Diet Composition and Fish Consumption of Double-Crested Cormorants from Three St. Lawrence River Colonies in 2003

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Since they were first observed nesting on Strachan Island in 1992, double-crested cormorants (Phalacrocorax auritus) have increased in abundance in the upper St. Lawrence River. Nest counts at the three largest upper river colonies (i.e. Griswold, McNair, and Strachan) have remained relatively stable and these river colonies are substantially smaller in size than neighboring cormorant colonies in eastern Lake Ontario (Johnson et al. 2003). Although smaller in colony size than the Lake Ontario colonies, cormorants at Griswold, McNair and Strachan Islands have consumed an estimated 23.52 million fish from 1999 to 2002 (Johnson et al. 2000, 2001, 2002, 2003). Cormorant colonies in the upper river may be sufficiently large to depress fish populations near the colony as has been documented in the eastern basin of Lake Ontario for yellow perch and smallmouth bass (Burnett et al. 2002, Lantry et al. 2002).

Because of concerns that cormorant predation could also deplete fish populations in the upper St. Lawrence River, studies were initiated in 1999 to quantify cormorant diet and fish consumption. This paper describes the diet and fish consumption of cormorants in the upper St. Lawrence River in 2003.

Methods

Diagnostic prey remains recovered in regurgitated pellets were used to describe the diet of double-crested cormorants at St. Lawrence River colonies in 2003. Pellets were collected beginning in late May and ending in late August. 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 the number of fish consumed by cormorants from each colony, we used a model similar to that of Weseloh and Casselman (unpublished report: Fish consumption by double-crested cormorants on Lake Ontario, Burlington, Ontario) to estimate the number of fish eaten by cormorants annually.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). 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 late September. 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 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 each 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 smallmouth bass (*Micropterus dolomieu*), 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 some cases <100 were in a sample) randomly selected otoliths from each species from each 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 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 each species (unpublished data).

Spatial and temporal variation in diet composition for the Griswold, McNair and Strachan Island colonies was determined by using the equation of Morisita (1959) as modified by Horn (1966). Overlap values can range from 0, when samples contain no food in common, to 1, when there is identical representation of food between samples. When using this formula, overlap values (Cλ) $ 0.60 are considered biologically significant (Zaret and Rand 1971).

Results

A total of 1,646 pellets were used to describe the feeding ecology of cormorants from Griswold (750 pellets), McNair (661 pellets), and Strachan (235 pellets) Islands in 2003 (Tables 1-3). Because of apparent temporal differences in daily fish consumption (fish/pellet), three distinct periods of cormorant feeding are described, i.e., pre-chick feeding, chick feeding, and post-chick feeding. For the Griswold Island colony the number of fish per pellet (adjusted for fecal loss) declined from 19.6 during the pre-chick feeding period, to 15.9 during the chick feeding period and 10.3 during the post-chick feeding period and averaged 14.4 for the entire period (Table 1). Cormorant pellets from the McNair Island colony contained the fewest number of fish per pellet (i.e., 12.3 for the entire season), and the number of fish per pellet remained relatively stable (i.e. 11.3 to 13.9 during all three feeding periods (Table 2). No pellet collections were made on Strachan Island during the pre-chick feeding period in 2003. The number of fish per pellet for cormorants from the Strachan Island colony was highest during the post-chick period (17.4), and average 15.8 fish per pellet for the chick and post-chick feeding periods (Table 3).

Diet Composition

Yellow perch dominated the diet of cormorants from Griswold Island during each feeding period (i.e. 47.1% to 70.5%) and made up 63.8% of the total diet (Table 1). Rock bass (10.4%), cyprinids (10.0%) and pumpkinseed (9.7%) were the other major prey of Griswold Island cormorants. Seasonal trends in consumption were evident for rock bass which increased in the diet during each feeding period (6.8% to 15.6%) (Table 1). For the entire season, panfish (i.e., yellow perch, rock bass, pumpkinseed, ictalurids) contributed 85.7% of the diet, forage fish (cyprinids, slimy sculpin, darters, alewife) composed 13.0%, and gamefish (mainly esocids and smallmouth bass) comprised 1.3% of the diet of Griswold Island cormorants.

Yellow perch (33.9%) and rock bass (28.6%) dominated the diet of cormorants at McNair Island (Table 2). Cyprinids (11.2%), pumpkinseed (9.0%) and darters (6.0%) were the only other species that made up at least five percent of the diet. The invasive species round goby appeared in the diet of cormorants from McNair Island for the first time in 2003 and made up 1.9% of the diet. Three species in the diet of McNair Island cormorants exhibited seasonal trends in consumption. The contribution of yellow perch in the diet increased (25.6% to 37.8%) during each feeding period whereas that of slimy sculpin (6.8% to 1.7%) and darters (14.6% to 1.2%) decreased. For the season panfish made up 73.3% of the diet of McNair Island cormorants, forage fish 25.0%, and gamefish (mostly smallmouth bass) 1.7% (Table 2).

Yellow perch (61.0%), cyprinids (11.9%), rock bass (11.8%), and pumpkinseed (6.1%) were the main prey of Strachan Island cormorants (Table 3). The lack of diet information from the pre-chick feeding period precludes discussion of the temporal differing in diet composition. Panfish made up 82.0% of the seasonal diet, forage fish 16.3% and gamefish 1.7% at Strachan Island in 2003 (Table 3).

Diet Overlap

Diet overlap for the entire season was significant (i.e.,Cλ$ 0.60) among all three upper St. Lawrence River colonies in 2003 (Table 4). Diet was the most similar between cormorants from Griswold and Strachan Islands (Cλ= 0.996) and least similar between Griswold and McNair Islands (Cλ= 0.808). When comparing the three colonies diet overlap between cormorants from McNair Island and the other two colonies was lowest (Cλ= 0.820), but still biologically significant. Diet overlap was low between cormorants at Griswold and McNair Islands during the pre-chick feeding (Cλ= 0.610). Diet overlap was highest during the post chick feeding (Cλ0= 0.919) period (Table 4). Temporal variation in diet composition among feeding periods within each colony was minimal (Table 5).

Fish Consumption

Based on nest counts of 291 on Griswold Island, 266 on McNair Island, and 332 on Strachan Island, and fledgling productivities of 1.8 chicks per nest (pers. comm. James Farquhar, NYSDEC, Watertown), we estimated 0.15, 0.13, and 0.17 million cormorant feeding days for these colonies, respectively, in 2003. Fish consumption for the Griswold Island colony was estimated at 2.14 million fish and 0.15 million pounds, for the McNair Island colony at 1.64 million fish and 0.13 million pounds, and for the Strachan Island colony at 2.57 million fish and 0.17 million pounds (Table 6).

We estimate that during 2003 cormorants from Griswold Island consumed 1.84 million panfish (including 1.37 million yellow perch, 0.22 rock bass, and 0.21 million pumpkinseed), 0.27 million forage fish (mostly cyprinids 0.22 million), and 0.02 million gamefish (primarily smallmouth bass and esocids) (Figure 1). We estimate that cormorants from McNair Island consumed 1.20 million panfish (mainly 0.55 million yellow perch and 0.47 million rock bass), 0.40 million forage fish (including 0.18 million cyprinids, 0.10 million darters and 0.07 million slimy sculpin), and 0.04 million gamefish (mostly smallmouth bass). Double-crested cormorants from the Strachan Island colony consumed 2.08 million panfish (yellow perch 1.57 million, rock bass 0.30 million, pumpkinseed 0.16 million), 0.44 million forage fish (0.31 million cyprinids, 0.03 million darters), and 0.05 million gamefish (mainly walleye) (Figure 1).

Size of fish consumed

Because pellets were not collected at Strachan Island during the pre-chick feeding period in 2003 seasonal trends in the size of fish consumed were not considered. At Griswold Island the only apparent seasonal trend was a decrease in the size of rock bass consumed over the season from 116 m during the pre-chick feeding period to 98 mm during the post chick feeding period (Table 7). At McNair Island, the size of smallmouth bass consumed decreased over the season (228 mm to 168 mm) whereas the size of yellow perch consumed increased (107 mm to 118 mm).

Discussion

Cormorant diet composition at the Griswold and Strachan Island colonies in 2003, where yellow perch was the primary prey, was similar to the previous three years (Johnson et al. 2000, 2001, 2002, 2003). Since 1999 yellow perch have contributed 56.5% and 59.0% of the diet of cormorants at the Griswold and Strachan Island colonies, respectively. Over this same period rock bass (14.3% and 12.0%), cyprinids (11.6% and 13.3%), and pumpkinseed (11.2% and 5.0%) have also been consistently important in the diet of cormorants from the Griswold and Strachan Island colonies, respectively. In 2002 and 2003 yellow perch replaced rock bass as the major prey of McNair Island cormorants. Since 1999, rock bass have been the major prey (36.9%) of McNair Island cormorants followed by yellow perch (30.9%), cyprinids (11.6%), slimy sculpin (4.8%), pumpkinseed (4.8%) and darters (4.6%).

With yellow perch dominating the diet of cormorants during each feeding period at all three upper St. Lawrence River colonies in 2003 spatial and temporal variation in diet composition was low. Similar to 2002 (Johnson et al. 2003), diet overlap among river colonies was lowest during the pre-chick feeding period and highest during the post-chick feeding period.

The dominance of panfish in the diet of upper St.

Lawrence River cormorants reported by Johnson et al. 2001, 2002, and 2003 continued in 2003. Panfish comprised 80.6% (range 73.2 to 86.0%) and forage fish 17.5% (range 12.6% to 24.3%) of the diet of cormorants at river colonies in 2003. Since 1999, panfish have composed 78.5% (range 75.2% to 83.7%) and forage fish 19.3% (range 13.4% to 23.1%) of cormorant diets in the upper St. Lawrence river. Over the past four years game fish have made up 2.1% (range 1.7% to 2.9%) of the diet of cormorants at these three river colonies (Johnson et al. 2000, 2001,2002, 2003).

Estimated fish consumption by cormorants from the three upper St. Lawrence River colonies in 2003 (6.35 million fish) was within the range (4.79 to 6.64 million) reported for the four previous years (Johnson et al. 2000, 2001, 2002, 2003). Average annual fish consumption by cormorants from Griswold, McNair, and Strachan Islands since 1999 is 5.97 million fish. Since 1999, we estimate that double-crested cormorants from these colonies have consumed 29.87 million fish including 15.34 million yellow perch, 5.35 million rock bass, 3.79 million cyprinids, 2.31 million pumpkinseed and 0.31 million smallmouth bass.

The average size of fish consumed decreased slightly in 2003 compared to 2002 and was more similar to 2000 and 2001 (Johnson et al. 2000, 2001, 2002, 2003). Although sample sizes were small the size of smallmouth bass consumed by cormorants at Strachan Island was smaller than previous years. As reported in 2000 and 2001 (but not 2002) the size of yellow perch consumed by cormorants at Strachan Island was smaller than at the other colonies.

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References

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.

Burnett, J.A.D., N.H. Ringler, T.H. Eckert, and B.F. Lantry. 2000. Yellow perch abundance and life history in the eastern basin of Lake Ontario in relation to recent increase in double-crested cormorants. Section 19 *in* NYSDEC Annual report 1999, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Burnett, J.A.D., N.H. Ringler, B.F. Lantry, and J.H. Johnson. 2002. Impact of double-crested cormorant (*Phalocrocorax auritus*) piscivory on the yellow perch (*Perca flavescens*) populations in the eastern basin of Lake Ontario, Journal of Great Lakes Research 28:202-211.

Carss, D.N. and 27 co-authors. 1997. Techniques for assessing cormorant diet and food intake: towards a consensus view. Pages 197-230 in N. Baccetti and G. Cherubini, editors, European Conference on Cormorants. Supplement alle. Ricerche di Bilogia dellaa Selvaggina, Volume XXVI.

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.

Horn, H.S. 1966. Measurement of "overlap" in comparative ecological studies. American Naturalist 100:419-424.

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., S.R. LaPan, and A. Bendig. 2000. Diet composition and fish consumption of double-crested cormorants from three St. Lawrence River colonies in 1999. Section 17 *in* NYSDEC Annual report 1999, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Johnson, J.H., S.R. La Pan, B. Edmonds, and A. Bendig. 2001. Diet composition and fish consumption of double-crested cormorants from three St. Lawrence River colonies in 2000. Section 17 *in* NYSDEC Annual report 2000, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Johnson, J.H., R.M. Klindt, B. Edmonds, and A. Bendig. 2002. Diet composition and fish consumption of double-crested cormorants from three St. Lawrence River colonies in 2001. Section 17 *in* NYSDEC Annual report 2001, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Johnson, J.H., R.M. Klindt, B. Edmonds, and A. Bendig. 2003. Diet composition and fish consumption of double-crested cormorants from three St. Lawrence River colonies in 2002. Section 17 *in* NYSDEC Annual report 2002, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Lantry, B.F., T.H. Eckert, C.P. Schneider, and J.R. Chrisman. 2002. The relationship between abundance of smallmouth bass and double-crested cormorants in the eastern basin of Lake Ontario. Journal of Great Lakes Research 28:193-201.

Morisita, M. 1959. Measuring of interspecific association and similarity between communities. Memeroirs. Faculty of Science Kyusshu University, Series E (Biology) 3:65-80.

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. In review. Relationship between fish size and otolith length in pumpkinseed (*Lepomis gibbosus*) and rock bass (*Ambloplites rupestris*). Journal of Great Lakes Research.

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.

Zaret, T.M. and A.S. Rand. 1971. Competition in tropical streams: support for the competitive exclusion principle. Ecology 52:336-342.

Table 1. Seasonal and total percent diet composition of double-crested cormorants from Griswold Island, 2003. Pre-chick feeding period includes pellets collected on 5/29/03, the chick feeding period includes pellets collected on 6/20/03 and 7/17/03, and the post-chick feeding period includes pellets collected on 8/20/03 and 9/11/03.

	Pre-chick	Chick	Post-chick	Total
No. of pellets	150	300	300	750
Fish/pellet (adjusted)	19.6	15.9	10.3	14.4
Yellow perch	70.5	70.2	47.1	63.8
Cyprinids	9.0	9.6	12.4	10.0
Rock bass	6.8	9.7	15.6	10.4
Pumpkinseed	8.0	5.4	17.3	9.7
Slimy sculpin	1.9	1.4	0.6	1.2
Darter	0.7	1.1	0.4	0.8
Ictalurid	0.8	0.7	4.3	1.8
Esocid	1.2	0.5	0.4	0.7
Smallmouth bass	0.5	0.6	0.4	0.5
Alewife	<0.1	0.1	1.1	0.4
Catostomid	<0.1	0.1	0.2	0.1
Banded killifish	0.5	0.6	0.2	0.5
American eel	---	<0.1	---	<0.1
	100.0	100.0	100.0	100.0

Table 2. Seasonal and total percent diet composition of double-crested cormorants from McNair Island, 2003. Pre-chick period includes pellets collected on 5/29/03, the chick feeding period includes pellets collected on 6/20/03 and 7/17/03, and the post-chick feeding period includes pellets collected on 8/20/03 and 9/11/03.

	Pre-chick	Chick	Post-chick	Total
No. of pellets	150	228	283	661
Fish/pellet (adjusted)	11.8	13.9	11.3	12.3
Rock bass	23.7	31.0	29.51	28.6
Yellow perch	25.6	35.5	37.8	33.9
Cyprinids	12.2	10.6	11.2	11.2
Slimy sculpin	6.8	5.2	1.7	4.3
Pumpkinseed	9.4	8.2	9.6	9.0
Darter	14.0	5.3	1.2	6.0
Smallmouth bass	1.5	1.3	1.0	1.2
Ictalurid	2.0	0.7	1.8	1.4
Catostomid	1.2	1.0	0.9	1.0
Esocid	1.0	0.2	0.2	0.4
Walleye	---	0.1	0.1	0.1
Band killifish	0.4	0.2	0.2	0.3
Alewife	0.1	0.3	0.4	0.3
Bluegill	1.0	0.1	0.3	0.4
Round goby	1.1	0.3	4.1	1.9
	100.0	100.0	100.0	100.0

Table 3. Seasonal and total percent diet composition of double-crested cormorants from Strachan Island, 2003. No pellets were collected during the pre-chick feeding period, the chick feeding period includes pellets collected on 6/20/03 and 7/17/03, and the post-chick feeding period includes pellets collected on 8/20/03.

	Pre-chick	Chick	Post-chick	Total
No. of pellets	NO	85	150	235
Fish/pellet (adjusted)	Samples	13.0	17.4	15.8
Yellow perch		61.8	60.5	61.0
Cyprinid		15.1	10.0	11.9
Rock bass		12.6	11.2	11.8
Ictalurid		2.2	3.6	3.1
Darter		1.1	1.6	1.4
Pumpkinseed		2.8	8.2	6.1
Smallmouth bass		0.5	0.4	0.4
Slimy sculpin		0.8	1.3	1.1
Catostomid		2.3	1.1	1.6
Esocid		0.2	0.6	0.4
Band killifish		0.4	<0.1	0.2
Walleye		---	1.3	0.8
Alewife		0.2	---	0.1
American eel		---	0.2	0.1
		100.0	100.0	100.0

Table 4. Spatial diet overlap among three St. Lawrence River cormorant colonies, 2003.

	Colonies		
Feeding period	Griswold I.-McNair I.	Griswold I.-Strachran I.	McNair I.-Strachan I.
Pre-chick	0.610	-----	-----
Chick	0.776	0.987	0.832
Post-chick	0.933	0.957	0.866
Entire season	0.808	0.996	0.831

Table 5. Temporal diet overlap at each of the three St. Lawrence River cormorant colonies, 2003.

Feeding period		Griswold I.	McNair I.	Strachan I.
Pre-chick feeding-Chick feeding		0.998	0.941	-----
Pre-chick feeding-Post-chick feeding		0.909	0.908	-----
Chick feeding-Post-chick feeding		0.909	0.989	0.992
	0 =	0.939	0.946	-----

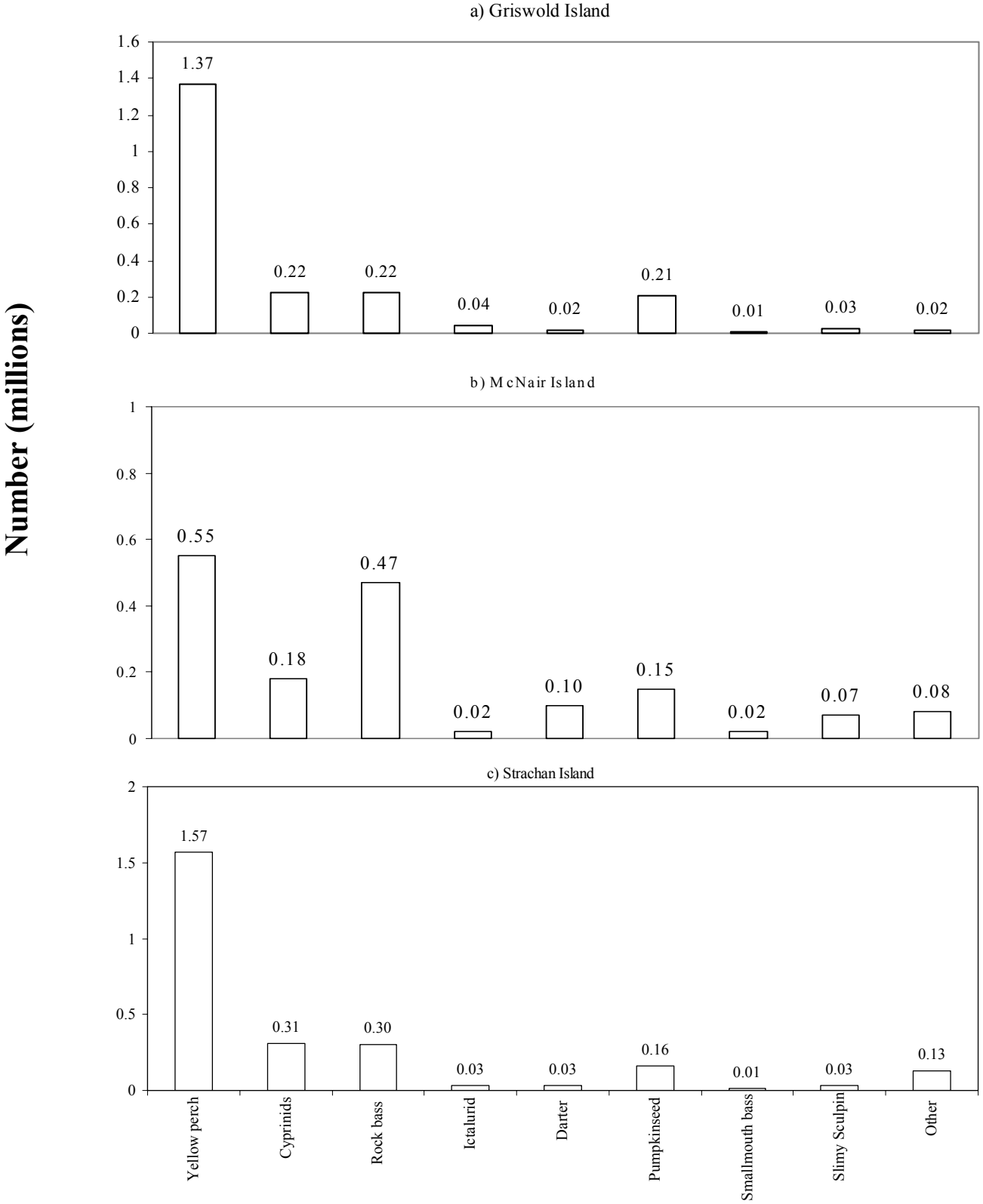
Table 6. Fish consumption estimates in millions for cormorants from three St. Lawrence River colonies, 2003.

	Griswold Island		McNair Island		Strachan Island	
Period	Number	Pounds	Number	Pounds	Number	Pounds
Pre-chick feeding	0.75	0.04	0.41	0.04	0.66	0.04
Chick feeding	0.78	0.05	0.61	0.04	0.73	0.06
Post-chick feeding	0.61	0.06	0.62	0.05	1.18	0.07
Total	2.14	0.15	1.64	0.13	2.57	0.17

Table 7. Estimated total length (TL, mm), 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 Griswold, McNair and Strachan Islands in 2003.

	Griswold			McNair			Strachan		
	TL	Wt.	No.	TL	Wt.	No.	TL	Wt.	No.
Pre-chick									
Smallmouth bass	231	164	4	228	157	8	---	---	---
Yellow perch	91	8	100	107	13	100	---	---	---
Rock bass	116	30	100	105	22	100	---	---	---
Pumpkinseed	99	20	100	107	26	100	---	---	---
Chick									
Smallmouth bass	195	94	13	213	126	14	---	---	---
Yellow perch	101	11	100	111	15	100	92	8	100
Rock bass	110	26	100	104	22	100	105	22	100
Pumpkinseed	99	20	100	109	28	100	94	17	44
Post-chick									
Smallmouth bass	222	144	4	168	58	10	111	15	6
Yellow perch	101	11	100	118	18	100	86	7	100
Rock bass	98	18	100	94	16	100	90	14	100
Pumpkinseed	111	29	100	107	26	100	79	9	100

Figure 1. Estimated number, in millions, of fish consumed by species by cormorants from colonies (a) Griswold , (b) McNair, and (c) Strachan Islands in the St. Lawrence River in 2003.


a) Griswold Island
1.37
0.22
0.22
0.04
0.02
0.21
0.01
0.03
0.02
b) McNair Island
0.55
0.18
0.47
0.02
0.10
0.15
0.02
0.07
0.08
c) Strachan Island
1.57
0.31
0.30
0.03
0.03
0.16
0.01
0.03
0.13
Number (millions)
Yellow perch
Cyprinids
Rock bass
Ictalurid
Darter
Pumpkinseed
Smallmouth bass
Slimy Sculpin
Other