Diet Composition and Fish Consumption of Double-Crested Cormorants in Eastern Lake Ontario, 1998

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Double-crested cormorant (Phalacrocorax auritus) breeding colonies in Lake Ontario have increased significantly raising concerns about their potential effects on fish populations. In the Lake Ontario watershed cormorants are present in substantial numbers generally from mid-April through the end of September. Initially concerns regarding cormorant predation on fish populations focused on impacts on stocked salmonines. Research has shown, however, that although predation by cormorants on individual plantings could be as high as 14%, releasing fish offshore could greatly reduce predation by cormorants (Ross and Johnson, in press, this volume).

Although reducing double-crested cormorant impacts on stocked salmonids seems to have been addressed, the cormorant-fish issue in eastern Lake Ontario is still a concern to many. To address this question examination of the diet of cormorants in eastern Lake Ontario has been underway since 1992 and has led to a number of published papers (Ross and Johnson 1995, Johnson and Ross 1996, Johnson et al. 1997, Neuman et al. 1997, Ross and Johnson, in press). The most intensive studies were carried out during 1992 to 1994. Since 1994, only minimum sampling has been done to characterize cormorant diet and fish consumption. The 1998 study represents, by far, the largest effort to quantify cormorant diet and fish consumption in eastern Lake Ontario, and was designed to improve seasonal estimates of prey composition and fish consumption.

Methods

The diet of double-crested cormorant in eastern Lake Ontario was described by identifying diagnostic remains found in regurgitated pellets collected on Little Galloo Island. Although some researchers have found that a single pellet is usually produced by adult birds each day (Craven and Lev 1987, Orta 1992, Derby and Lovvorn 1997), others report a range of pellet production, from less than a pellet per day to more than a pellet per day (Duffy and Laurenson 1983, Johnstone et al. 1990). Because of this reported variation in pellet production, some argue that a single pellet may not represent one day's food intake (Neuman et al. 1997). For this study we considered the contents of a pellet to represent daily food intake since we concur with the assessment of Derby and Lovvorn (1997) that pellets integrate meals of adult cormorants over an entire day.

Pellets were collected weekly from mid-April to late September, 1998. Sample size (n=150) was determined using power analyses based on sample variability from earlier work that used pellets to describe the diet of double-crested cormorants on Little Galloo Island (Ross and Johnson, in press). In the laboratory, diagnostic fish material including

bones (e.g., clethrum, opercle, premaxilla, dentary, pharyngeal teeth and pads), scales, and otoliths were removed and identified under magnification. Otoliths were the primary diagnostic structure used for species identification and estimates of fish eaten were derived by dividing the number of otoliths by 2. Eye lenses were also enumerated since although they are not diagnostic, they sometimes were used to estimate the number of fish eaten (number of lenses/2). For prey species identified, diagnostic fish material recovered from cormorant pellets were compared with bones, scales, and otoliths from known specimens that had been defleshed in NaOH solution.

To estimate the number of fish consumed by cormorants in eastern Lake Ontario, we used a model similar to that of Weseloh and Casselman (unpublished report: Fish consumption by double-crested cormorants on lake Ontario, Burlington, Ontario). The model essentially is comprised of two variables, the number of cormorant feeding days and mean daily ingestion rates. The number of cormorant feeding days is largely based on annual nest counts and estimates of fledgling productivity. Model assumptions include (1) the population of mature birds is twice that of the nest counts, (2) the number of immature cormorants is approximately 10% of the adult population, and (3) residence time for breeding adults, immatures and young-of-year is approximately 158, 112, and 92 days, respectively (Wesloh and Casselman, previously cited unpublished report). The model does not account for bird mortality during the time of residence or the migrant double-crested cormorant population (transient birds that stay an unknown amount of time on Lake Ontario). Incorporating bird mortality estimates into the model would decrease fish consumption estimates whereas adding migrant birds would increase consumption estimates. Double crested cormorants nest counts in eastern Lake Ontario in 1998 totaled 16,366 (U.S. waters = 7,657) (Weseloh and Pekarik, Canadian Wildlife Service, personal communication). Fledgling productivity was estimated at 1.8 chicks per nest. Daily ingestion rate was estimated as the mean number of fish per pellet (10.2) multiplied by a fecal correction factor (1.042) (Johnson and Ross 1996), or 10.6 fish per day.

Results

Substantial variation occurred among months in diet composition and daily fish consumption of cormorants in 1998. Alewife (Alosa pseudoharengus) were the major prey of cormorants (27%), but represented less than 10% of the diet during some months (June - 1%, September - 8.3%) (Table 1). Three-spine stickelback (Gasterosteus aculeatus) represented 21.6% of the fish eaten based largely on their dominance in the diet in May (50.9%). In other months, stickelbacks did not exceed 5.0% of the diet. Yellow perch (Perca flavescens), the third most abundant prey in the diet (18.1%) over the 6 month period, comprised more of the diet later in the season (July-September - 33%) (Table 1). Pumpkinseed (Lepomis gibbosus) (6.0%) and rock bass (Ambloplites rupestris) (3.0%) collectively made up 9% of the diet of double-crested cormorants. Gamefish made up 1.6% of the diet, composed of mainly smallmouth bass (Micropterus dolomieu) (1.5%) (Table 1). The number of fish per pellet ranged from 6.8 (August) to 16.0 (May) and averaged 10.2 (unadjusted) for the 6 month period (Table 1).

Based on approximately 8.25 million cormorant feeding days and a mean daily consumption rate of 10.6 fish (adjusted for fecal loss), we estimate that double-crested cormorants consumed 87.5 million fish in eastern lake Ontario in 1998. Forage fish dominated the diet of cormorants (68.9% - 60.3 million) with the primary species being alewife (23.6 million), threespine stickelback (18.9 million), minnows (cyprinids) (11.5 million), slimy sculpin (Cottus cognatus) (3.7 million) and trout perch (Percopsis omiscomaycus) (1.6 million). Cormorants ate 25.8 million panfish (29.4% of the diet) including 15.8 million yellow perch, 6 million pumpkinseed, 2.6 million rock bass, and 0.7 million ictalurids (bullhead/catfish). About 1.4 million gamefish (1.6%) were eaten by cormorants with most of these (1.3 million) being smallmouth bass. Other gamefish eaten by cormorants include largemouth bass (M. salmoides), walleye

(Stizostedion vitreum), brown trout (Salmo trutta), lake trout (Salvelinus namaycush), and esocids (pikes) (Figure 1).

Discussion

Since 1992 the breeding colony on Little Galloo Island has represented almost one-half of the cormorant population on Lake Ontario. Studies have shown that in the eastern basin of Lake Ontario, some difference occurs in the diet composition of cormorants among colonies on different islands (Neuman et al. 1997). These differences occurred, however, only prior to egg hatching after which the diet was similar among islands. The major difference in double-crested cormorant diet composition between Little Galloo Island and other eastern basin islands during the egg stage was due to a higher proportion of alewife and a lower proportion of centrarchids and yellow perch in the diet of birds on Little Galloo Island. These differences would tend to overestimate the consumption of alewife and underestimate the consumption of centrarchids and yellow perch in our extrapolation of cormorant diet information from Little Galloo to eastern Lake Ontario.

Except for the abundance of threespine stickelback (21.6% in the 1998 diet), the diet composition of double-crested cormorants was similar to previous years in eastern Lake Ontario (Ross and Johnson, in press). Due in part to the presence of stickelback in the diet, the contribution of forage fish in cormorant diets increased from 65% (1992-1997) to 69% (1998) from previous years (Figure 2). The major addition of stickelback to the diet coincided with a decline in the consumption of other forage species by cormorants in 1998, e.g., alewife - 42% (1992-1997) to 27% (1998) and trout-perch - 9% (1992-1997) to 2% (1998) (Figure 2). Populations of three spine stickelback, a native species, are increasing in Lake Ontario after years of being suppressed possibly by predation on early life history stages by non-native forage fishes. Another native forage fish, emerald shiner (Notropis athernoides), is also recovering in lake Ontario. Cyprinids, the family that includes emerald shiner, were the only forage fish category besides stickelback to measurably increase in the diet of cormorants from previous years (9.4% to 13.1%). The percentage contribution of all other fish species in the diet of cormorants in 1998 was similar to the previous 5 year period.

The fish consumption estimate by cormorants in eastern Lake Ontario in 1998 (87.5 million) was only slightly higher than the mean consumption reported for the previous 5 years of 82.8 million (range 37.4 to 128.5 million) (Ross and Johnson, in press). The addition of 18.9 million stickelback in the diet in 1998 was offset by declines from the previous 5 years in the estimated consumption of other forage species including alewife (-11 million) and trout-perch (-5.5 million). Besides stickelback, the only prey group whose consumption markedly increased in 1998 from previous years were cyprinids (+ 4.1 million).

Examination of the diet of double-crested cormorants on Little Galloo Island through September in 1998 provided a more thorough understanding of the feeding ecology of these birds. In previous years, pellet collections were generally not made after early July. Extending the pellet collection period through September revealed seasonal variation in utilization of some prey species by cormorants. The major increase in threespine stickelback in cormorant diets in 1998 was not an artifact of the extended pellet collection period since stickelback were only abundant in the diet in May, a month that had ample pellet sampling in previous years. Because of seasonal variation in both diet composition and the number of fish per pellet, the extended sampling period in 1998 provided a better representation of cormorant diet and fish consumption than earlier studies on Little Galloo Island.

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Table 1: Monthly and total percent diet composition of double-crested cormorants from Little Galloo Island, 1998.

	April	May	June	July	August	September	Total
No. of Pellets	276	742	601	715	304	301	2,939
Fish/Pellet	10.1	16.0	8.0	7.9	6.8	9.0	10.2
Alewife	28.6	1.0	67.5	52.5	36.5	8.3	27.0
Stickleback (3-spine)	1.3	50.9	5.0	0.9	2.9	0.0	21.6
Yellow perch	19.5	11.6	7.3	22.1	29.2	47.6	18.1
Cyprinid	10.8	14.3	4.9	10.1	11.4	32.3	13.1
Pumpkinseed	18.1	7.4	3.6	3.1	7.1	5.6	6.8
Slimy sculpin	7.5	5.5	3.6	2.2	3.7	1.4	4.2
Rock bass	2.2	3.6	2.1	3.3	2.9	2.3	3.0
Trout perch	5.7	2.1	2.9	0.1	0.1	0.0	1.8
Smallmouth bass	0.3	0.7	1.4	3.4	3.4	1.0	1.5
Ictalurid	1.3	0.8	0.6	0.2	1.1	0.6	0.8
Other	4.7	2.1	1.1	2.1	1.7	0.9	2.1
	100.0	100.0	100.0	100.0	100.0	100.0	100.0

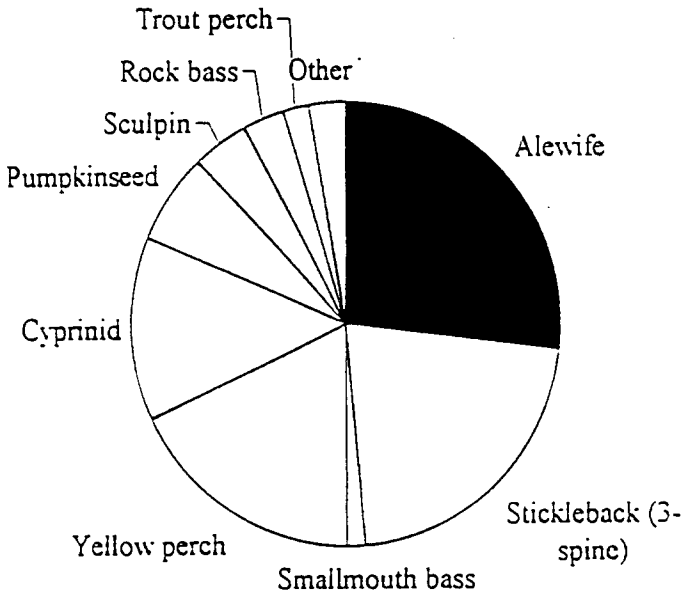

Figure 1. Diet composition (numbers) of double-crested cormorants from eastern Lake Ontario, 1998.

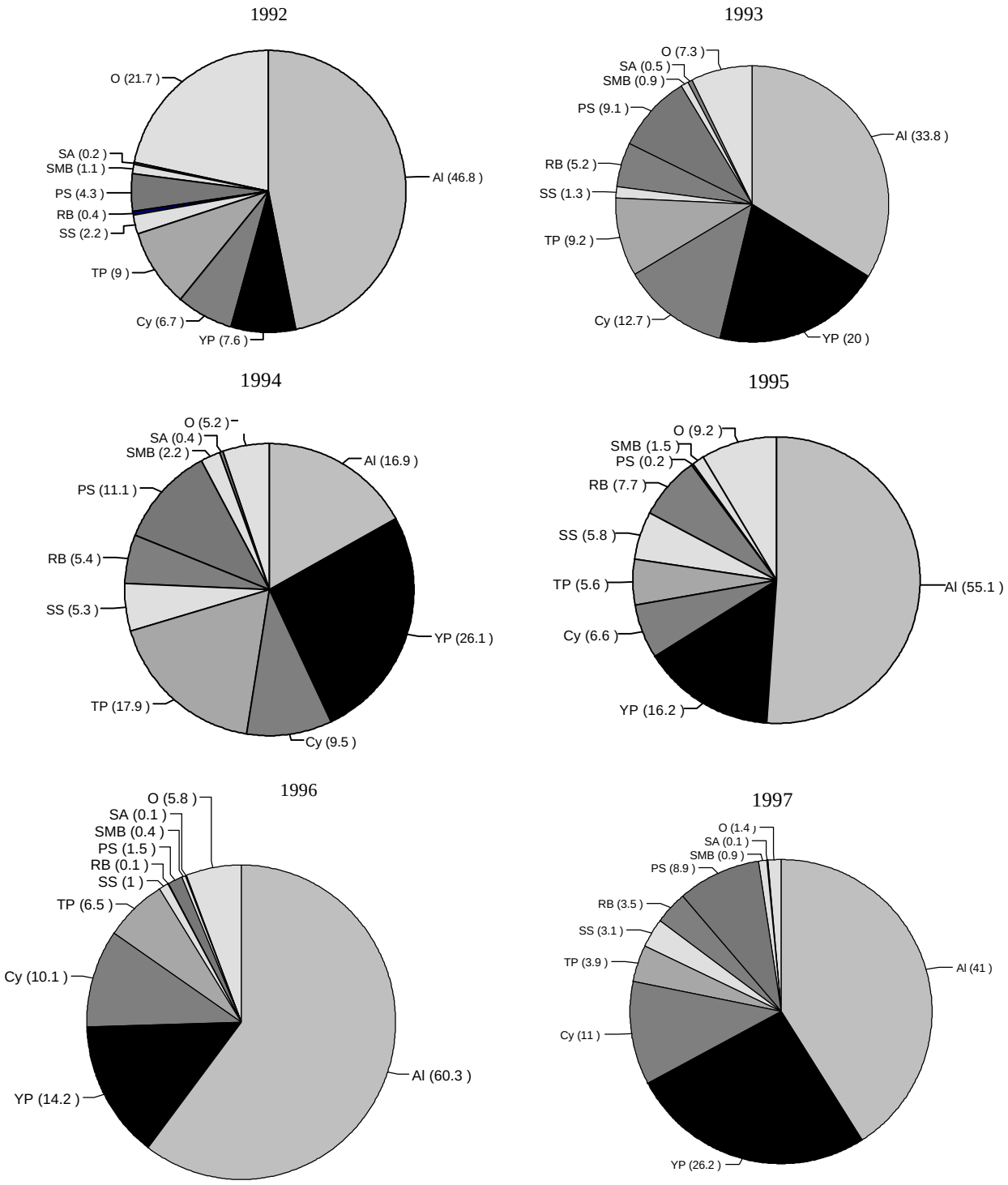

Figure 2. Percent diet composition of double-crested cormorants from eastern Lake Ontario, 1992-1997. (Data for 1992 from Karwowski 1994.) A1 = alewife, YP = yellow perch, Cy = cyprinids TP = trout perch, SS = slimy sculpin, RB = rock bass, PS = pumpkinseed, SMB = smallmouth bass, SB = stickelback, SA = salmonines, O = other.