency for 111 smallmouth bass recovered from chick regurgitate is provided in Table 3; the modal size group was 200 mm (7.9 in), the overall mean total length was 199 mm (7.8 in) and 5.4% of the smallmouth bass were over 254 mm (10 in).

It may be impossible to identify yearling smallmouth bass from an examination of otoliths. Due to the lack of a prominent rostrum, otoliths extracted from a 77 mm and 81 mm (3 in) smallmouth bass recovered from chick regurgitate could not be differentiated from yellow perch otoliths. These sizes are associated with yearling smallmouth bass, and the two fish represented 1.8% of the regurgitate sample.

The length frequency distribution of smallmouth bass was used to estimate age composition by applying the lengths to an age-length key developed from smallmouth bass collected in summer gillnet surveys of the eastern basin by NYSDEC (Eckert 1998a). The estimated age distribution of the 111 smallmouth bass regurgitated by double-crested cormorant chicks ranged from ages 1 to 7, the mean age was 2.7 years, and the modal group was age 3 (Table 4). Age composition of smallmouth bass was also determined by aging the scales taken from regurgitated bass. This group of smallmouth bass ranged in age from 1 to 5, the mean age was 3.3 years, and the modal age group was age 3 (Table 4).

<u>Pellet Data:</u> For smallmouth bass otoliths recovered from double-crested cormorant pellets, total lengths predicted from Level 1 (least degraded) and Level 2 stages of otolith erosion were not significantly different, whereas

Levels 3-5 (most degraded) were significantly smaller (ANOVA, P>0.05), similar to that reported in Lake Ontario in 1993-94 (Adams et al 1998). Consequently, the length frequency distribution for smallmouth bass pellet samples was compiled for only those total lengths predicted from Level 1 and 2 otoliths (Table 3). Estimated total lengths ranged from 33 mm to 323 mm (1.3 to 12.7 in) with a mean length of 190 mm (7.5 in). Compared to the length distribution calculated from chick regurgitate data, the mean ranks of the two distributions were not significantly different (Kruskal-Wallis ANOVA P<0.05). Mean total lengths for each of 16 different collection dates are plotted in Figure 4. The individual sample means varied from 290 mm (11.4 in) collected on April 22 to 143 mm (5.6 in) from September 2. The decline in size throughout the summer was statistically significant (P<0.05), with a 55% decline in the predicted total length from April 22 (268 mm, 10.6 in) to September 2 (120 mm, 4.7 in).

The smallmouth bass length distribution estimated from the pellet samples was applied to the age-length key to calculate an age distribution (Table 4). The age composition of smallmouth bass, estimated from otoliths retrieved from double-crested cormorant pellets, ranged from 1 to 7 years with a mean age of 2.9 years. The age distribution of smallmouth bass collected in NYSDEC survey gillnets were compared to the four methods for estimating the age distributions of smallmouth bass consumed by double-crested cormorants (Figure 5). The modal group for all five age distributions was age 3. Smallmouth bass older than age 5 were common in the gillnet samples, but were rare in the diet of double-crested cormorants. Mean ages for all sample types described in Table 4 were similar, ranging from 2.7 to 3.3 years, although Chi-Square tests indicate the age distributions, excepting the stomach sample (too few fish), were all significantly different (P<0.05).

The length distribution of yellow perch estimated from 925 otoliths recovered from double-crested cormorant pellets is presented in Figure 6. Estimated total lengths from otoliths recovered from pellets ranged from 23 mm (0.9 in) to 257 mm (10.1 in); with a mean size of 112 mm (4.4 in). The length distribution of 38 yellow perch collected and measured from the stomachs of adult double-crested cormorants ranged from 95 mm (3.7 in) to 185 mm (7.3 in) and averaged 141 mm (5.6 in). These two distributions were significantly different from one another (Kruskal-Wallis ANOVA, P<0.05) with more small yellow perch represented in the pellet collection than stomachs. However, the upper end of both length distributions was similar, e.g., 190 mm (7.5 in). The size distribution of yellow perch captured in gillnets was very different from the two double-crested cormorant distributions (Figure 6). There was so little overlap in the gillnet distribution that it precluded using the age-length key from gillnetted fish to describe yellow perch age composition. For comparison, the length frequency distribution of yellow perch collected in bottom trawls during a June 1998 survey of the eastern basin showed a bi-modal distribution, with a 80 mm (3 in) peak representing yearlings and a 130 mm (5.1 in) peak comprised of age-2 and older yellow perch.

The size of yellow perch consumed by double-crested cormorants did not change throughout the bird's resident period in the eastern basin of Lake Ontario. Yellow perch mean total lengths were computed for 15 different sample dates from April 22 to September 2. When mean total lengths were regressed on collection date there was no statistically significant trend in the lengths (P>0.05).

Discussion

Because the feeding range was restricted for those birds shot for stomach content analysis, the composition results should not be used to describe double-crested cormorant diet. Rather, the purpose of this collection technique was to determine the size and age of smallmouth bass. Cormorants commonly regurgitated fish at the time they were shot; consequently, there was a high incidence of empty stomachs (34.4%) and other stomachs undoubtedly may have been partially evacuated. Therefore, weight of stomach contents should be considered a minimal estimate because the average weight of stomach contents (116 g) was less than the approximate 250 to 500 g average daily consumption reported elsewhere (Schramm et al 1987). However, we would not expect to find an entire day's ration in cormorant stomachs at the time they were collected, since they have more than one feeding period each day. The eight smallmouth bass recovered from stomachs represent 3% of the identified fish, which is twice as great as the 1.5% estimated from pellets in 1998 (Johnson et al 1998). The higher incidence of smallmouth bass in the stomachs was most likely related to shooting only those double-crested cormorants that were actively feeding on bass grounds within the eastern basin. The range in sizes of all fish recovered from stomachs (e.g., 48 to 300 mm) was similar to that described for double-crested cormorants feeding in Lake Erie (Bur et al 1998). Too few smallmouth bass, however, were recovered (eight) to confidently describe size and age for all the smallmouth bass consumed by double-crested cormorants in 1998, although there was general agreement with the size and age estimates from regurgitate and pellet samples.

In contrast to the small sample of bass recovered from stomachs, there were 111 smallmouth bass recovered from the regurgitate of double-crested cormorant chicks, and this proved to be an important source of information to estimate size and age of smallmouth consumed by double-crested cormorants. Since most smallmouth bass recovered from chick regurgitate are incomplete (lacking a head or tail), total length-to-otolith length and caudal peduncle height relationships enabled us to estimate total length from portions of a bass. The use of these predictive models is confirmed by the good agreement of regurgitate samples with these regressions (Figures 3 and 4), as well as the lack of significant differences in predicted mean lengths and actual total length for 24 smallmouth bass retrieved from chick regurgitate. For smallmouth bass collected in 1998, the upper size that was vulnerable to double-crested cormorants is about 300 mm (11.8 in). In 1993-94, however, 14.1% of smallmouth bass consumed by cormorants were larger than 305 mm (12 in, Adams et al 1998). This implies that larger bass are safe from predation, and most double-crested cormorant induced mortality on smallmouth bass is occurring prior to the size that angling mortality becomes an important factor. The minimum size limit for the smallmouth bass fishery in New York waters of the eastern basin of Lake Ontario is 12 in. (305 mm).

Because yearling smallmouth bass may be misidentified as yellow perch using otolith analysis, smallmouth bass may be under represented in double-crested cormorant consumption estimates, and yellow perch may be overestimated. However, the relatively few age-2 smallmouth bass in the age composition data implies that the low estimates of age-1 smallmouth bass in the diet of double-crested cormorants are probably correct. Also, because few smallmouth bass less than 100 mm (4 in) were collected from chick regurgitate, it suggests consumption of age-1 smallmouth bass by cormorants is minimal compared to consumption of ages 2-5.

Total lengths of smallmouth bass estimated from otoliths recovered from pellets were not statistically different from lengths estimated from regurgitate samples, but the lengths estimated from the pellet declined significantly, 55% from April 22 to September 2. The collection of pellet samples encompassed a greater length of time (133 days) than the regurgitate samples (48 days), but the median dates of collection were very similar -- June 27 and 29 for pellet and regurgitate samples, respectively. This could explain why there was no difference in size distributions for the two samples (same median date of collection), and why there was a significant decline in total length in the pellet samples (longer period of time in the collection). The decline in length for smallmouth bass consumed by double-crested cormorants is contrary to what would have been expected. During summer, smallmouth bass, particularly younger ages, are growing relatively quickly and we would have expected an increase in size of smallmouth bass. Most smallmouth bass consumed by double-crested cormorants in 1998 were between 150 to 250 mm (6 to 10 in) total length, and in 1993-94 most were between 200 to 300 mm (8 to 12 in, Adams et al 1998).

Smallmouth bass smaller than 150 mm were less common dietary components during both periods. If large numbers of smaller smallmouth bass were present in 1998, they could become more vulnerable to double-crested cormorant predation as they grew. The subsequent increase in proportion of smaller fish could thereby result in a smaller mean length.

Another alternative explanation may be linked to predation pressure. If predation were sufficiently intense and double-crested cormorants preferred slightly larger smallmouth bass, as they did in 1993-94 (Adams et al 1998), then the decline in total length may have been the result of intensive size selective predation, cropping-off the larger individuals.

In the eastern basin of Lake Ontario in 1998, the mean ages of smallmouth bass consumed by double-crested cormorants varied between 2.7 and 3.3 years for three independent samples and the modal age of each of the distributions was age-3. There were some differences in the distributions, however, particularly the proportion of younger fish. The age distributions using total length-to-otolith length regressions and age-length key expansions estimated at least 25% of consumption was composed of age-1 and age-2 bass (Table 4). In contrast, where scales were used to assign age directly, only 8.1% of smallmouth bass were age-1 and age-2 in the regurgitate. The most obvious explanation is that smaller, younger smallmouth bass were estimated from pellet data because pellets were collected through September when smaller bass were more common in the diet (Figure 4); whereas, regurgitate samples were limited to June and July. What confounds this interpretation, however, is the proportion of young smallmouth bass estimated from otoliths collected from regurgitate samples in June and July, 31.1% were age-1 and age-2. The higher incidence of younger ages seemed to be related more to the use of the age-length key. In adapting the key to our use, we had to arbitrarily assign ages to the smallest sizes of smallmouth bass because none were represented in the sample of gillnetted fish. In 1993-94, when cormorants were preying on larger sizes of smallmouth bass, only 5.7% of the 1993-94 smallmouth bass consumption were age-1 and age-2 (Adams et al 1998). It suggests that more smaller, younger smallmouth bass would be useful in developing age-length keys, particularly in years when small bass are targeted by double-crested cormorants. It also seems reasonable that the low frequency of age-1 and age-2 smallmouth bass estimated in the regurgitate samples using scales provides a better age assessment of smallmouth bass in the diet of double-crested cormorants during 1998.

In 1993-94, the mean age of smallmouth bass consumed by double-crested cormorants in the eastern basin of Lake Ontario was 4.4 years (Adams et al 1998). The difference between the 1993-94 estimate and the 3.3 year mean age reported in our study is most likely related to the age composition of the smallmouth bass that were in the population. The mean ages of gillnetted smallmouth bass less than age-6 were 4.3, 3.6 and 3.3 years for 1993, 1994 and 1998, respectively (T. Eckert Cape Vincent Fisheries Station, Cape Vincent, NY. personal communication). The correspondence between gillnet and cormorant samples suggests that double-crested cormorants and NYSDEC survey gillnets have similar selective characteristics (except for those smallmouth bass over 300 mm in gillnets), and that age-5 fish were more common in 1993-94 and age-3 smallmouth bass were more common in 1998. It also suggests that in future years the age of smallmouth bass targeted by double-crested cormorants may be approximated using the age distribution of gillnet samples for smallmouth bass smaller than 300 mm (12 in). The mean ages of smallmouth bass consumed by double-crested cormorants in Lake Ontario were in marked contrast to those described for Oneida Lake, where young-of-year smallmouth bass were the predominant age group eaten by double-crested cormorants (C. M. Adams, unpublished data). All methods used for estimating the age composition of smallmouth bass consumed by double-crested cormorants in this and the 1993-94 study (Adams et al 1998) indicate cormorants began feeding on age-2 fish, and that the bulk of consumption was composed of age-3 to 5 smallmouth bass.

The length frequency distribution of yellow perch collected in June bottom trawls in the eastern basin was probably representative of what was available, and they generally agreed with sizes of yellow perch recovered from double-crested cormorant stomachs (Figure 6). The length frequency of yellow perch recovered from double-crested cormorant stomachs suggests they were targeting age-2 and older yellow perch; few yellow perch smaller than 100 mm (3.9 in) were recovered from stomachs. In contrast, the length frequency distribution based on otoliths recovered from pellets suggests double-crested cormorants were preying on smaller yellow perch than were observed in stomachs. Indeed, nearly 15% of the lengths estimated from otoliths recovered from pellets were smaller than the smallest yellow perch collected in bottom trawls (70 mm, 2.7 in). There are two likely explanations. First, small yellow perch could have escaped the trawls, or second, there may have been some undetected erosion of the otoliths. Since bottom trawls can capture young-of-year alewives and smelt smaller than 70 mm, it is unlikely that all yellow perch smaller than 70 mm escaped through the meshes of the trawl. The very small yellow perch predicted from otoliths recovered from pellets may have been the result of slight erosion of the otolith while in the double-crested cormorant stomach. Since small otoliths were used in the total length-to-otolith length relation, we did not predict sizes beyond the scope of our regression. Hence, there was probably less error associated with predicting small total lengths of yellow perch than had small otoliths been missing from the relationship. We recognize the possibility that some erosion of yellow perch otoliths may have occurred.

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Table 1. Species composition of fish collected from double-crested cormorant stomachs from shallow water, bass grounds in the eastern basin of Lake Ontario, 1998.

Species	Total	Percentage
Alewife	127	47.6%
Spottail Shiner	6	2.2%
Brown Bullhead	4	1.5%
Channel Catfish	1	0.4%
Burbot	1	0.4%
Three-spine Stickleback	3	1.1%
White Perch	1	0.%
Rock Bass	8	3.0%
Smallmouth Bass	8	3.0%
Darter sp.	14	5.2%
Yellow Perch	54	20.2%
Sculpin sp.	40	15.0%
Total	267	

Table 2. Age frequency of yellow perch and smallmouth bass recovered from double-crested cormorant stomachs from shallow water, bass grounds from the eastern basin of Lake Ontario, 1998.

	Yellow Perch		Smallmouth Bass	
Age Group	Number	% Frequency	Number	% Frequency
1	0	0	1	16.7
2	3	16.7	1	16.7
3	7	38.9	3	50.0
4	8	44.4	1	16.7
Total	18	100.0	6	100.0

Table 3. Length frequency distributions for smallmouth bass from regurgitate and pellet samples collected from Little Galloo Island in 1998.

Size	Regurgitate		Pellets	
Group (mm)	Number	% Freq.	Number	% Freq.
25	0	0.0%	2	1.8%
50	0	0.0%	7	6.4%
75	2	1.8%	5	4.5%
100	1	0.9%	6	5.5%
125	5	4.5%	9	8.2%
150	18	16.2%	12	10.9%
175	31	27.9%	20	18.2%
200	36	32.4%	11	10.0%
225	11	9.9%	15	13.6%
250	4	3.6%	13	11.8%
275	2	1.8%	8	7.3%
300	1	0.9%	2	1.8%
325	0	0	0	0.0%
Total Number:	111		110	
Mean Length (mm):	199		211	
Mean Length (in):	7.8		8.3	

Table 4. Age composition (proportion) of smallmouth bass consumed by double-crested cormorants for four sample type collections made in the eastern basin of Lake Ontario, 1998. "Key" denotes a length frequency distribution applied to an age-length key.

Age Group	Stomach	Regurg-Scales	Regurg-Key	Pellets-Key
1	0.167	**0.023**	0.067	0.105
2	0.167	**0.058**	0.244	0.145
3	0.500	**0.547**	0.639	0.560
4	0.167	**0.314**	0.041	0.147
5		**0.058**	0.008	0.042
6			0.000	0.000
7			0.001	0.001
Sample:	6	**86**	111	62
Mean Age:	2.7	**3.3**	2.7	2.9

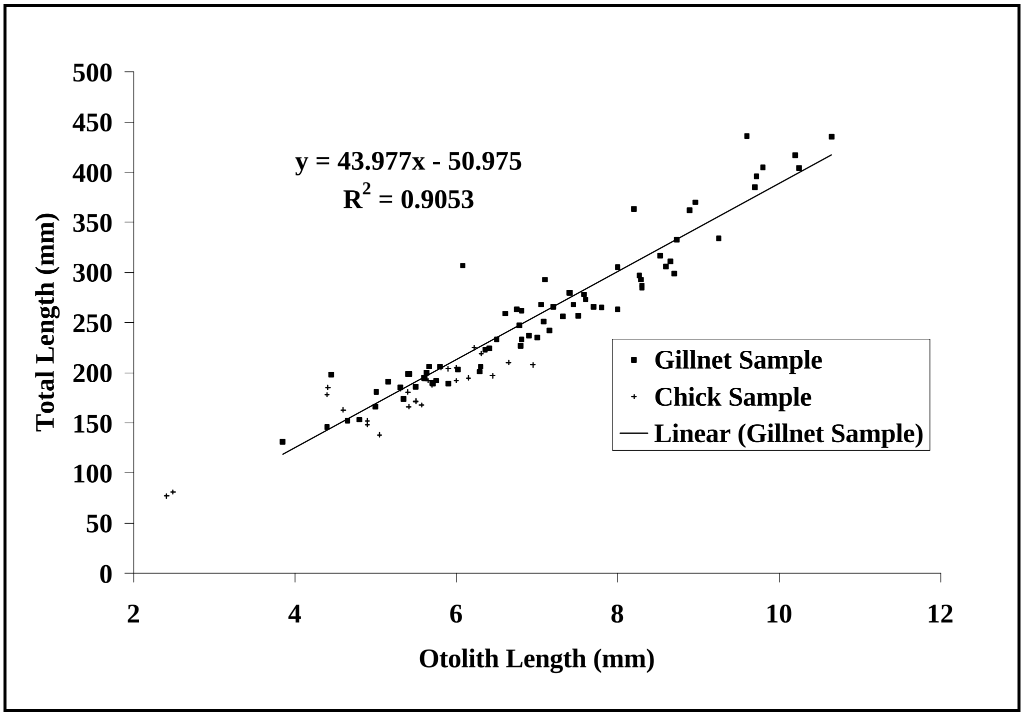

Figure 1. Relationship of total length to otolith length for smallmouth bass collected from gillnets in the eastern basin of Lake Ontario, 1998. The chick sample represents smallmouth bass recovered from chick regurgitate; these points were not included in the calculation of the regression equation.

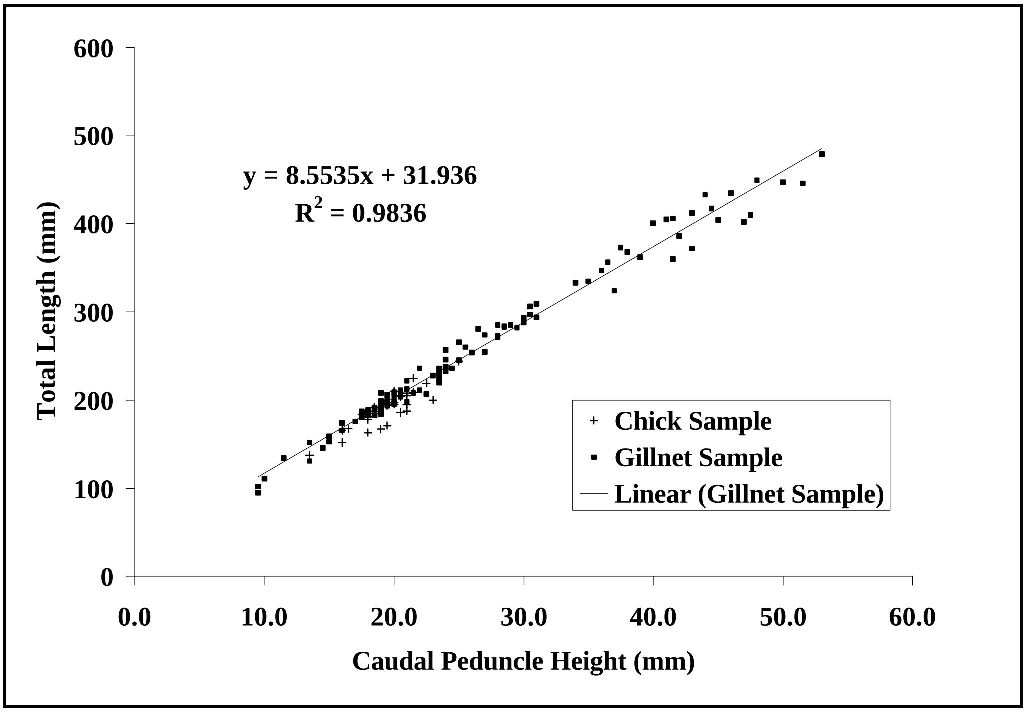

Figure 2: Relationship of total length to caudal peduncle height for smallmouth bass collected with gillnets in the eastern basin of Lake Ontario, 1998. The chick sample represents smallmouth bass recovered from chick regurgitate; these points were not included in the calculation of the regression equation.

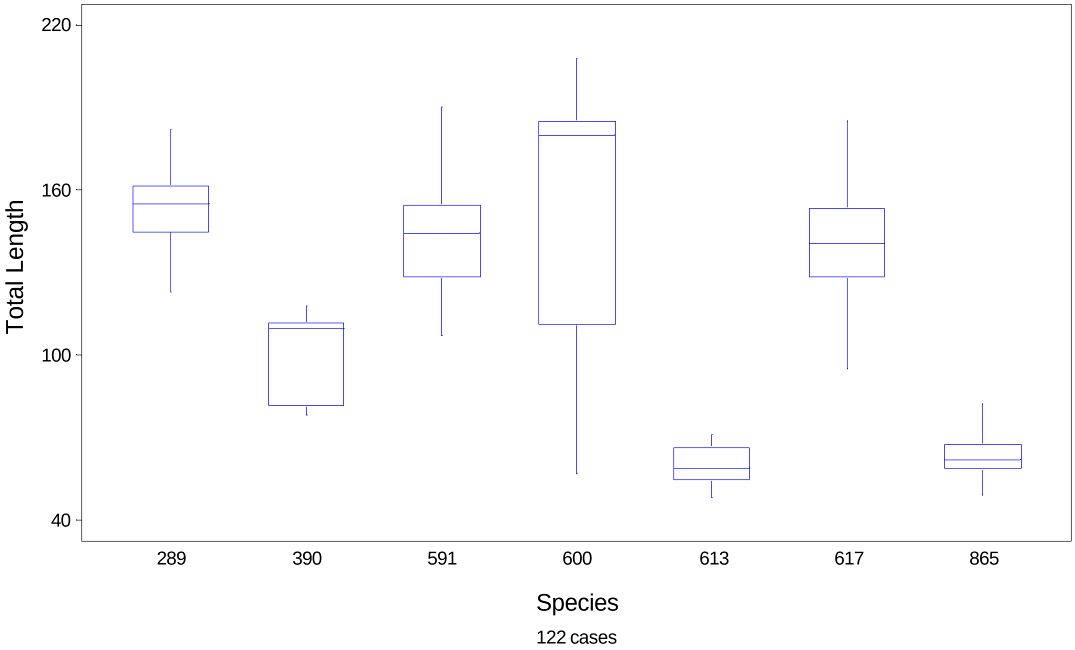

Figure 3. Box-whisker plots of total length for seven species of fish recovered from double-crested cormorant stomachs from the eastern basin of Lake Ontario in 1998. Specie codes are: 289= alewife, 390= spottail shiner, 591= rock bass, 600= smallmouth bass, 613= three-spine stickleback, 617= yellow perch, and 865= sculpin.

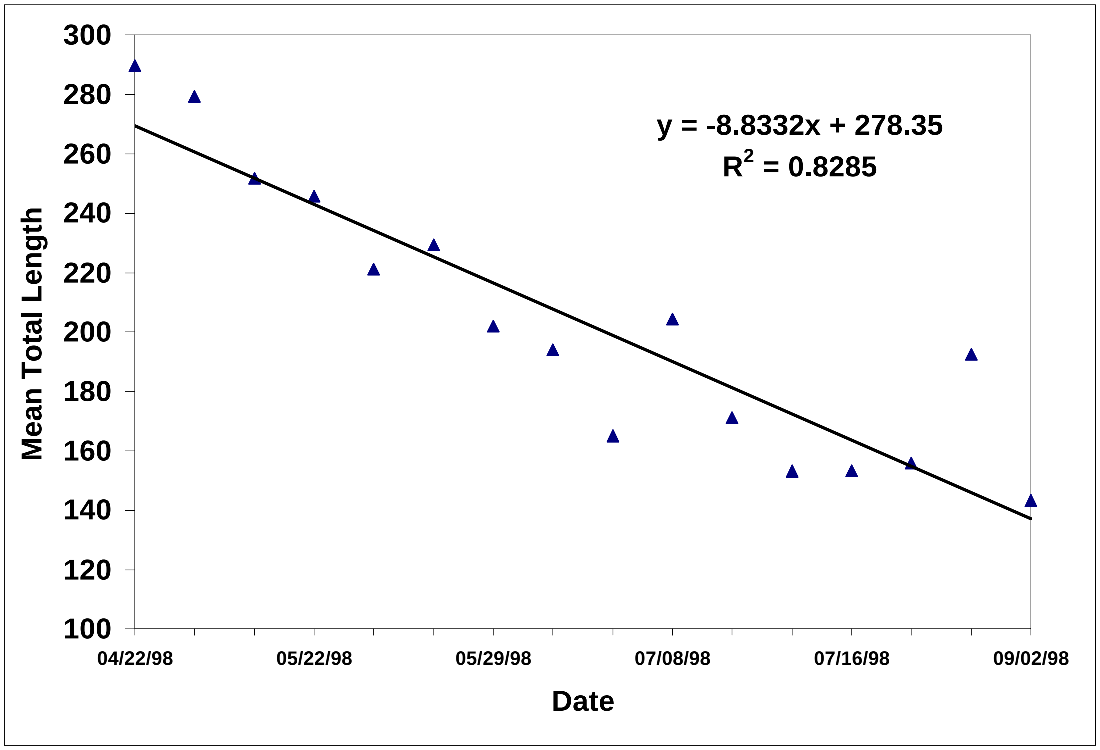

Figure 4. Mean total length of smallmouth bass estimated from otoliths recovered from pellets collected on Little Galloo Island from April 22 to September 2, 1998.

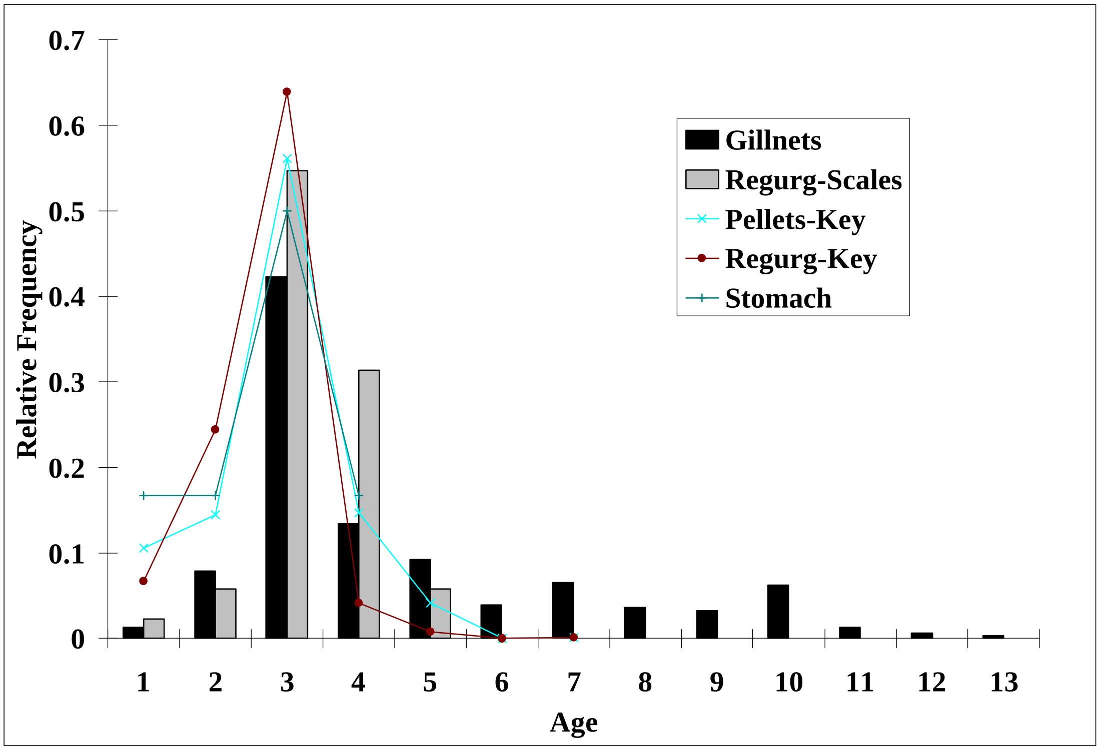

Figure 5. Smallmouth bass age distributions from the eastern basin of Lake Ontario in 1998.

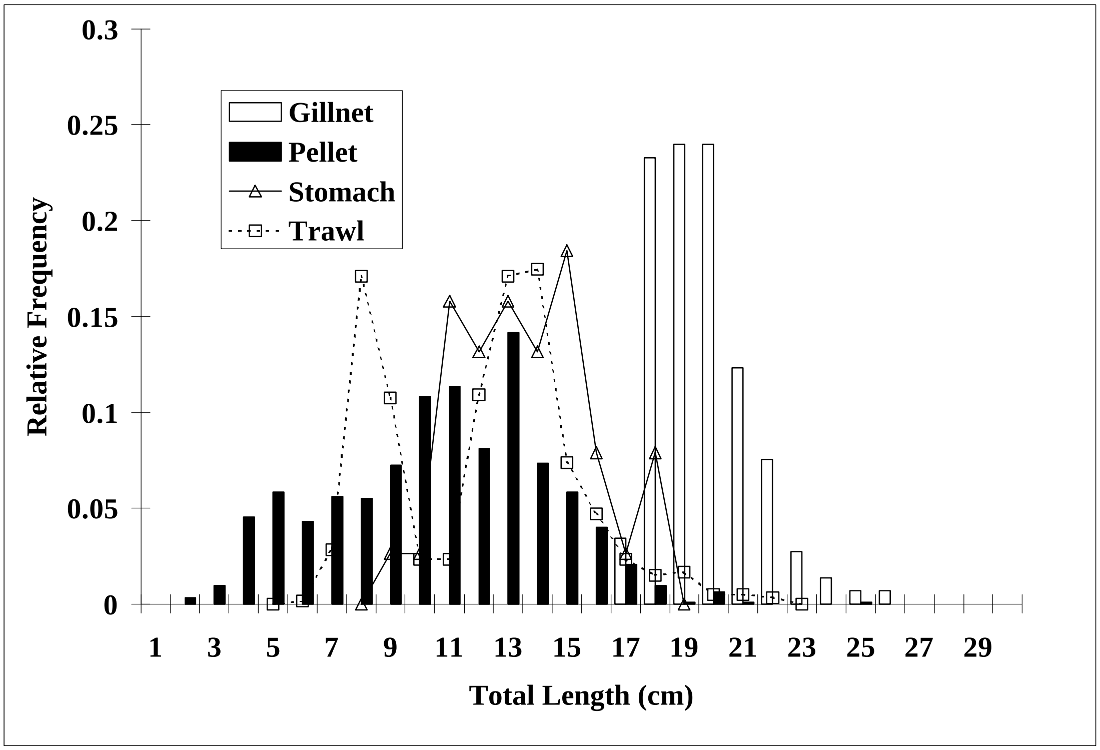

Figure 6. Length frequency distributions for yellow perch from the eastern basin of Lake Ontario, 1998.