Diet Composition and Fish Consumption of Double-Crested Cormorants from the Little Galloo Island Colony of Eastern Lake Ontario in 1999

James H. Johnson
Tunison Laboratory of Aquatic Science
Great Lakes Science Center
U.S. Geological Survey
Cortland, NY 13045

Robert M. Ross
Research and Development Laboratory
Leetown Science Center
U.S. Geological Survey
Wellsboro, PA 16901

Russell D. McCullough
New York State Department of Environmental Conservation
Watertown, NY 13601

Introduction

The double-crested cormorant (Phalacrocorax auritus) colony on Little Galloo Island is the largest cormorant colony in the eastern basin of Lake Ontario. Because of concerns regarding the effects of cormorant predation on local fish populations, examination of the diet of cormorants from the Little Galloo colony began in 1992 (Ross and Johnson 1995, Johnson and Ross 1996, Johnson et al. 1997, Newman et al. 1997, Adams et al. 1999, Johnson et al. 1999, Ross and Johnson 1999, Schneider and Adams 1999). Cormorant diet studies carried out in 1998 and 1999 represent the most thorough examination of the feeding ecology of birds from the Little Galloo colony. This paper reports on the findings from the work carried out in 1999.

Methods

Diagnostic prey remains recovered in regurgitated pellets were used to describe the diet of double-crested cormorants on Little Galloo Island in 1999. Approximately 150 pellets were collected on each of 13 dates at 2 week intervals beginning in mid-April and ending in early October. The sample size (150) was determined using power analysis based on sample variability from earlier work that used pellets to describe the diet of cormorants on Little Galloo Island (Ross and Johnson, in press). In the laboratory, diagnostic bones, all otoliths, and representative scales were removed from the pellets and identified under magnification. Eye lenses were also enumerated since, although they could not be used in species identification, their total number (i.e., number of lenses/2) generated fish counts that exceeded those based on bones or otoliths in some pellets. 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 a NaOH solution.

To estimate number of fish consumed by cormorants from the Little Galloo colony, we used a model similar to that of Weseloh and Casselman (unpublished report: Fish consumption by double-crested cormorants on Lake Ontario, Burlington, Ontario) to estimate the annual number of fish

eaten by cormorants. This model incorporated cormorant age-class population size and seasonal residence time (time spent feeding in area), mean daily fish ingestion rates, a fecal pathway correction factor for fish not detected in pellets, and several assumptions based on values from the literature or personal communication from colleagues. We assumed that (1) residence time for breeding adults, immatures, and young of year (YOY) was 158, 112, and 92 days, respectively (Weseloh and Casselman, report cited above); (2) number of immatures was approximately 10% of adult population; and (3) the number of young-of-year (YOY) cormorants is the product of the fledgling productivity estimate for the year and the number of active nests. 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. To examine cormorant fish consumption by feeding period (i.e., pre-chick, chick, and post-chick) we further broke down the number of cormorants feeding days by age-class as follows:

	Days			
	Pre-chick	Chick	Post-chick	Total
Adults	64	42	52	158
Immatures	18	42	52	112
YOY	0	42	50	92

For estimates of mean daily ingestion rates, we used the mean number of fish per pellet multiplied by a fecal correction factor (1.042) (Johnson and Ross 1996). Although there is some variation, a single pellet is usually produced by adult cormorants each day (Craven and Lev 1987, Orta 1992, Derby and Lovvorn 1997). Consequently, we considered the contents of a pellet to represent daily fish consumption. Fish consumption estimates were derived for each of the three feeding periods using our estimates of the number of days each age-class of cormorants fed in that period (see text table above) and the specific mean daily ingestion rates (number of fish per pellet) for that period. To estimate the biomass of fish eaten, we assumed that cormorants consumed 0.47 kg fish per day (Schramm et al. 1984, 1987; Weseloh and Casselman 1992). This represents about 25% of their body weight (Dunn 1975). Since 0.47 kg is about 1 pound, a straight forward estimator of biomass consumed, in pounds, is the number of cormorant feeding days (i.e., 1 cormorant feeding day equals 1 pound of fish consumed). To estimate the size of smallmouth bass consumed in 1999, we followed the technique described by Adams et al. 1999 and measured (with calipers) only those otoliths that exhibited little wear (i.e., levels 1 and 2). We used annual length-weight regressions for smallmouth bass in the eastern basin (pers. comm. and unpublished data, Tom Eckert, NYSDEC, Cape Vincent) to estimate the weight of smallmouth bass consumed by cormorants.

Results

A total of 1,827 pellets were used to describe the feeding ecology of the cormorant colony on Little Galloo Island in 1999 (Table 1). Because of apparent differences in diet composition and daily fish consumption (fish/pellet) over the 5 ½ month residence period, three distinct periods of cormorant feeding activity are described, i.e., pre-chick feeding, chick feeding, and post-chick feeding. The number of fish per pellet (adjusted for fecal loss) declined from 12.2 during the pre-chick feeding period to 7.2 during the post-chick feeding period and averaged 9.1 for the entire period (Table 1).

Diet Composition

Yellow perch (27.6%), alewife (27.1%), and cyprinids (18.0%) were the major prey, by number, of cormorants from the Little Galloo colony, however all three prey groups exhibited substantial seasonal variation in abundance in the diet (Table 1). Yellow perch (33.5% versus 15.5%) and cyprinids (23.4% versus 4.7%) each contributed substantially more to the diet during the pre-chick feeding period than during the chick feeding period, when alewife (64.5%) dominated the diet (Table 1). The contribution of smallmouth bass in the diet

increased from 0.9% during the pre-chick feeding period to 4.5% during the chick feeding period to 8.0% during the post-chick feeding period. For the entire period, forage fish (i.e., alewife, cyprinids, threespine stickleback, slimy sculpin, trout perch, etc.) species contributed about 55.7% of the diet of cormorants compared to 40.1% for panfish (i.e., yellow perch, rock bass, pumpkinseed) and 4.2% (mostly smallmouth bass, 3.6%) for gamefish (Table 1).

Fish Consumption

A peak count of 5,681 double-crested cormorant nests were observed on Little Galloo Island on May 20, 1999 and fledgling productivity was estimated at 0.035 chicks/nest (pers. comm. Jim Farquhar, NYSDEC, Watertown). Consequently, the Little Galloo colony provided about 1.94 million cormorant feeding days and consumed about 1.94 million pounds of fish in 1999. We estimate that cormorants from this colony consumed 17.94 million fish in 1999, including 9.12, 4.00, and 4.82 million for the pre-chick, chick, and post-chick feeding periods, respectively. Forage fish dominated the diet (9.87 million) with the primary species being alewife (4.87 million), cyprinids (3.22 million), threespine stickleback (0.68 million), slimy sculpin (0.67 million) and trout perch (0.38 million) (Table 2). Cormorants consumed an estimated 7.32 million panfish including 4.95 million yellow perch, 1.06 million rock bass, 1.02 million pumpkinseed, and 0.11 million ictalurids. About 0.75 million gamefish were eaten by cormorants including 0.65 million smallmouth bass and 0.08 million esocids (Table 2).

Smallmouth Bass

Besides the percent contribution in the diet by number, we were also able to estimate the percent contribution by weight of smallmouth bass in the cormorant diet using otolith size. A total of 53 smallmouth bass otoliths (levels 1-2) were recovered and measured from cormorant pellets in 1999. The mean size of these otoliths was 5.5 mm, which represents a bass of about 195 mm total length (Schneider and Adams 1999). A smallmouth bass of this length in eastern Lake Ontario would weigh 0.194 pounds. Consequently, the total biomass of smallmouth bass in the diet of cormorants from the Little Galloo colony in 1999 was about 126,000 lbs (i.e., 0.194 lbs x 650,000 smallmouth bass consumed). This represented 6.5% of the diet of cormorants by weight versus 3.6% by number. We were further able to estimate the percent contribution by weight in the diet of cormorants from Little Galloo Island in 1993, 1994, and 1998 using information on the length of smallmouth bass consumed (Adams et al. 1999, Schneider and Adams 1999), annual length-weight relationships for smallmouth bass in the eastern basin and annual cormorant diet information (Johnson et al. 1999 unpublished data). During these four years smallmouth bass contributed an average of 2.1% (range 0.9% to 3.6%) by number and 7.2% (range 5.2% to 11.6%) by weight to diet of cormorants from Little Galloo Island (Table 3). The mean weight (0.50 lbs) of bass consumed in 1993-94 was about twice that (0.23 lbs) during 1998-99 (Table 3).

Discussion

Similar to previous years, alewife and yellow perch dominated the diet of cormorants from the colony on Little Galloo Island. However, only in one (1994) of the previous seven years had yellow perch been the primary prey (Johnson et al. 1999, Ross and Johnson in press). Threespine stickleback did not appear in cormorant diets until 1998 when they contributed 21.6% (Johnson et al. 1999). In 1999, stickleback were again present in the diet but their contribution declined to 3.8%. Cyprinids continued a trend of increasing annual importance in the diet of double-crested cormorants comprising 18% (up from 13.1% in 1998 and 9.4% from 1992 to 1997). Although still relatively small, the contribution of gamefish in the diet in 1999 (4.2%) was the highest observed since studies began in 1992. The diet portion of smallmouth bass (3.6%) was the highest recorded for this species. Esocids, although comprising only 0.4% were much more abundant in the diet of cormorants in 1999 than in

previous years.

In 1999, seasonal variation in diet composition was similar to that observed in 1998. The contribution of yellow perch in the diet declined in June and July when alewife dominated the diet during the chick feeding period. This diet shift is likely related to the increased availability of alewife in June and July when they move inshore to spawn. After spawning alewife move offshore and presumably become less available to cormorants from Little Galloo Island, while yellow perch and cyprinids become more important in the diet. As in 1998, threespine stickleback were a major diet component only during the pre-chick feeding period. Conversely, as in 1998, the contribution of smallmouth bass in the diet was low early in the season and steadily increased.

Although the number of cormorant nests on Little Galloo Island was similar in 1998 (5,839 nests) and 1999 (5,681 nests), fish consumption estimates for the colony were considerably lower in 1999. We estimate that the Little Galloo colony consumed 17.94 million fish totaling 1.94 million pounds fish in 1999. Fish consumption in 1999 was only 45% by number and 58% by weight of the mean of the previous seven years for the Little Galloo colony (Figure 1). The reduction in fish consumption likely is largely due to an experimental program to reduce cormorant reproductive success on Little Galloo Island by oiling eggs, initiated by the New York State Department of Environmental Conservation in 1999 (Johnson et al. 2000). Chick productivity by the Little Galloo colony was estimated as 1.8 chicks/nest in 1998 but only 0.035 in 1999 (pers. comm. Jim Farquhar, NYSDEC, Watertown).

Deriving an estimate of the size of fish consumed by cormorants using pellets includes not only a great deal of effort but requires caution. Researchers have urged caution when estimating fish size using otoliths recovered in pellets because digestive process may lead to an underestimation of fish size (Jobling and Breiby 1986). Consequently, we measured only those smallmouth bass otoliths that exhibited very little wear (<10% of all bass otoliths that were recovered in pellets). The use of otoliths to determine fish size requires considerable information on the relationship of otolith length to fish length. Presently, smallmouth bass is the only species in eastern Lake Ontario where there is sufficient information to estimate fish length from otolith length (Schneider and Adams 1999). However, this information is presently being gathered for yellow perch, rock bass and pumpkinseed. Although it took considerable additional effort to determine the relationship between otolith length and total fish length for smallmouth bass, the information was useful in helping to better document the importance of bass in the diet of cormorants. Smallmouth bass contributed only 2.1% of the diet by number over a 4 year period but because they are one of the larger fish species eaten by cormorants, their contribution in the diet by weight was 7.2%. It is likely that the percent contribution in cormorant diet of some of the more abundant panfish species such as yellow perch, rock bass, and pumpkinseed will also be greater by biomass than by number.

As in 1998, the examination of the diet of double-crested cormorants on Little Galloo Island at 2 week intervals from mid-April to early October provided a more complete understanding of the feeding ecology of these birds. The 5.5 month sampling period is needed to best describe seasonal variation in diet composition and mean daily fish consumption.

Acknowledgements

We thank Laura Brown, Brian Edmonds, Mandi Walseman, Peter Moles, Irene Mazzocchi, Clif Schneider, Dick McDonald, John Burnett, Randy Bennett, and Tim Wallbridge for their efforts in collecting and processing double-crested cormorant pellets.

Literature Cited

Adams, C.M., C.P. Schneider, and J.H. Johnson. 1999. Predicting the size and age of smallmouth bass consumed by double-crested cormorants in

eastern Lake Ontario, 1993-94. Section 6-1 to 6-8 in Final Report: To assess the impact of double-crested cormorant predation on the smallmouth bass and other fishes of the eastern basin of Lake Ontario. New York State Department of Environmental Conservation, Albany, NY.

Craven, S.R. and E. Lev. 1987. Double-crested cormorants in the Apostle Islands, Wisconsin, USA: population trends, food habits, and fishery depredations. Colonial Waterbirds 10:64-71.

Derby, C.E. and J.R. Lovvorn. 1997. Comparison of pellets versus collected birds for sampling diets of double-crested cormorants. Condor 99:549-553.

Dunn, E.H. 1975. Caloric intake of nesting double-crested cormorants. Auk. 92:553-565.

Jobling, M. and A. Breiby. 1986. The use and abuse of fish otoliths in studies of feeding habits of marine piscivores. Sarsia 71:265-274.

Johnson, J.H. and R.M. Ross. 1996. Pellets versus feces: their relative importance in describing the food habits of double-crested cormorants. Journal of Great Lakes Research 22:795-798.

Johnson, J.H., R.M. Ross, and D.R. Smith. 1997. Evidence of secondary consumption of invertebrate prey by double-crested cormorants. Colonial Waterbirds 20:547-551.

Johnson, J.H., R.M. Ross, and C.M. Adams. 1999. Diet composition and fish consumption of double-crested cormorants in eastern Lake Ontario, 1998. Section 5-1 to 5-7 in Final Report: To assess the impact of double-crested cormorant predation on the smallmouth bass and other fishes of the eastern basin of Lake Ontario. New York State Department of Environmental Conservation, Albany, NY.

Johnson, J.H., R.M. Ross and J. Farquhar. 2000. The effects of egg oiling on fish consumption by double-crested cormorants on Little Galloo Island, Lake Ontario. USGS, Cortland, NY.

Neuman J., D.L. Pearl, P.J. Ewins, R. Black, D. V. Weseloh, M. Pike, and K. Karwowski. 1997. Spatial and temporal variations in the diet of double-crested cormorants (Phalacrocorax auritus) breeding on the lower Great Lakes in the early 1990s. Canadian Journal of Fisheries and Aquatic Science 54:1569-1584.

Orta, J. 1992. Family Phalacrocoracidae (Cormorants). Pages 326-353 in J. Del Hoyo, A. Elliott, and J. Sargatal (eds.), Handbook of the Birds of the World, Vol. 1. Lynx Edicions, Barcelona. 696 pp.

Ross, R.M. and J.H. Johnson. 1995. Seasonal and annual changes in the diet of double-crested cormorants: implications for Lake Ontario's fishery. Great Lakes Research Review 2:1-9.

Ross, R.M. and J.H. Johnson. 1999. Effect of altered salmonid stocking methods on cormorant predation in eastern Lake Ontario. Section 11-1 to 11-3 in Final Report: To assess the impact of double-crested cormorant predation on the

smallmouth bass and other fishes of the eastern basin of Lake Ontario. New York State Department of Environmental Conservation, Albany, NY.

Ross, R.M, and J.H. Johnson. In press. Fish losses to double-crested cormorants in eastern Lake Ontario, 1992-1997. Pages 000-000 in M.E. Tobin (ed.). Symposium on Double-crested Cormorants: Population Status and Management Issues in the Midwest (9 December 1997, Milwaukee, Wisconsin). U.S. Department of Agriculture Technical Bulletin.

Schneider, C.P. and C.M. Adams. 1999. Estimating the size and age of smallmouth bass and yellow perch consumed by double-crested cormorants in the eastern basin of Lake Ontario, 1998. Section 7-1 to 7-14 in Final Report: To assess the impact of double-crested cormorant predation on the smallmouth bass and other fishes of the eastern basin of Lake Ontario. New York State Department of Environmental Conservation, Albany, NY.

Schramm, H.L., B. French, and M. Ednoff. 1984. Predation of channel catfish, Ictalurus punctatus by Florida double-crested cormorants, Phalacrocorax auritus floridanus. Progressive Fish Culturist 46:41-43.

Schramm, H.L., M.W. Callopy, and E.A. Okrah. 1987. Potential problems of bird predation for fish culture in Florida. Progressive Fish Culturist 49:44-49.

Weseloh, D.V. and J. Casselman. 1992. Calculated fish consumption by double-crested cormorants in eastern Lake Ontario. Colonial Waterbird Society Bulletin 16(2):63-64.

Table 1: Seasonal and total percent diet composition of double-crested cormorants from Little Galloo Island, 1999. The pre-chick feeding period includes pellets collected from 4/14/99 to 6/3/99, the chick feeding period includes pellets collected from 6/17/99 to 8/4/99 and the post-chick feeding includes pellets collected from 8/19/99 to 10/6/99.

	Pre-chick	Chick	Post-chick	Total
No. of pellets	654	598	575	1,827
Fish/pellet (adjusted)	12.2	7.5	7.3	9.1 (mean)
Yellow perch	33.5	15.5	26.5	27.6
Alewife	11.5	64.5	26.0	27.1
Cyprinid	23.4	4.7	18.7	18.0
Rock bass	4.6	5.5	8.8	5.9
Pumpkinseed	8.2	2.3	3.8	5.7
Threespine stickleback	7.4	---	0.2	3.8
Slimy sculpin	4.6	1.9	3.6	3.7
Smallmouth bass	0.9	4.5	8.0	3.6
Trout perch	3.9	0.4	0.1	2.1
Ictalurid	0.8	0.1	0.7	0.6
Gizzard shad	---	---	2.0	0.5
Esocid	0.2	0.1	1.1	0.4
Catostomid	0.2	0.1	0.1	0.2
Darter	---	0.1	0.1	0.1
Rainbow smelt	0.1	0.1	---	0.1
Centrarchid	0.2	---	---	0.1
Burbot	0.1	0.1	0.1	0.1
Walleye	0.1	0.1	0.1	0.1
Coregonid	0.1	---	---	<0.1
Lake trout	0.1	---	---	<0.1
Salmonine	0.1	---	---	<0.1
White perch	---	---	0.1	<0.1
	100.0	100.0	100.0	100.0

Table 2: Estimated species specific fish consumption by double-crested cormorants at the Little Galloo colony, 1999.

	Number (millions)
Yellow perch	4.95
Alewife	4.87
Cyprinids	3.22
Rock bass	1.06
Pumpkinseed	1.02
Threespine stickleback	0.67
Slimy sculpin	0.66
Smallmouth bass	0.65
Trout perch	0.38
Other	0.46
Total	17.94

Table 3: Percent contribution of smallmouth bass in the diet of cormorants from the Little Galloo colony.

Year	Number consumed	❶ Weight Pounds lbs	% of diet consumed	% of diet by number	by weight
1993	312,000	0.49	153,000	0.9	5.4
1994	333,000	0.50	166,500	2.2	11.6
1998	561,000	0.27	151,500	1.8	5.2
1999	650,000	0.19	126,000	3.6	6.5
		❶ =	2.1	7.2	