Diet Composition and Fish Consumption of Double-Crested Cormorants from the Little Galloo Island Colony of Eastern Lake Ontario in 2001[1]

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The double-crested cormorants (*Phalacrocorax auritus*) colony on Little Galloo Island (LGI) is the largest colony in the eastern basin of Lake Ontario. Because of the piscivorous feeding habit of this species, concern arose in the early 1990's regarding the impacts of this colony on local fish populations. The first examination of the diet of LGI cormorants was initiated in 1992 (Karwowski 1994). Since 1992 diet information on LGI cormorants has been gathered annually and can be broadly categorized as minimal (1995-1997), moderate (1992-1994), and comprehensive (1998-2001). Johnson et al. (In press) review nine years of cormorant diet and fish consumption information for the LGI colony through 2000. This paper reports the findings from work carried out in 2001, the fourth consecutive year of comprehensive work on LGI cormorant diet composition and fish consumption.

Methods

Diagnostic prey remains recovered in regurgitated pellets were used to describe the diet of double-crested cormorants on LGI in 2001. Approximately 150 pellets were collected on each of 14 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number of fish consumed by cormorants from the LGI colony, we used a model similar to that of Weseloh and Casselman (unpublished report: Fish consumption by double-crested cormorants on Lake Ontario, Burlington, Ontario) to estimate the number of fish eaten by cormorants annually.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:

	Days			
	Pre-chick	Chick	Post-chick	Total
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 and Johnson 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 1,929 regurgitated cormorant pellets were examined for LGI in 2001. These pellets represented cormorant diets from April 19 to October 10. 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. However, these three feeding periods were not as well differentiated in 2001 as they were in prior years. Genrally the three feeding periods were delineated by differences in diet composition and daily fish consumption. In 2001, temporal differences in diet composition and daily fish consumption between feeding periods was minor compared to previous years. The number of fish per pellet (adjusted for fecal loss) remained fairly uniform over the season ranging from 10.9 (chick feeding period) to 12.2 (pre-chick feeding period) and averaged 11.4 for the season (Table 1).

Diet Composition

For the first time since comprehensive diet studies of LGI cormorants began in 1998 a single species, alewife, dominated the diet during each feeding period (Table 1). For the season alewife comprised 43.6% of the diet ranging from 30.3% (pre-chick feeding period) to 63.0% (chick feeding period). Yellow perch was the second most abundant species in the diet (21.1%) and contributed at least 15% to the diet in each feeding period. Other species that contributed at least 1% of the diet include pumpkinseed (7.5%), three-spine stickleback (7.0%), cyprinids (6.1%), rock bass (5.8%), slimy sculpin (3.6%) and smallmouth bass (3.5%). Pumpkinseed and three-spine stickleback were both more important in the diet of cormorants during the pre-chick feeding period compared to later in the season. Smallmouth bass were the only prey species to exhibit of temporal trend in consumption over the entire season increasing in the diet from 1.1% during the pre-chick feeding period to 4.3% during the chick feeding period and 5.9% during the post-chick feeding period (Table 1). For the entire period, forage species (i.e. alewife, three-spine stickleback, cyprinids, slimy sculpin, trout-perch, etc.) contributed 61% of the diet of LGI cormorants and panfish (i.e. yellow perch, pumpkinseed, rock bass, ictalurids, etc.) and gamefish (smallmouth bass, esocids, walleye) comprised 35% and 4%, respectively.

Fish Consumption

A peak count of 5,440 cormorant nests was observed on LGI in 2001 and chick productivity was estimated at about 0.074 chicks per nests (pers. Comm. Jim Farquhar, NYSDEC, Watertown, NY). Using the Weseloh and Casselman model we estimate about 1.88 million feeding days for the LGI colony in 2001 and about 1.88 million pounds of fish consumed (Figure 1). Total numerical fish consumption by the LGI colony in 2001 was estimated at 21.46 million (Figure 1). Fish consumption by feeding period in 2001 included 8.67 million during the pre-chick feeding period, 5.67 million during the chick feeding period, and 7.12 million during the post-chick feeding period.

In 2001, LGI cormorants consumed 13.16 million forage fish including 9.36 million alewife, 1.49 million three-spine stickleback, 1.32 million cyprinids, 0.76 million slimy sculpin, and 0.16 million trout-perch (Figure 2). About 7.51 million panfish were eaten including 4.52 million yellow perch, 1.61 million pumpkinseed, 1.24 million rock bass and 0.12 million ictaluirids. Cormorants consumed about 0.79 million game fish, mostly smallmouth bass (0.76 million) (Figure 2).

Size of fish consumed

We measured a total of 1,162 otoliths recovered from cormorant pellets in 2001. The size of smallmouth bass and rock bass consumed by LGI cormorants in 2001 declined over the season (Table 2). Smallmouth declined from 212 mm during the pre-chick feeding period to 159 mm during the post-chick feeding period.

The size of rock bass consumed declined from 111 mm during the pre-chick feeding period to 95 mm during the post-chick feeding period. The size of yellow perch consumed by cormorants increased over the season from 101 mm during the pre-chick feeding period to 118 mm during the post-chick feeding period. There was no apparent seasonal trend in the size of pumpkinseed consumed by LGI cormorants in 2001. 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 97,000 pounds of smallmouth bass, 146,000 pounds of yellow perch, 99,000 pounds of pumpkinseed, and 56,000 pounds of rock bass.

Discussion

Over the 10 year period of investigation of the diet composition and fish consumption of the LGI cormorant colony either alewife or yellow perch have been the dominant prey in the annual diet (Johnson et al. In press). In 2001 at LGI, alewife were once again the major prey, but unlike previous years when yellow perch were the main component in the diet during at least one feeding period, alewife were the principle prey during all three feeding periods. Consequently, the diet of the LGI cormorants in 2001 exhibited the lowest amount of temporal variation seen at the colony to date. Temporal patterns in the diet composition observed at the LGI colony in 2001 that were consistent with previously observed patterns 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 (Johnson et al. In press).

Compared to previous years daily fish consumption was remarkably uniform over the entire season by LGI cormorants in 2001. Fish consumption (i.e. number of fish/pellet) was significantly higher during the pre-chick feeding period than the other two feeding periods from 1998 to 2000 (Johnson et al. In press). Although daily fish consumption was slightly higher during the pre-chick feeding period in 2001, the difference was not significant.

Cormorant nest counts on LGI in 2001 increased slightly from 2000 (5,440 versus 5,119). Similarly, estimated fish consumption by cormorants in 2001 (21.36 million) was slightly higher than in 2000 (20.24 million) with the difference being largely attributable to more cormorants being present on LGI in 2001 (Johnson et al. 2001) Fish consumption by the LGI cormorant colony has been substantially reduced since 1999 due to fewer birds using the island to nest and because of management actions to reduce the reproductive success of cormorants. Since 1999, the number of fish consumed and the biomass of fish consumed has been reduced by 46% and 45%, respectively, from the previous 7 year period (Figure 1).

Johnson et al. (In press) provides estimates of the size of smallmouth bass, yellow perch, rock bass, and pumpkinseed consumed by LGI cormorants from 1993 to 2000. With the exception of rock bass, which were smaller in 2001 than in previous years, the size of these species consumed by cormorants in 2001 was similar to previous years. Temporal trends in size utilization of yellow perch (increased size over the season) and rock bass (decreased size over the season) by LGI cormorants in 2001 had not been observed in previous years (Johnson et al. In press). The decrease in the size of smallmouth bass consumed over the season in 2001 was consistent with previous years.

Since 1992 (10 years) we estimate LGI cormorants have consumed about 316 million fish, weighing approximately 29 million pounds. Unfortunately, in the absence of information on the size of fish stocks in the eastern basin of Lake Ontario, we cannot determine the proportion of these stocks consumed by LGI cormorants. However, declines in the abundance of smallmouth bass (Lantry et al. In press) and yellow perch (Burnett et al. In press) have been associated with cormorant population increases in eastern Lake Ontario and cormorant-fish relationships remain a high priority for Lake Ontario fishery management agencies.

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Table 1: Seasonal and total percent diet composition of double-crested cormorants from Little Galloo Island, 2001. Sample dates for the pre-chick, chick, and post-chick feeding periods were from 4/19/01 to 5/19/01, 6/12/01 to 7/28/01, and 8/1/01 to 10/10/01, respectively.

	Pre-chick	Chick	Post-chick	Total
No. of pellets	561	739	629	1,929
Fish/pellet (adjusted)	12.2	10.9	11.1	11.4
Alewife	30.3	63.0	44.5	43.6
Yellow perch	23.0	14.7	23.8	21.1
Pumpkinseed	12.7	1.9	5.6	7.5
Three-spine stickleback	16.6	0.3	0.5	7.0
Cyprinids	5.5	4.0	8.6	6.1
Rock bass	4.6	4.9	7.9	5.8
Slimy Sculpin	4.0	5.2	1.7	3.6
Smallmouth bass	1.1	4.3	5.9	3.5
Trout-perch	1.0	1.2	<0.1	0.7
Ictalurid	0.6	0.1	0.8	0.5
Catostomid	0.2	0.3	0.5	0.3
Esocid	0.1	<0.1	<0.1	<0.1
White perch	0.1	<0.1	<0.1	<0.1
Rainbow smelt	0.1	<0.1	<0.1	<0.1
Walleye	<0.1	---	<0.1	<0.1
Burbot	---	<0.1	<0.1	<0.1
Darter	<0.1	---	<0.1	<0.1
Gizzard shad	---	---	<0.1	<0.1
	100.0	100.0	100.0	100.0

Table 2: Estimated total length (TL, mm), mean weight (Wt., g), number examined (No.), and standard error (SE) of smallmouth bass, yellow perch, rock bass and pumpkinseed consumed by double-crested cormorants during each feeding period on Little Galloo Island in 2001.

	Feeding Period											
	Pre-chick				Chick				Post-chick			
	TL	No.	Wt.	SE	TL	No.	Wt.	SE	TL	No.	Wt.	SE
Smallmouth bass	212	26	126	10.4	161	117	50	4.7	159	119	48	4.3
Yellow perch	101	100	11	3.1	116	100	17	2.6	118	100	18	2.7
Rock bass	111	100	26	5.4	105	100	22	3.9	95	100	16	4.0
Pumpkinseed	108	100	26	3.4	101	100	21	2.6	118	100	35	3.2

Figure 1: Estimated annual fish consumption in terms of numbers and pounds by the Little Galloo Island Colony, 1992-2001.

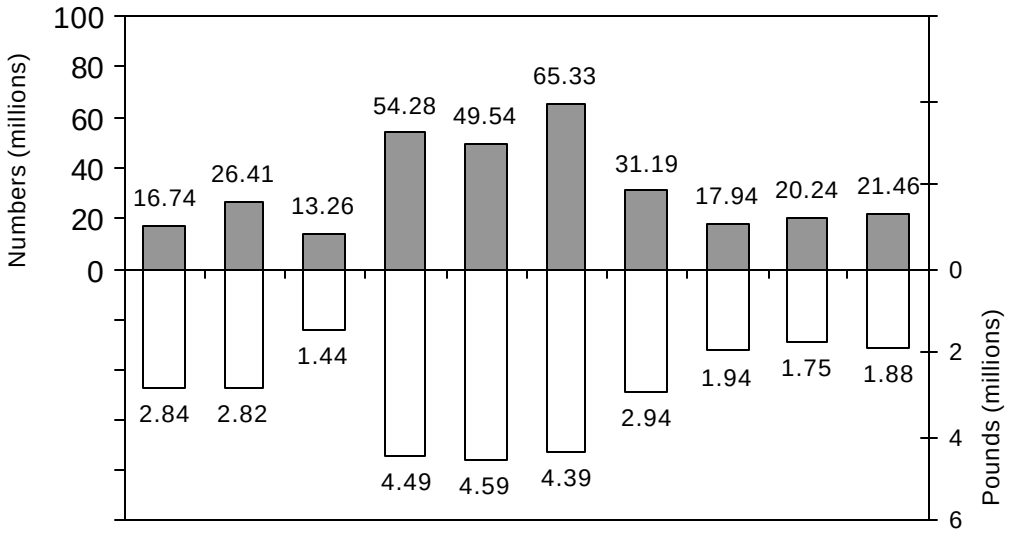

Figure 2: Estimate species specific fish consumption by double-crested cormorants at the Little Galloo colony, 2001.