

**Double-Crested Cormorant Studies at Little Galloo Island, Lake Ontario in 2008:
Diet Composition, Fish Consumption and the Efficacy of Management Activities
in Reducing Fish Predation**

James H. Johnson
*Tunison Laboratory of Aquatic Science
U.S. Geological Survey
Cortland, NY 13045*

Russell D. McCullough and James F. Farquhar
*New York State Department of Environmental Conservation
Watertown, NY 13601*

For almost two decades Little Galloo Island (LGI) has supported the largest colony of double-crested cormorants (*Phalacrocorax auritus*) in the eastern basin of Lake Ontario. Cormorant nest counts on the island since the early 1990's have averaged about 5,000 per year reaching a high of 8,400 in 1996. Johnson et al. (2008) estimate that cormorants from LGI alone have consumed 400 million fish since 1992. The proliferation of cormorants in the eastern basin of Lake Ontario has coincided with declines in two important recreational fish species, smallmouth bass and yellow perch. Lantry et al. (2002) and Burnett et al. (2002) provide convincing evidence linking cormorant population increases to declining eastern basin smallmouth bass and yellow perch stocks. Decline of these fish stocks is evident only in the eastern basin, suggesting a localized problem which is consistent with the halo effect where large piscivorous waterbird colonies may deplete local fish stocks (Birt et al. 1987).

The year 2008 marked the seventeenth consecutive year of study of the food habits and fish consumption of LGI cormorants, and represented the tenth consecutive year evaluating the efficacy of management activities to control the reproductive success of cormorants nesting at LGI. The program consists mainly of spraying cormorant eggs with oil as well as the culling of adult and immature birds. This paper reports the findings of work carried out in 2008 at LGI.

Methods

Diet Examination

Diagnostic prey remains recovered in regurgitated pellets were used to describe the diet of double-crested cormorants on LGI in 2008. A total of 300 pellets were collected including 100 each during the pre-chick feeding period (4/22/08 - 5/28/08), chick feeding period (6/11/08 - 7/21/08) and post-chick feeding period (8/5/08 - 10/10/08). Prior to 2007, a sample size of 150 per sampling period 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 a minimum of 85 per sampling period. 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.

Fish Consumption Estimation

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). 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 LGI 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 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 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 composition and daily fish consumption (i.e. the number of fish per pellet). Pre-chick feeding was 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 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 (approximately 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 sizes 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 undamaged otoliths from each species/period to the nearest 0.1 mm with calipers. We used otolith-length fish-length regressions derived for yellow perch (Burnett et al. 2001), 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).

Control Measures

NYSDEC staff began treating accessible double-crested cormorant nests on LGI with corn oil beginning on May 7 and ending July 7, 2008. The oiling process was conducted four times over the season on each nest with eggs. Oil was applied from a backpack sprayer unit in sufficient volume to cover the exposed surface of each egg (approximately 6 ml/egg or 0.2 oz/egg). The number of eggs treated per nest was recorded and each nest or group of nests were marked with spray paint to facilitate efficient movement throughout the colony as well as complete nest coverage. Also recorded were the number of nests not treated and the number of chicks present per visit. We adjusted the number of cormorant feeding days and total number of fish consumed to account for 360 cormorants culled at LGI (6/6/08) as part of NYSDEC management programs. To account for the absence of these birds in determining the effects of egg oiling on fish consumption, we subtracted 180 nests (50% of the number of adult birds that were culled) from the total nest count. We estimated fish consumption for each feeding period using the number of chick feeding days (either 42 or 50), the total number of chicks present, the period specific percent diet composition by number, and daily fish consumption estimates.

We estimated reductions in cormorant feeding days and fish consumption annually from egg oiling. For chicks, these estimates were determined from 1999-2008, for immature cormorants, from 2000-2008 and for adult cormorants, from 2002-2007. These time periods assume that the effects on chicks began immediately (1999), the effects on immature birds began one year post initial treatment (2000), and effects on adult cormorants began when they reach maturity at age 3 (2002). To derive projected estimates, a standard of 5,681 nests from 1999 when egg oiling was first started was used. For each subsequent year, that nest count was subtracted from 5,681 (example: 2005 was 5,681-3,401=2,280 fewer nests). That nest count figure was then used to derive adult, immature, and YOY reductions in both feeding days and fish consumption using the standard Weseloh and Casselman model. This estimate plus the annual estimated reduction in feeding days from chicks alone and the actual number of feeding days for each year for the entire colony were summed to provide the projected estimate. Projected feeding day estimates were multiplied by the annual number of fish per pellet (i.e. daily fish consumption) to provide the projected estimate for fish consumption.

Results

Diet Composition

Round goby (93.0%) were the major prey of LGI cormorants in 2008 and dominated the diet during all feeding periods (Table 1). Alewife (2.9%) and yellow perch (2.5%) were the second and third most abundant species in the diet. No other fish species contributed more than 0.5% of the diet. For the entire season forage species (i.e. round goby, alewife, cyprinids, slimy sculpin, etc.) contributed 96.3% of the diet of LGI cormorants while panfish (i.e. yellow perch, pumpkinseed, rock bass, ictalurids, etc.) and gamefish (smallmouth bass), composed 3.4% and 0.3%, respectively.

Fish Consumption

The number of fish per pellet (adjusted for fecal loss) was highest during the post-chick feeding period (23.4) and averaged 16.4 for the season (Table 1). A peak count of 2,492 cormorant nests was observed on LGI in 2008 and chick productivity was estimated at about 0.22 chicks per nest. On June 6, 2008, 360 cormorants (mainly adults) were

shot at LGI as part of NYSDEC management programs. To account for the absence of these birds in the fish consumption model the adult bird estimate was reduced from 4,984 to 4,624 for the chick and post-chick feeding periods. Using the Weseloh and Casselman model we estimate about 0.86 million feeding days for the LGI colony in 2008 and about 0.86 million pounds of fish consumed (Figure 1). Numbers of fish consumed by feeding period in 2008 included 4.30 million during the pre-chick feeding period, 3.00 million during the chick feeding period, and 6.80 million during the post-chick feeding period.

In 2008, LGI cormorants consumed 13.60 million forage fish including 13.13 million round goby and 0.42 million alewife (Figure 2). About 0.49 million panfish were eaten including 0.35 million yellow perch, 0.08 million rock bass, 0.05 million pumpkinseed, and 0.01 million ictalurids. Cormorants consumed about 0.05 million game fish, mostly smallmouth bass (Figure 2).

Size of fish consumed

A total of 250 otoliths recovered from cormorant pellets were measured in 2008. There was no apparent seasonal trend in the size of any species consumed by LGI cormorants in 2008. The average weight of 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 three species consumed by cormorants during each feeding period. For the entire feeding season on LGI, cormorants consumed an estimated 11,400 pounds of yellow perch, 4,700 pounds of rock bass, and 2,800 pounds of pumpkinseed.

Effects of Control Measures

The removal of 360, mostly adult cormorants, from the LGI population reduced the number of cormorant feeding days by about 33,900 and reduced total fish consumption by 629,000. Consequently, these feeding days and number of fish were not considered in estimating the effects of egg oiling. Chicks accounted for 46,000 cormorant feeding days from early June to mid October (Table 3). The total number of cormorant feeding days by the LGI colony in 2008 was estimated at 0.86 million (Table 3). We estimated that 4,486 chicks would have been produced on LGI from 2,492 nests

in 2008 in the absence of reproductive suppression (i.e. egg oiling) by using the chick productivity estimate of 1.8 chicks per nest. Egg oiling limited cormorant chick production to 500 chicks, an 89% reduction. The number of chick feeding days by the LGI colony was also reduced by 89%. For the entire LGI colony in 2008, reproductive suppression reduced the total number of cormorant feeding days from 1.24 million to 0.86 million (30.6%) and the number of fish consumed from 20.0 million to 14.1 million (29.5%) (Table 3). The relative magnitude of the reduction in fish consumption caused by reproductive suppression at LGI in 2008 was consistent with what was achieved in the previous 5 years (Figure 3).

We estimate that the 500 cormorant chicks produced on LGI in 2008 consumed about 847,000 fish (Table 4). If egg oiling was not carried out and 4,486 cormorant chicks were produced on LGI in 2008, we estimate that these chicks would have consumed 7.61 million fish (Table 4). Consequently, egg oiling reduced fish consumption by 6.76 million fish in 2008. Using diet composition information for the chick and post-chick feeding periods, the reduced fish consumption represented 6.20 million round goby, 0.25 million alewife, 0.21 million yellow perch, and 0.04 million smallmouth bass (Table 4).

Discussion

Since the egg oiling program was initiated in 1999 the number of cormorant nests at LGI has decreased from 5,681 (1999) to 2,492 (2008). Results achieved by the double-crested cormorant reproductive suppression program on LGI since 1999 have been remarkably consistent. Chick productivity has been reduced from an average of about 2.00 chicks per nest (1992-1998) to 0.09 chicks per nest (1999-2008), a 95% reduction. Since initiated in 1999, egg oiling has resulted in: (1) a 95.0% (annual range 89.0% to 98.0%) reduction in cormorant chick production, (2) a 29.3% (annual range 23.9% to 32.7%) reduction in cormorant feeding days, and (3) a 26.4% (annual range 19.1% to 31.1%) reduction in total fish consumption (Johnson et al. 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008).

We estimate that the cormorant reproductive suppression program on LGI has cumulatively

reduced fish consumption by chicks at the colony by 56.7 million fish since it was initiated in 1999. Included in this estimate are approximately 9.0 million yellow perch and 2.4 million smallmouth bass that were not consumed by cormorants. These two species are especially important since declines in their abundance in the eastern basin of Lake Ontario have been associated with cormorant population increases (Burnett et al. 2002, Lantry et al. 2002).

Cumulative Effects of Egg Oiling

The annual reduction in chick productivity at LGI provides only partial insight into the overall cumulative effects in terms of the reduction in both cormorant feeding days and fish consumption at the colony. Full consideration of the effects of egg oiling on these parameters should include projections for the immature and adult birds that would have been produced annually at the colony in the absence of egg oiling. Since egg oiling was initiated at LGI in 1999 about 3,100 chicks have been fledged compared to an estimated 64,950 if egg oiling had not occurred. If these 61,850 chicks had survived we estimate that fish consumption by chicks alone (56.7 million) would increase to 94.5 million (Figure 4). In addition, the number of cormorant feeding days declined by 68% (2% attributed to cull; 2.71 million to 0.86 million from 1999 to 2008) (Figure 5) and actual annual fish consumption declined by 40% (3% attributed to cull; 23.6 million to 14.1 million) during the same period (Figure 6).

Acknowledgements

We thank Aaron Harvill for collecting and processing samples; Tim Wallbridge for measuring otoliths and Chris Nack for data analysis.

References

Birt, V.L. T.B. Birt, D. Goulet, D.K. Cairns, and W.A. Montevecchi. 1987. Ashmole's halo: direct evidence for prey depletion by a seabird. *Marine Ecology Progress Series* 40:205-208.

Burnett, J.A.D., N.H. Ringler, T.H. Eckert, and B.F. Lantry. 2001. 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* 2000 NYSDEC annual Report, 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 (*Phalacrocorax 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 Biologia della 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.

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., R.M. Ross, and J. Farquhar. 2000. The effects of egg oiling on fish consumption by double-crested cormorants on Little Galloo Island, Lake Ontario in 1999. Section 15 *In* 1999 NYSDEC Annual Report, 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. Ross, and J. Farquhar. 2001. The effects of egg oiling on fish consumption by double-crested cormorants on Little Galloo Island, Lake Ontario in 2000. Section 15 *In* 2000 NYSDEC Annual Report, 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. Ross, and J. Farquhar. 2002. The effects of egg oiling on fish consumption by double-crested cormorants on Little Galloo Island, Lake Ontario in 2001. Section 15 *In* 2001 NYSDEC Annual Report, 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. Ross, and J. Farquhar. 2003. The effects of egg oiling on fish consumption by double-crested cormorants on Little Galloo Island, Lake Ontario in 2002. Section 15 *In* 2002 NYSDEC Annual Report, 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. Ross, and J. Farquhar. 2004. The effects of egg oiling on fish consumption by double-crested cormorants on Little Galloo Island, Lake Ontario in 2003. Section 15 *In* 2003 NYSDEC Annual Report, 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. Ross, and J. Farquhar. 2005. The effects of egg oiling on fish consumption by double-crested cormorants on Little Galloo Island, Lake Ontario in 2004. Section 15 *In* 2004 NYSDEC Annual Report, 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. Ross, and J. Farquhar. 2006. The effects of egg oiling on fish consumption by double-crested cormorants on Little Galloo Island, Lake Ontario in 2005. Section 15 *In* 2005 NYSDEC Annual Report, 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. Ross, and J. Farquhar. 2007. The effects of egg oiling on fish consumption by double-crested cormorants on Little Galloo Island, Lake Ontario in 2006. Section 15 *In* 2006 NYSDEC Annual Report, 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. Ross, and J. Farquhar. 2008. The effects of egg oiling on fish consumption by double-crested cormorants on Little Galloo Island, Lake Ontario in 2007. Section 15 *In* 2007 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Johnson, J.H. and R.D. McCullough, 2008. Diet composition and fish consumption of double-crested cormorants from the Little Galloo Island colony of eastern Lake Ontario in 2007. Section 14 *In* NYSDEC Annual Report 2007, 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 the abundance of smallmouth bass and double-crested cormorants in the eastern basin of Lake Ontario. *Journal of Great Lakes Research* 28:193-201.

Mazzocchi, I.M., J.M. Farquhar, and R. D. McCullough. 2003. Nest site fidelity and movements of double-crested cormorants in response to management practices on Little Galloo Island, New York, 2002. New York State Dept. of Environmental Conservation, Watertown, New York.

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. 1999. Fish losses to double-crested cormorants in eastern Lake Ontario, 1992-1997. Pages 61-70 *In* M.E. Tobin (ed.). *Symposium on Double-crested Cormorants: Population Status and Management Issues in the Midwest U.S.* Department of Agriculture (APHIS) Technical Bulletin No. 1879.

Ross, R.M., J.H. Johnson and C Adams. 2005. Use of fish otolith-length regressions to infer size of double-crested cormorant prey fish from recovered otoliths in Lake Ontario. *Northeastern Naturalist* 12:133-140.

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

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.

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.

Table 1: Seasonal and total percent diet composition of double-crested cormorants from Little Galloo Island, 2008. Sample dates for the pre-chick, chick, and post-chick feeding periods were from 4/22/08 to 5/28/08, 6/11/08 to 7/21/08, and 8/5/08 to 10/10/08, respectively.

	<u>Pre-chick</u>	<u>Chick</u>	<u>Post-chick</u>	<u>Total</u>
No. of pellets	100	100	100	300
Fish/pellet (adjusted x 1.042)	13.2	12.6	23.4	16.4
Round goby	97.4	86.0	93.2	93.0
Alewife	0.8	5.9	3.0	2.9
Yellow perch	0.8	4.6	2.6	2.5
Rock bass	0.1	1.3	0.5	0.5
Pumpkinseed	0.4	0.4	0.3	0.3
Cyprinids	0.1	0.9	0.1	0.3
Smallmouth bass	0.1	0.8	0.2	0.3
Slimy sculpin	0.2	0.1	---	0.1
Ictalurid	<u>0.1</u>	---	<u>0.1</u>	<u>0.1</u>
	100.0	100.0	100.0	100.0

Table 2. Estimated total length (TL, inches), mean weight (Wt., pounds), and number examined (No.), of yellow perch, rock bass, and pumpkinseed consumed by double-crested cormorants during each feeding period on Little Galloo Island in 2008.

	Feeding Period								
	<u>Pre-chick</u>			<u>Chick</u>			<u>Post-chick</u>		
	<u>TL(SD)</u>	<u>Wt.</u>	<u>No.</u>	<u>TL(SD)</u>	<u>Wt.</u>	<u>No.</u>	<u>TL(SD)</u>	<u>Wt.</u>	<u>No.</u>
Yellow perch	2.2 (0.8)	0.01	14	4.8 (1.0)	0.04	83	4.4 (1.2)	0.03	86
Rock bass	----	----	----	4.2 (1.0)	0.05	25	4.6 (1.3)	0.07	15
Pumpkinseed	4.3 (1.1)	0.06	10	3.7 (2.0)	0.04	9	4.3 (1.5)	0.06	8

Table 3. Estimated number of chicks produced, chick feeding days, total cormorant feeding days, and the number of fish eaten based on chick productivities of 0.22 (control = egg oiling) and 1.8 chicks per nest (no control) on Little Galloo Island in 2008.

Action	No. of chicks	No. of chick feeding days	Total cormorant feeding days	No. of fish eaten
No control	4,486	421,684	1.24 million	20.0 million
Control (egg oiling)	500	46,000	0.86 million	14.1 million
Difference	3,986	375,684	0.38 million	5.9 million

Table 4. Fish consumption estimates for double-crested cormorant chicks based on chick productivities of 0.22 (control = egg oiling) and 1.8 chicks per nest (no control) on Little Galloo Island in 2008.

Species	Number of fish consumed		
	Control	No control	Difference
Round goby	735,000	6,933,000	6,198,000
Alewife	48,000	298,000	250,000
Yellow perch	38,000	246,000	208,000
Rock bass	11,000	30,000	19,000
Cyprinids	7,000	27,000	20,000
Smallmouth bass	7,000	30,000	23,000
Other	<u>1,000</u>	<u>41,000</u>	<u>40,000</u>
	847,000	7,605,000	6,758,000

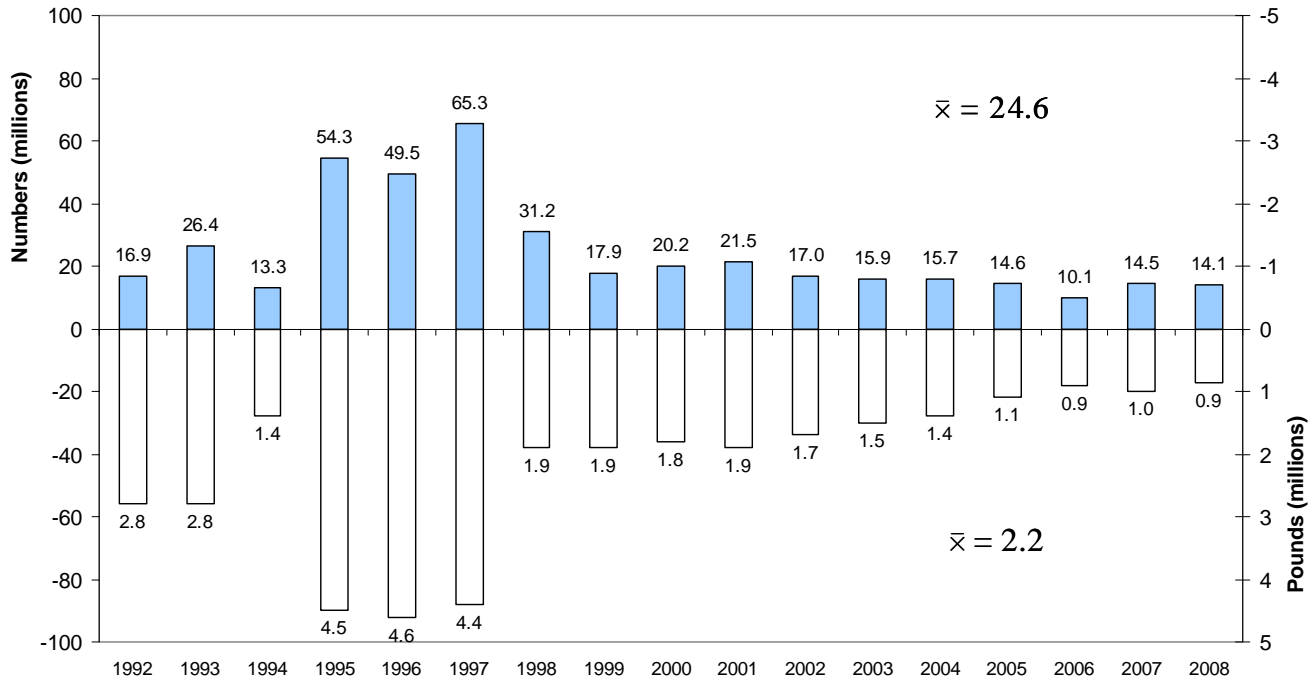


Figure 1. Estimated annual fish consumption in terms of numbers (top) and pounds (bottom) by the Little Galloo Island colony, 1992-2008.

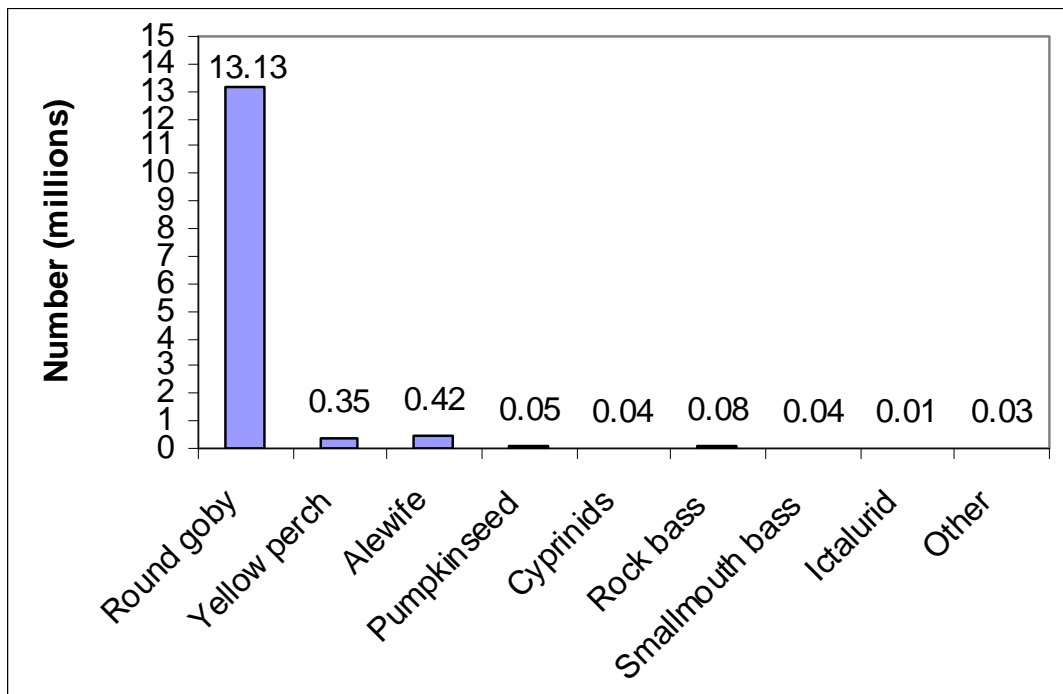


Figure 2. Estimated species-specific fish consumption by double-crested cormorants at the Little Galloo colony, 2008.

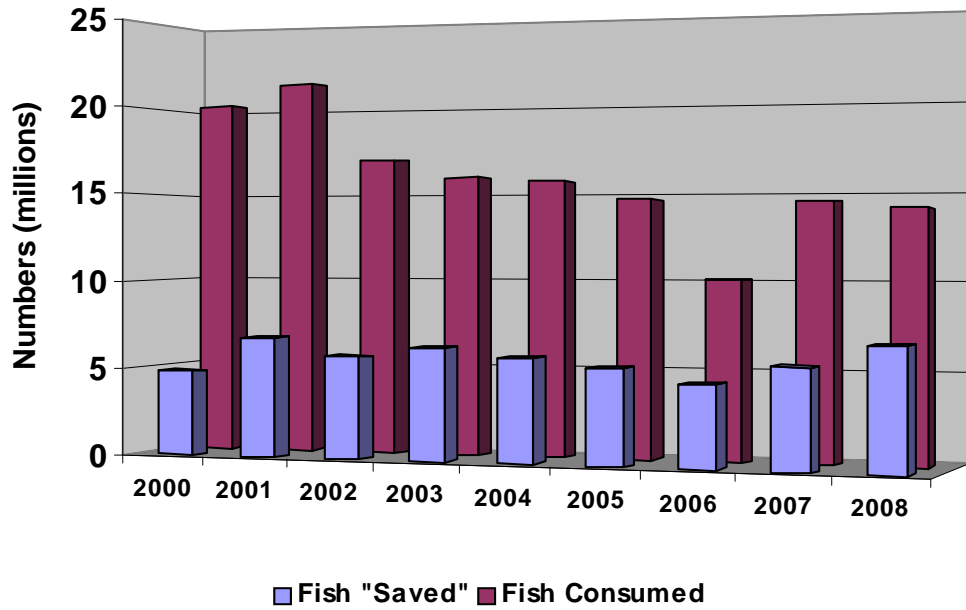


Figure 3. Estimated numbers of fish consumed by double-crested cormorant chicks and estimated number of fish “saved” by cormorant reproductive suppression since 1999 on Little Galloo Island.

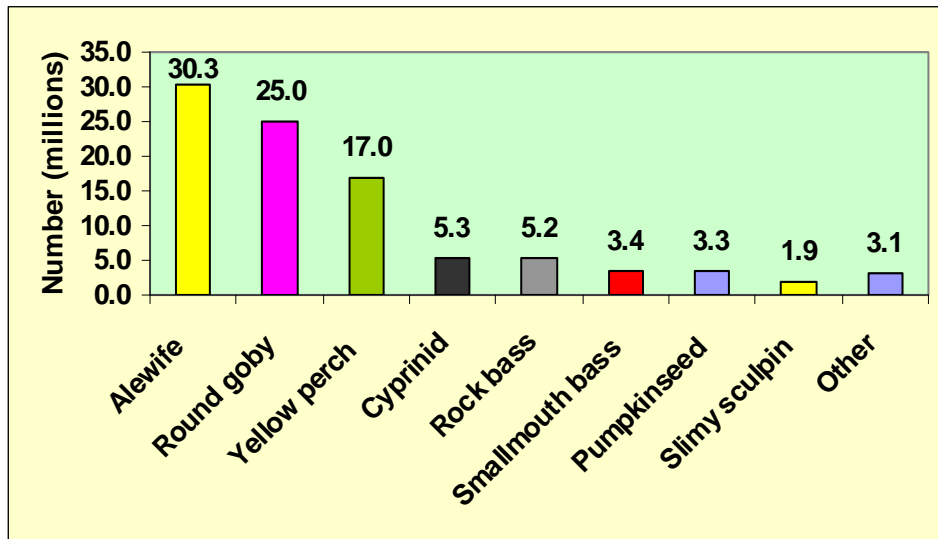


Figure 4. Total Number (millions) of fish “saved” by egg oiling program at Little Galloo Island, 1999-2008.

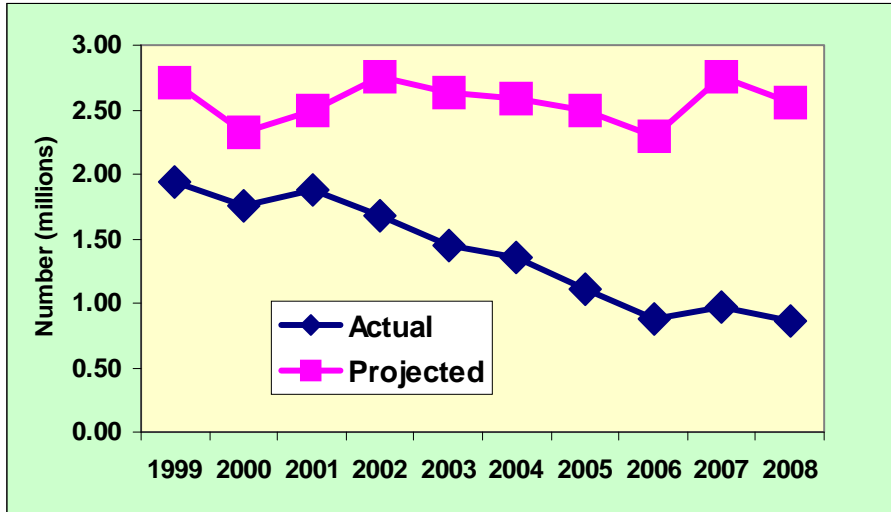


Figure 5. Actual (control-egg oiling) and projected (no control) double-crested cormorant feeding days at Little Galloo Island, Lake Ontario, 1999-2008.

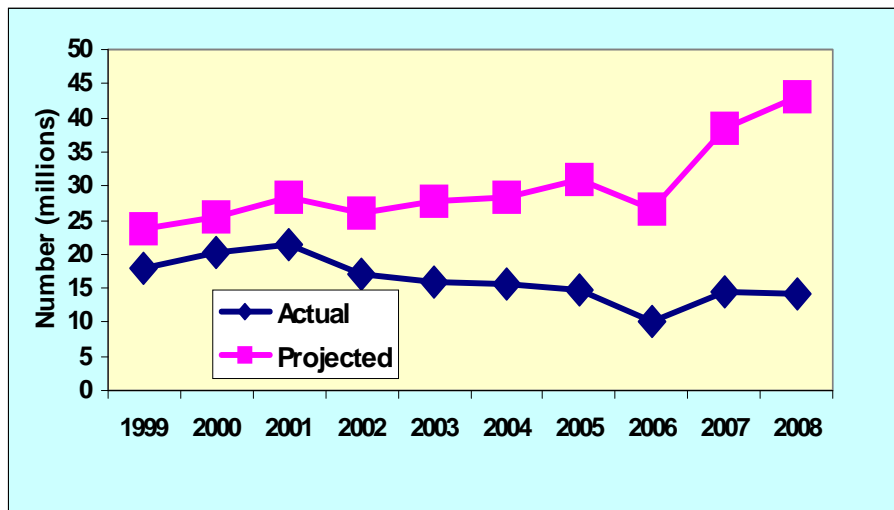


Figure 6. Actual (control-egg oiling) and projected (no control) estimates of double-crested cormorant fish consumption at Little Galloo Island, Lake Ontario, 1999-2008.