

**Diet Composition and Fish Consumption of Double-Crested Cormorants
from the Pigeon and Snake Island Colonies of Eastern Lake Ontario in 2007**

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Pigeon Island (PI) and Snake Island (SI) are home to intermediate-sized colonies of double-crested cormorants (*Phalacrocorax auritus*) in the Eastern Basin of Lake Ontario. The proliferation of cormorant colonies in this area has created concern as to the effects that these piscivorous birds may have on local fish populations (Schneider et al. 1999). This year (2007) represents the 9th consecutive year of diet sampling of the nesting cormorants on PI and SI, based on regurgitated digestive pellets for prey enumeration. Since 1999 over 11,000 cormorant pellets have been collected on PI (5,649) and SI (6,062), while some 15,600 were examined at a neighboring island, Little Galloo (LGI). This paper reports on the diet composition and fish consumption of cormorants from PI and SI colonies in 2007. We also estimate the size of important species of fish consumed by cormorants. Our goal is to not only quantify these aspects of cormorant diet, but also to identify changes from previous years.

Methods

Diagnostic prey remains recovered in regurgitated pellets were used to describe the diet of double-crested cormorants at PI and SI in 2007. Eighty-five pellets were collected on each of two dates at PI and a single collection of 85 pellets was made at SI. Prior to 2007 a sample size of 150 was established 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). Because of the dominance of round goby in cormorant diets in recent years power analysis was again used to estimate sample size based on 2005 and 2006 diet data. Based on

this analysis sample size was reduced to 85. In the laboratory, diagnostic bones, all otoliths, and representative scales were removed from the pellets and identified under magnification. Eye lenses were also enumerated and, 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 PI and SI colonies, 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 YOY cormorants is the product of the fledgling productivity estimate for the year and the number of active nests. Residence times at PI and SI may actually be shorter because of annual management activities at the colony. Mazzocchi et al. (2003) found that the departure date of cormorants was 16 days later for a sub-colony of cormorants at nearby LGI where no management activities occurred compared to a sub-colony in the managed area. 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 three 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). Although immature cormorants are essentially fully grown, they are non-reproductive birds.

Because of the apparent differences in feeding patterns of cormorants over the season, we have 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 are characterized by differences in diet composition and daily fish consumption (i.e. the number of fish per pellet). Pre-chick feeding is from late April to early June, the chick feeding period from mid 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 cormorant 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 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 have been observed in cormorants (Carss et al. 1997) many 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 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 (approximately 1 pound) fish per day (Schramm et al. 1984, 1987; Weseloh and Casselman 1992), representing about 25% of their body weight (Dunn 1975).

When at least 10 otoliths were recovered from pellets 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 up to 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. We used otolith-length fish-length relationships derived for yellow perch (Burnett et al. 2000), and rock bass and pumpkinseed (Ross et al. 2005) 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

A total of 170 regurgitated cormorant pellets were examined from PI and 85 from SI in 2007. These pellets represented cormorant diets from June 26 to August 9. The number of fish per pellet (adjusted for fecal loss) was considerably higher at SI (\bar{x} = 42.2) than at PI (\bar{x} = 15.7).

Diet Composition

Round goby were the major prey of cormorants at both PI (70.1%) and SI (80.1%) in 2007 (Tables 1,2). Alewife (16.9%) and yellow perch (9.1%) were the second and third most abundant species in the diet at PI. At SI, yellow perch (12.7%) and cyprinids (4.1%) were the second and third ranked prey. For the entire season forage species (i.e. round goby, alewife, cyprinids etc) contributed 89.2% and 84%, panfish (i.e. yellow perch, rock bass, pumpkinseed, ictalurids etc) 10.6% and 15.7%, and gamefish (smallmouth bass) 0.2% and 0.1% of the diet of cormorants at PI and SI, respectively.

Fish Consumption

Peak nest counts of 1,645 and 411 were observed on PI and SI, respectively in 2007 and chick productivity was estimated at about 1.8 chicks per nest (pers. comm. J. Farquhar, NYSDEC, Watertown, NY). Using the Weseloh and Casselman model we estimate about 0.84 million cormorant feeding days for the PI colony in 2007 and about 0.84 million pounds of fish consumed (Table 3). At SI, we estimate 0.23 million cormorant feeding days and 0.23 million pounds of fish consumed.

In 2007, PI cormorants consumed 11.80 million forage fish including 9.27 million round goby and 2.24 million alewife (Figure 1). About 1.38 million panfish were eaten including 1.20 million yellow perch and 0.17 million rock bass. Cormorants consumed about 0.03 million game fish, mostly smallmouth bass (Figure 1).

At SI in 2007 cormorants consumed 8.06 million forage fish including 7.67 million round goby and 0.39 million cyprinids (Figure 1). Additionally, 1.49 million panfish were eaten including 1.22 million yellow perch, 0.14 million pumpkinseed and 0.10 million rock bass. Cormorant at SI consumed about 0.02 million game fish, all smallmouth bass.

Diet Overlap

Diet overlap in cormorants was significant ($C\lambda \geq 0.60$) and high among LGI, PI, and SI for the feeding periods examined. The prey of these groups were essentially the same throughout the season (Table 4). Significant and high temporal diet overlap was observed at LGI as well (Table 5). Because cormorant pellets were not collected during each feeding period at PI and SI in 2007 little information is available on temporal trends in diet composition at these colonies.

Size of fish consumed

A total of 464 otoliths recovered from cormorant pellets were measured in 2007 (Table 6). The average weight of yellow perch, rock bass, and pumpkinseed (computed from length-weight regression) for each feeding period is provided in Table 6. We estimated the biomass of each of these species consumed by cormorants during each feeding period. For the entire feeding season at PI cormorants consumed an estimated 30,000 pounds of yellow perch, and 6,000 pounds of rock bass. At SI cormorants consumed 37,000 pounds of yellow perch, 5,000 pounds of rock bass and 4,000 pounds of pumpkinseed.

Discussion

Because cormorant pellets were not collected during all feeding periods at PI and SI in 2007 extrapolations were required to project fish consumption for the entire season. Since 2004 (Ross et al. 2005b, 2006, 2007), including the present season, very little interannual variation in cormorant diets has been observed at either PI or SI, clearly due to domination of round goby in the diet at all colonies. Although season variation in diet composition has been reduced some variability stills occurs as well as seasonal differences in the number of fish/pellet. In 2007, round goby comprised 70% and 80% of the diet of cormorants at PI and SI, respectively. At both islands, round goby has apparently saturated benthic communities and reached a plateau in abundance based on observed cormorant diets. With the exception of yellow perch, all other prey species are now either insignificant or rare components of cormorant diets at these two islands.

Since round gobies have dominated cormorant diets at all colonies significant spatial variation in cormorant diets has been eliminated among the three islands (LGI, PI, and SI). Significant temporal variation was also completely eliminated at all three islands. Domination (~70%) of cormorant diets by round goby probably explains this phenomenon. Seasonal inshore movement of spawning alewife and use of this resource by cormorants feeding chicks was still evident, though a minor phenomenon, at all three island colonies.

Over the past 9 years, we estimate that cormorants from PI and SI have consumed about 17.3 million fish per year weighing 0.9 million pounds per year. In 2007, cormorants from LGI (Johnson et al. 2008), PI, and SI consumed 37.3 million fish weighing 2.06 million pounds. Since 1999, we estimate that cormorants from these three colonies have eaten approximately 34.4 million fish per year weighing about 2.40 million pounds per year.

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Table 1. Seasonal and total percent diet composition of double-crested cormorants from Pigeon Island, 2007. Cormorant pellets were sampled during the chick (6/26/07) and post-chick (8/9/07) feeding periods.

	<u>Chick</u>	<u>Post-chick</u>	<u>Total</u>
No. of pellets	85	85	170
No. fish/pellet	11.5	19.9	15.7
Round goby	47.3	82.0	70.1
Alewife	44.7	2.1	16.9
Yellow Perch	5.0	11.5	9.1
Rock Bass	1.6	1.1	1.3
Smallmouth bass	0.2	0.2	0.2
Cyprinid	1.0	2.9	2.2
Ictalurid	---	0.1	<0.1
Catostomid	0.1	---	<0.1
Pumpkinseed	---	0.1	<0.1
White perch	0.1	---	<0.1
	100.0	100.0	100.0

Table 2. Percent diet composition of double-crested cormorants from Snake Island, during the post-chick feeding period (8/9/07).

	<u>Post-chick</u>
No. of pellets	85
No. fish/pellet	42.2

Round goby	80.1
Yellow perch	12.7
Cyprinids	4.1
Rock bass	1.1
Pumpkinseed	1.4
Ictalurid	0.4
Slimy sculpin	<0.1
Smallmouth bass	0.1
Catostomid	<0.1
Freshwater drum	1.0
Bluegill	<0.1

	100.0
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Table 3. Fish consumption estimates (in millions) for cormorants from the Pigeon and Snake Island colonies in eastern Lake Ontario, 2007.

<u>Feeding period</u>	<u>Pigeon Island</u>		<u>Snake Island</u>	
	<u>Number</u>	<u>Pounds</u>	<u>Number</u>	<u>Pounds</u>
Pre-chick	3.3	0.22	2.3	0.05
Chick	3.5	0.30	3.7	0.09
Post-chick	<u>6.4</u>	<u>0.32</u>	<u>3.6</u>	<u>0.08</u>
Total	13.2	0.84	9.6	0.22

Table 4. Spatial diet overlap ($C\lambda$) among three eastern Lake Ontario cormorant colonies, 2007.

<u>Feeding period</u>	<u>Colonies</u>		<u>Colonies</u>	
	<u>L. Galloo I. Vs Pigeon I.</u>	<u>L. Galloo I. Vs Snake I.</u>	<u>Pigeon I. Vs Snake I.</u>	
Pre-chick	----	----	----	
Chick	0.675	----	----	
Post-chick	0.986	0.984	0.965	
Entire Season	0.989	----	----	

Table 5. Temporal diet overlap ($C\lambda$) among feeding periods at each of the three eastern Lake Ontario cormorant colonies, 2007.

<u>Feeding period</u>	<u>Little Galloo Island</u>	<u>Pigeon Island</u>
Pre-chick vs chick	0.967	----
Pre-chick vs post-chick	0.972	----
Chick vs post-chick	0.997	0.724
Seasonal Average	0.979	----

Table 6. Estimated total length (TL, inches), weight (Wt, pounds), and number examined (No.) for yellow perch, rock bass, and pumpkinseed consumed by double-crested cormorants during each feeding period on Pigeon and Snake Island in 2007.

<u>Species</u>	<u>Pigeon Island</u>			<u>Snake Island</u>		
	<u>TL(SD)</u>	<u>Wt.</u>	<u>No.</u>	<u>TL(SD)</u>	<u>Wt.</u>	<u>No.</u>
	Chick					
Yellow perch	3.7 (1.1)	0.02	62	---	---	---
Rock bass	3.5 (1.1)	0.03	24	---	---	---
	Post-chick					
<u>Species</u>	<u>TL(SD)</u>	<u>Wt.</u>	<u>No.</u>	<u>TL(SD)</u>	<u>Wt.</u>	<u>No.</u>
Yellow perch	3.8 (0.8)	0.03	100	4.1 (1.1)	0.03	100
Rock bass	3.6 (0.9)	0.04	32	3.9 (1.4)	0.05	64
Pumpkinseed	---	---	---	3.4 (0.9)	0.03	82

a) Pigeon Island

b) Snake
Island

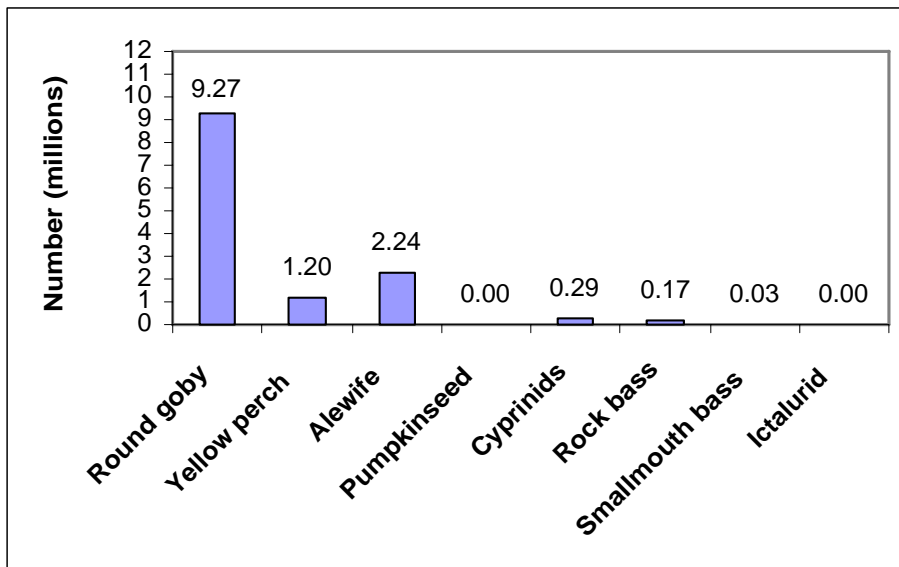


Figure 1: Estimated species-specific fish consumption by double-crested cormorants at Pigeon Island (a) and Snake Island (b) in 2007.

