Diet Composition and Fish Consumption of Double-Crested Cormorants from the Little Galloo Island Colony of Eastern Lake Ontario in 2004

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Since the early 1990's increasing populations of double crested cormorants (*Phalacrocorax auritus*) in the eastern basin of Lake Ontario have concerned both members of the public and the New York State Department of Environmental Conservation (NYSDEC) in regards to impacts on fish populations. Although the number and size of cormorant colonies in the eastern basin have not increased for several years, the cormorant population in the area remains high, at levels where impacts on local fish populations may occur. Because it supports the largest cormorant colony in the eastern basin, Little Galloo Island (LGI) has received the most attention regarding cormorant-fish associations with annual diet studies dating back 12 years. These studies (Johnson et al. 2002a,b) together with other studies which examined the status of fish populations surrounding Little Galloo Island (Burnett et al. 2002, Lantry et al. 2002) have shown a significant relationship between increased cormorant numbers and decreased numbers of yellow perch and smallmouth bass.

The year 2004 marked the thirteenth year of study of the food habits and fish consumption of LGI cormorants. Johnson et al. (2002a) characterized these studies as minimal (1995 - 1997), moderate (1992-1994), and comprehensive (1998 - 2001). This paper reports the findings of work carried out in 2004, the seventh consecutive year of comprehensive work on diet composition and fish consumption on the LGI cormorant colony.

Methods

Diagnostic prey remains recovered in regurgitated pellets were used to describe the diet of double-crested cormorants on LGI in 2004. Approximately 150 pellets were collected on each of 12 dates at approximately 2 week intervals beginning in early May and ending in mid 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 LGI (Ross and Johnson 1999). 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 was compared with bones, scales, and otoliths from known specimens defleshed in NaOH.

To estimate number of fish consumed by cormorants from the LGI 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 number of fish eaten by cormorants annually. This model incorporated cormorant age-class population size and seasonal residence time (time spent feeding in area) to estimate the number of cormorant feeding days, mean daily fish ingestion rates, a fecal pathway correction factor for fish not detected in pellets (Johnson and Ross, 1996), and several assumptions based on values from the literature or personal communication from colleagues. To estimate the number of cormorants feeding we used annual nest counts (all nests counted) provided by the Canadian Wildlife Service and NYSDEC and assumed that (1) residence time for breeding adults, immatures, and young-of-year (YOY) was 158, 112, and 92 days, respectively (Weseloh and Casselman, unpublished report); (2) number of immatures was about 10% of adult population which was taken as twice the number of nests; 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. We did 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 reduce fish consumption estimates whereas including migrant birds would increase estimated consumption. Although YOY cormorants are generally present for about 113 days, consumption by chicks during the first 3 weeks post-hatch is considered minimal, and for the remainder of the season their daily food intake approximates that of adults (Weseloh and Casselman, unpublished report). Immature cormorants are essentially fully grown but non-reproductive birds.

Because of the apparent differences in feeding patterns of cormorants over the season, we identified three separate feeding phases, pre-chick (prior to chick hatch), chick (chicks present and being fed by adults), and post-chick (cessation of feeding chicks by adult) feeding. These phases were characterized by differences in diet consumption and daily fish consumption (i.e., the number of fish per pellet). Pre-chick feeding was from early April to early June, the chick feeding period from mid June to late July, and the post-chick feeding period from early August to mid October. 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

To estimate the number of fish consumed by cormorants during each feeding period we multiplied the number of double-crested cormorant feeding days by mean daily ingestion rates for that period. For estimates of mean daily ingestion rates, we used the mean number of fish per pellet multiplied by a fecal correction factor of 1.042 (Johnson and Ross 1996). Although variation in pellet production rates has been observed in cormorants (Carss et al. 1997) some researchers consider that a single pellet is typically produced by adult cormorants each day (Craven and Lev 1987, Orta 1992, Derby and Lovvorn 1997). Pellet production rates greater than one per day would increase our fish consumption estimates for LGI colony whereas rates less than one per day would reduce our estimates. Fish consumption estimates for each of the three feeding periods were summed to provide an annual fish consumption estimate. Specific fish consumption was estimated by multiplying the percent

composition by number for a species in the diet for each feeding period by the total fish consumption estimate for that period. Consumption estimates were then summed for all three periods to provide annual consumption estimates for each species or taxon. The use of the Weseloh and Casselman model, which did not include variance estimates associated with the number of feeding days for each life stage, precluded us from generating standard error estimates for fish consumption estimates. To estimate the biomass of fish eaten, we assumed that cormorants consumed 0.47 kg (1 pound) fish per day (Schramm et al. 1984, 1987; Weseloh and Casselman 1992), representing about 25% of their body weight (Dunn 1975).

We estimated the size of yellow perch (*Perca flavescens*), rock bass (*Ambloplites rupestris*) and pumpkinseed (*Lepomis gibbosus*) consumed during each cormorant feeding period by measuring at least 100 (in a few cases <100 were in a sample) randomly selected otoliths from each species /period to the nearest 0.1 mm with calipers. Broken or chipped otoliths were not considered for measurement. For smallmouth bass (*Micropterus dolomieu*), we measured all unbroken otoliths from each feeding period even if the total exceeded 100. We used otolith-length fish-length relationships derived for smallmouth bass (Adams et al. 1999), yellow perch (Burnett et al. 2000), and rock bass and pumpkinseed (Ross et al. In press) to estimate the length of these species eaten by cormorants. To estimate the weight of these species consumed by cormorants we used length-weight regressions for eastern Lake Ontario populations (unpublished data).

Results

In all, 1,800 regurgitated cormorant pellets were examined from LGI in 2004. These pellets represented cormorant diets from May 4 to October 12. Similar to previous years we described the diet in terms of three distinct feeding periods, pre-chick feeding, chick feeding, and post-chick feeding periods. The three feeding periods are delineated by differences in diet composition and daily fish consumption. The number of fish per pellet (adjusted for fecal loss) declined over the season from a peak of 15.3 during the pre-chick feeding to 9.1 during the post-chick feeding period and averaged 10.7 for the season (Table 1).

Diet Composition

Alewife (41.9%) were the major prey of LGI cormorants in 2004 and were the main prey during each feeding period (37.6% - 52.6%) (Table 1). Yellow perch was the second most abundant species in the diet during all three periods and contributed 31.4% to the total diet. Pumpkinseed (7.2%), and rock bass (7.1%) were the third and fourth most abundant prey in cormorant diets. Cyprinids (4.8%), smallmouth bass (2.7%), and slimy sculpin (2.1%) were the only other prey species or groups that contributed at least 1% of the diet (Table 1). Smallmouth bass was the only prey species to exhibit temporal trends in consumption over the entire season. Smallmouth bass increased in the diet from 0.4% during the pre-chick feeding period to 4.8% during the chick feeding period and 5.3% during the post-chick feeding period. For the entire season forage species (i.e. alewife, cyprinids, three-spine stickleback, slimy sculpin, trout-perch, etc) contributed 51% of the diet of LGI cormorants while panfish (i.e. yellow perch, pumpkinseed, rock bass, ictalurids, etc.) and gamefish (smallmouth bass, esocids, walleye) composed 46% and 3%, respectively.

Fish Consumption

A peak count of 3,967 cormorant nests was observed on LGI in 2004 and chick productivity was estimated at about 0.05 chicks per nest (pers. comm. Jim Farquhar, NYSDEC, Watertown, NY). Using the Weseloh and Casselman model we estimate about 1.36 million feeding days for the LGI colony in 2004 and about 1.36 million pounds of fish consumed (Figure 1). Total numerical fish consumption by the LGI colony in 2004 was estimated at 15.66 million (Figure 1). Fish consumption by feeding period in 2004 included 7.99 million during the pre-chick feeding period, 3.45 million during the chick feeding period and 4.22 million during the post-chick feeding period.

In 2004, LGI cormorants consumed 7.96 million forage fish including 6.58 million alewife, 0.77 million cyprinids, 0.32 million slimy sculpin, and 0.11 million trout-perch (Figure 2). About 7.27 million panfish were eaten including 4.91 million yellow perch, 1.12 million pumpkinseed, 1.12 million rock bass and 0.09 million ictalurids. Cormorants consumed about 0.44 million game fish, mostly smallmouth bass (0.42 million) (Figure 2).

Size of fish consumed

We measured a total of 1,060 otoliths recovered from cormorant pellets in 2004. The size of smallmouth bass consumed by LGI cormorants in 2004 declined over the season from 8.78 in during the pre-chick feeding period to 6.46 in during the post-chick feeding period (Table 2). The size of rock bass and pumpkinseed consumed increased over the season. There was no apparent seasonal trend in the size of yellow perch consumed by LGI cormorants in 2004. The average weight of smallmouth bass, yellow perch, rock bass, and pumpkinseed (computed from length-weight regression) for each feeding period is provided in Table 2. We estimated the biomass of each of these four species consumed by cormorants during each feeding period. For the entire feeding season on LGI cormorants consumed an estimated 105,000 pounds of yellow perch, 69,000 pounds of smallmouth bass, 60,000 pounds of rock bass, and 36,000 pounds of pumpkinseed.

Discussion

The diet composition of LGI cormorants in 2004 was similar to that reported from 1992 to 2003 with alewife and yellow perch dominating the diet (Johnson et al. 2002a, Johnson et al. 2002b, Johnson et al. 2003, Johnson et al. 2004). As in 2003 (Johnson et al. 2004), alewife contributed a larger proportion of the diet than yellow perch (i.e. 41.9% versus 31.4%) in 2004 compared to the previous eleven years when yellow perch was the main prey in the diet (31.5% versus 26.3%). Temporal trends in diet composition in 2004 were generally consistent with earlier years. Temporal patterns that were consistent with earlier years included early season (pre-chick feeding period) importance of pumpkinseed in the diet and increased importance of smallmouth bass over the season.

Similar to most previous years (Johnson et al. 2003) daily fish consumption declined over the season at LGI. In 2004, daily fish consumption declined from 15.3 during the pre-chick feeding period to 9.1 during the post-chick feeding period. Total fish consumption by the LGI colony in 2003 was the lowest (i.e. 15.66 million) observed since cormorant control measures were implemented on the island in 1999 (range 15.66 - 21.46 million). Since 1999, the number of fish consumed and the biomass of fish consumed has been reduced by 49 and 50%, respectively, from the previous 7 year period (Figure 1).

Since 1992 we estimate that LGI cormorants have consumed about 365 million fish, weighing about 34 million pounds, including 123 million alewife, 93 million yellow perch, 45 million cyprinds, 25 million pumpkinseed, 22 million rock bass and 14 million smallmouth bass. Of these species, predation by LGI cormorants has been tied to declines in smallmouth bass (Lantry et al. 2002) and yellow perch (Burnett et al. 2002) populations in the eastern basin of Lake Ontario.

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Table 1: Seasonal and total percent diet composition of double-crested cormorants from Little Galloo Island, 2004. Sample dates for the pre-chick, chick, and post-chick feeding periods were from 5/4/04 to 6/1/04, 6/16/04 to 7/21/04, and 8/4/04 to 10/12/04, respectively.

	Pre-chick	Chick	Post-chick	Total
No. of pellets	450	450	900	1,800
Fish/pellet (adjusted)	15.3	9.2	9.1	10.7
Alewife	37.6	52.6	41.2	41.9
Yellow perch	35.1	24.7	29.8	31.4
Pumpkinseed	11.3	1.9	3.7	7.2
Rock bass	6.3	8.6	7.6	7.1
Cyprinids	4.2	4.3	6.8	4.8
Smallmouth bass	0.4	4.8	5.3	2.7
Slimy sculpin	2.6	1.5	1.5	2.1
Ictalurid	0.6	0.1	0.9	0.6
Trout-perch	1.3	0.1	< 0.1	0.7
Darter	0.3	---	0.1	0.2
Catostomid	< 0.1	0.2	0.3	0.1
Esocid	0.1	0.1	0.1	0.1
White perch	0.1	---	< 0.1	0.1
Banded killifish	0.1	0.1	0.1	0.1
Round goby	---	1.0	2.6	0.9
Burbot	<0.1	<0.1	<0.1	<0.1
Lake trout	---	0.1	---	<0.1
Bluegill	<0.1	---	<0.1	<0.1
Walleye	---	---	<0.1	<0.1
	100.0	100.0	100.0	100.0

Table 2: Estimated total length (TL, mm), mean weight (Wt., g), and number examined (No.), of smallmouth bass, yellow perch, rock bass, and pumpkinseed consumed by double-crested cormorants during each feeding period on Little Galloo Island in 2004.

	Feeding Period								
	Pre-chick			Chick			Post-chick		
	TL	Wt.	No.	TL	Wt.	No.	TL	Wt.	No.
Smallmouth bass	223	146	5	192	89	51	164	53	104
Yellow perch	98	10	100	98	11	100	92	8	100
Rock bass	96	17	100	115	29	100	117	31	100
Pumpkinseed	86	12	100	90	14	100	111	29	100

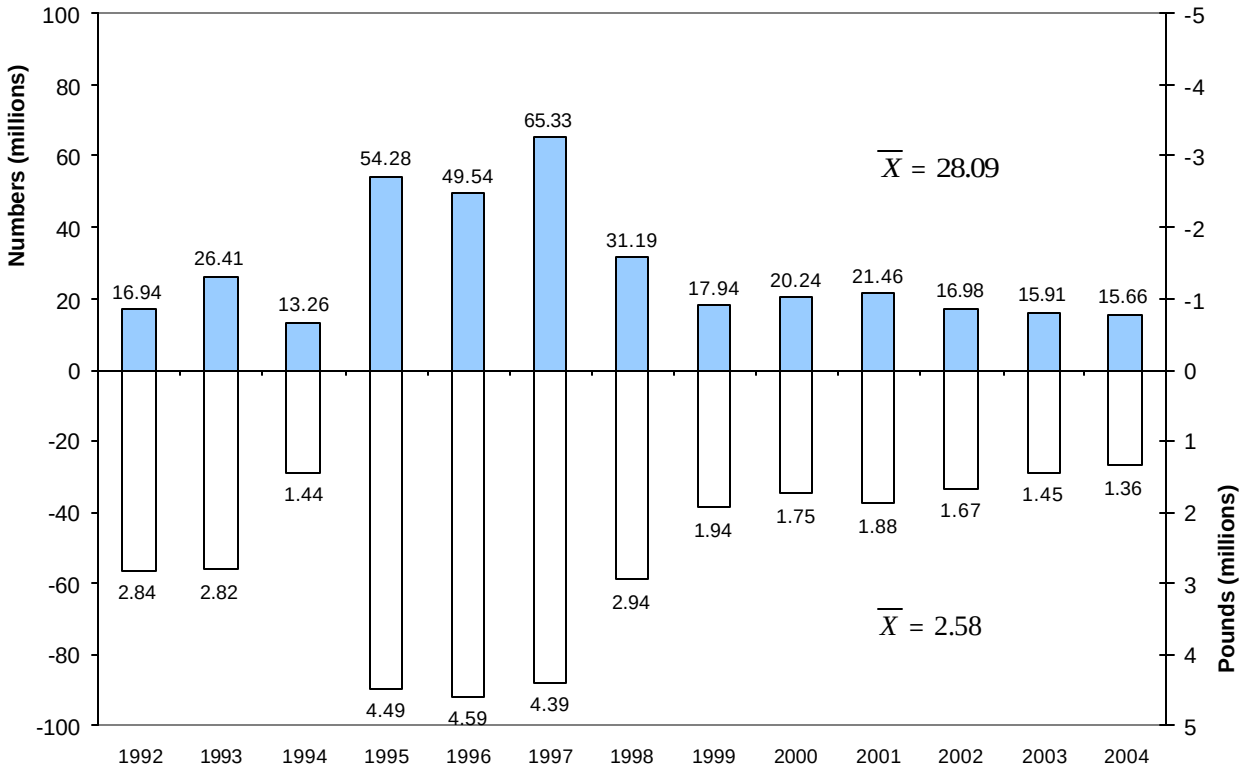

Figure 1: Estimated annual fish consumption in terms of numbers and pounds by the Little Galloo Island colony, 1992-2004.

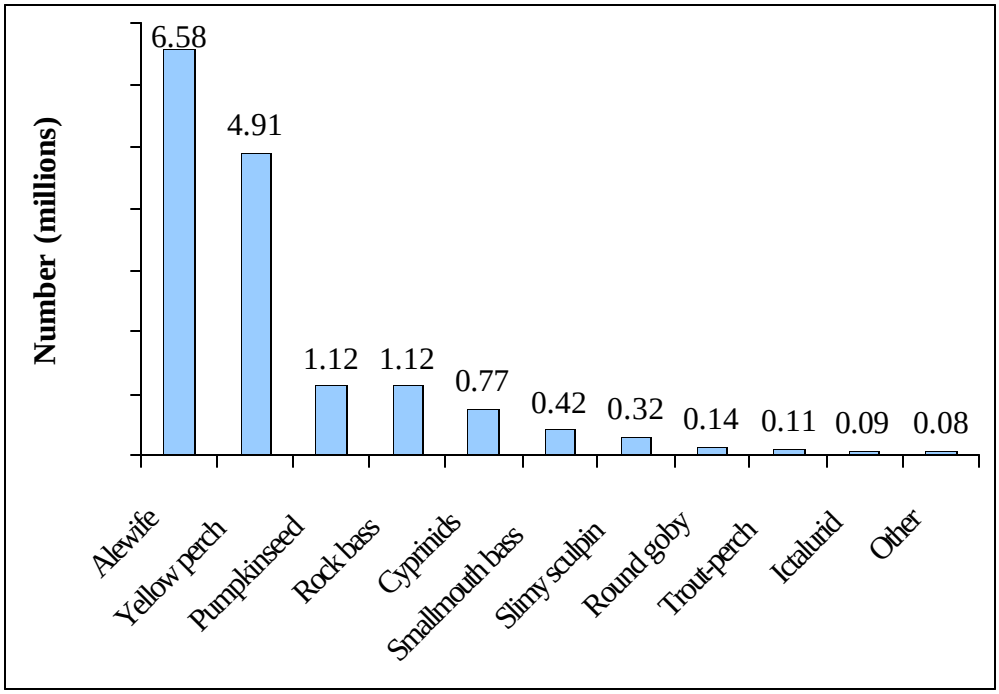

Figure 2: Estimated species-specific fish consumption by double-crested cormorants at the Little Galloo colony, 2004.