

**Diet Composition and Fish Consumption of Double-Crested Cormorants
from the Little Galloo Island Colony of Eastern Lake Ontario in 2002**

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Little Galloo Island (LGI) supports the largest nesting colony of double-crested cormorants (*Phalacrocorax auritus*) in the eastern basin of Lake Ontario and is one of the largest colonies in the Great Lakes. Because cormorants are largely piscivorous, concern arose in the early 1990's regarding the impacts of this colony on fish populations. Initially concern was directed at impacts on stocked salmonids, mainly brown trout and lake trout, because flocks of cormorants were observed aggregating at salmonid stocking sites. Diet studies confirmed that cormorants were consuming recently released salmonids (Ross and Johnson 1995) but that modifications of stocking practices could reduce predation (Ross and Johnson 1999). Later concern regarding cormorant predation on fish populations was directed at impacts on warmwater species, initially smallmouth bass then yellow perch. Declines in smallmouth bass and yellow perch populations surrounding LGI have been associated with increases in cormorant abundance (Burnett et al 2002, Lantry et al. 2002).

The year 2002 marked the eleventh 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 2002, the fifth 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 2002. Approximately 150 pellets were collected on each of 13 dates at approximately 2 week intervals beginning in late 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 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 were 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 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 feed 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 early June to late July, and the post-chick feeding period from early August to early 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:

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

To estimates 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 have 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 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 by 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 review) 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 1,928 regurgitated cormorant pellets were examined from LGI in 2002. These pellets represented cormorant diets from April 16 to October 8. 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 14.1 during the pre-chick feeding, to 6.4 during the post-chick feeding period, and averaged 9.7 for the season (Table 1).

Diet Composition

Alewife (39.9%) were the major prey of LGI cormorants in 2002, dominating the diet during the chick-feeding (85.5%) and post-chick (30.6%) feeding periods (Table 1). Yellow perch was the second most abundant species in the diet (19.3%) and were the major prey during the pre-chick (25.6%) feeding period. Pumpkinseed were the third most abundant prey consumed by LGI cormorants (11.7%), and contributed a large portion (20.6%) of the diet during the pre-chick feeding period (Table 1). Rock bass (7.2%), cyprinids (7.2%) and three-spine sticklebacks (5.2%) were the fourth, fifth and sixth most abundant prey in cormorant diets. Smallmouth bass (2.8%), slimy sculpin (2.7%) and

trout-perch were the only other prey species that contributed at least 1% of the diet (Table 1). Smallmouth bass and three-spine stickleback were the only prey species to exhibit temporal trends in consumption over the entire season with bass increasing in the diet from 1.0% during the pre-chick feeding period to 2.0% during the chick feeding period and 8.0% during the post-chick feeding period and stickleback decreasing from 9.3% to 0.5%. For the entire season forage species (i.e. alewife, cyprinids, three-spine stickleback slimy sculpin, trout-perch, etc) contributed 58% of the die of LGI cormorants and panfish (i.e. yellow perch, pumpkinseed, rock bass, ictalurids, etc) and gamefish (smallmouth bass, esocids, walleye) composed 39% and 3%, respectively.

Fish Consumption

A peak count of 4,780 cormorant nests was observed on LGI in 2002 and chick productivity was estimated at about 0.12 chicks per nest based on observations at a small undisturbed control colony on LGI (pers. comm. Jim Farquhar, NYSDEC, Watertown, NY). Using the Weseloh and Casselman model we estimate about 1.67 million feeding days for the LGI colony in 2002 and about 1.67 million pounds of fish consumed (Figure 1). Total numerical fish consumption by the LGI colony in 2002 was estimated at 16.98 million (Figure 1). Fish consumption by feeding period in 2002 included 8.89 during the pre-chick feeding period, 4.44 million during the post-chick feeding period and 3.65 million during the post-chick feeding period.

In 2002, LGI cormorants consumed 9.86 million forage fish including 6.78 million alewife, 1.21 million cyprinids, 0.88 million three-spine stickleback, 0.46 million slimy sculpin, and 0.33 million trout-perch (Figure 2). About 6.63 million panfish were eaten including 3.29 million yellow perch, 2.00 million pumpkinseed, 1.23 million rock bass, and 0.13 million ictalurids. Cormorants consumed about 0.51 million game fish, mostly smallmouth bass (0.47 million) (Figure 2).

Size of fish consumed

We measured a total of 1,238 otoliths recovered from cormorant pellets in 2002. The size of smallmouth bass and alewife consumed by LGI cormorants in 2002 declined over the season (Table 2). Smallmouth declined from 233 mm during the pre-chick feeding period to 150 mm during the post-chick feeding period. The size of

alewife consumed declined from 125 mm during the pre-chick feeding period to 113 mm during the post-chick feeding period. There was no apparent seasonal trend in the size of rock bass and pumpkinseed consumed by LGI cormorants in 2002. 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 determined the biomass of each of these four species consumed by cormorants during each feeding period. For the entire feeding season on LGI cormorants consumed 78,000 pounds of smallmouth bass, 123,000 pounds of yellow perch, 121,000 pounds of pumpkinseed, and 99,000 pounds of rock bass.

Discussion

The diet composition of LGI cormorants in 2002 was similar to that reported from 1992 to 2001 with alewife and yellow perch dominating the diet (Johnson et al 2002a). However, in 2002 alewife contributed a larger proportion of the diet than yellow perch (i.e. 39.9% versus 19.3%) compared to the previous ten years (31.5% versus 24.7%). Temporal trends in diet composition in 2002 were generally consistent with earlier years with the exception of alewife being the major prey during the post-chick feeding period compared to yellow perch dominating the late season diet of LGI cormorants from 1999 to 2001 (Johnson et al 2002a). Temporal patterns that were consistent with earlier years included early season (pre-chick feeding period) importance of pumpkinseed and three-spine stickleback in the diet and increased importance of smallmouth bass over the season.

A significant decline in daily fish consumption over the season that was observed from 1992 to 2000 (Johnson et al. 2002a) but did not occur in 2001 (Johnson et al. 2002b) was again evident in 2002. In 2002, daily fish consumption declined from 14.1 during the pre-chick feeding period to 6.4 during the post-chick feeding period. Total fish consumption by the LGI colony in 2002 was the lowest (i.e. 16.98 million) observed since cormorant control measures were implemented on the island in 1999 (range 17.94 - 21.46 million). Since 1999, the number of fish consumed and the biomass of fish consumed has been reduced by 48 and 46%, respectively from the previous 7 year period (Figure 1).

Since 1992 we estimate that LGI cormorants have consumed about 333 million fish, weighing about 31 million pounds including 109 million alewife, 84 million yellow perch, 43 million cyprinids, 23 million pumpkinseed, 20 million rock bass and 12 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, 2002. Sample dates for the pre-chick, chick, and post-chick feeding periods were from 4/16/02 to 6/6/02, 6/19/02 to 7/24/02, and 8/7/02 to 10/8/02, respectively.

	<u>Pre-chick</u>	<u>Chick</u>	<u>Post-chick</u>	<u>Total</u>
No. of pellets	587	591	750	1,928
Fish/pellet (adjusted)	14.1	9.5	6.4	9.7
Alewife	21.0	85.5	30.6	39.9
Yellow perch	25.6	4.6	22.0	19.3
Pumpkinseed	20.6	<0.1	4.4	11.7
Three-spine stickleback	9.3	0.7	0.5	5.2
Cyprinids	8.5	1.6	10.6	7.2
Rock bass	5.1	2.8	17.7	7.2
Slimy sculpin	2.7	2.3	3.2	2.7
Smallmouth bass	1.0	2.0	8.0	2.8
Trout-perch	3.4	0.2	0.6	2.0
Ictalurid	1.0	<0.1	1.1	0.8
Catostomid	0.2	0.1	0.2	0.2
Esocid	0.1	<0.1	0.2	0.1
White perch	0.1	<0.1	0.1	0.1
Rainbow smelt	0.2	<0.1	---	0.1
Burbot	<0.1	---	<0.1	<0.1
Darter	1.2	0.1	---	0.7
Gizzard shad	---	---	<0.1	<0.1
Lake trout	<0.1	---	---	<0.1
American eel	<0.1	---	---	<0.1
Banded killifish	<0.1	---	0.1	<0.1
Coregonid	---	---	<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, pumpkinseed, and alewife consumed by double-crested cormorants during each feeding period on Little Galloo Island in 2002.

	<u>Feeding Period</u>								
	<u>Pre-chick</u>			<u>Chick</u>			<u>Post-chick</u>		
	<u>TL</u>	<u>No.</u>	<u>Wt.</u>	<u>TL</u>	<u>No.</u>	<u>Wt.</u>	<u>TL</u>	<u>No.</u>	<u>Wt.</u>
Smallmouth bass	233	19	169	196	45	96	150	71	40
Yellow perch	106	100	13	125	100	22	135	100	27
Rock bass	127	100	39	119	100	32	123	100	36
Pumpkinseed	109	100	28	109	3	28	105	100	24
Alewife	125	100	—	123	100	—	113	100	—

Figure 1. Estimated annual fish consumption in terms of numbers and pounds by the Little Galloo Island Colony, 1992-2002.

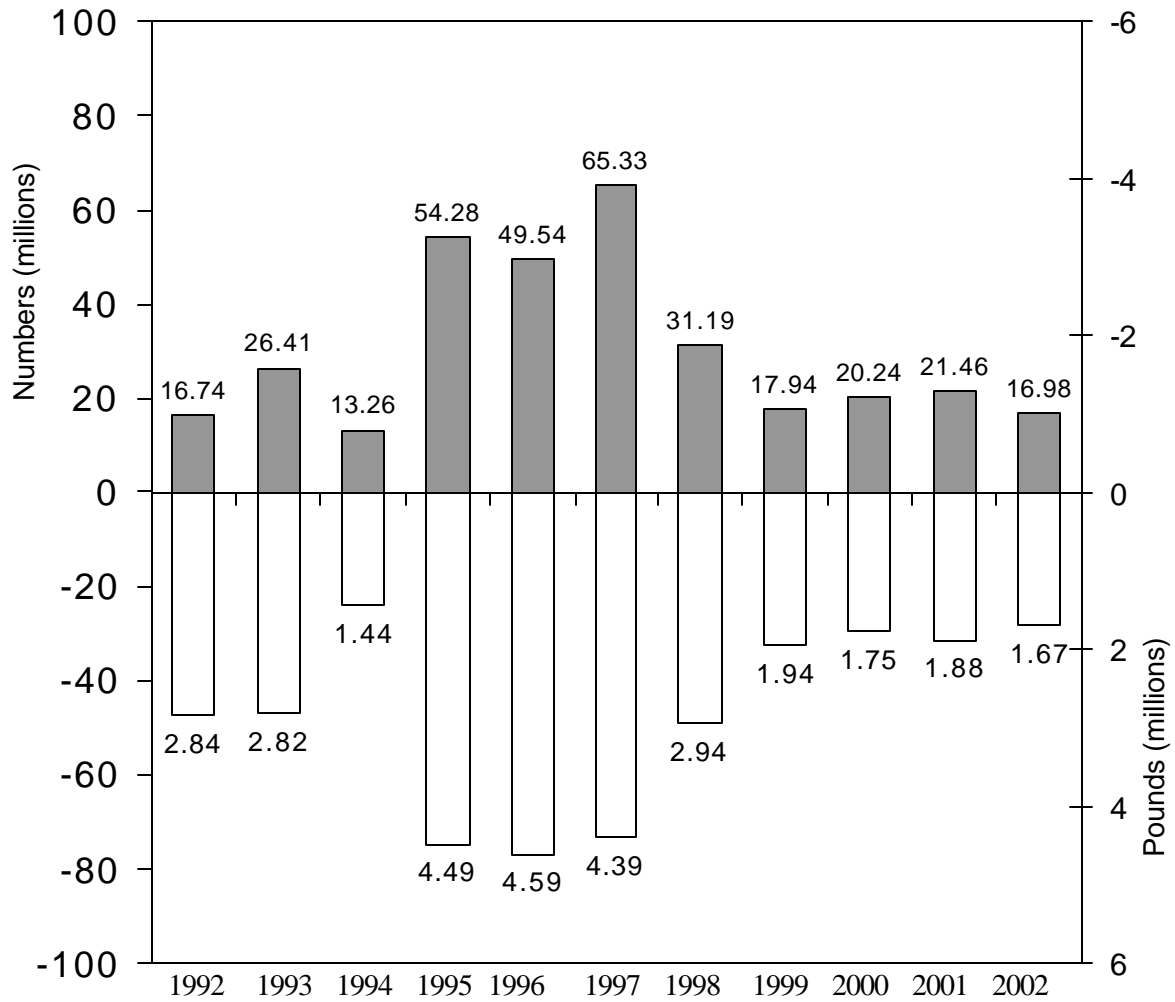


Figure 2. Estimate species-specific fish consumption by double-crested cormorants at the Little Galloo colony, 2002.

