

**Diet Composition and Fish Consumption of Double-Crested Cormorants  
from Three St. Lawrence River Colonies in 2011**

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Double-crested cormorants (*Phalacrocorax auritus*) were first observed nesting in the upper St. Lawrence River at Strachan Island in 1992. Cormorants now nest at a number of islands in the Thousand Islands section of the river. Griswold, McNair, and Strachan islands are among the largest colonies in the upper river. Until 2011, nest counts have remained relatively stable, ranging from 200 to 603 nests per colony. In 2011, nest counts at Bergin Island (replaced Strachan Island) were 627 and were 833 at McNair Island. Although the size of cormorant colonies in the upper St. Lawrence River is smaller than those in the eastern basin of Lake Ontario, the close proximity of islands in the upper river that have colonies may cause a cumulative fish consumption effect similar to a larger colony.

Because of increasing numbers of double-crested cormorants in the upper St. Lawrence River and the possible impacts on fish populations, studies were initiated in 1999 to quantify cormorant diet and fish consumption at the three largest colonies. From 1999 to 2010 these studies have shown that cormorants consumed about 97.7 million fish including 33.7 million yellow perch (*Perca flavescens*), 12.2 million rock bass (*Ambloplites rupestris*) and 0.9 million smallmouth bass (*Micropterus dolomieu*) (Johnson et al. 2011). During this same time period fish assessment studies near some of these islands have shown a major decrease in yellow perch populations (Klindt 2007). This occurrence is known as the

halo effect and happens when piscivorous birds deplete local fish populations in areas immediately surrounding the colony (Ashmole 1963). This paper describes the diet and fish consumption of cormorants in the upper St. Lawrence River in 2011.

### **Methods**

Cormorant nesting activity decreased at Strachan Island for the third consecutive year while nesting at nearby Bergin Island (about 2 miles away) remained stable. Consequently, similar to 2010, pellet collection efforts were made at Bergin in 2011.

Diagnostic prey remains recovered in regurgitated pellets were used to describe the diet of double-crested cormorants at St. Lawrence River colonies in 2011. Pellets were collected beginning in early June and ending in late July. 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 a concentrated sodium hydroxide

solution. Species were identified to the lowest practical taxonomic level.

To estimate the number of fish consumed by cormorants from each colony, we used a model similar to that of Weseloh and Casselman (1992) 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, and a fecal pathway correction factor for fish not detected in pellets (Johnson and Ross 1996). To estimate the number of cormorants feeding we used annual nest counts (all nests counted) provided by the Canadian Wildlife Service and the 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. 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 fed 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 mid 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 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 has 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 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. When pellets were not collected during a single feeding period a mean value was calculated from the two feeding periods to estimate total fish consumption. 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 1 lb 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 (total length) of key species including yellow perch, rock bass and pumpkinseed consumed during each cormorant feeding period by measuring otoliths from each species/period to the nearest 0.1 mm with calipers (Burnett et al. 2001, Ross et al. 2005). Broken or chipped otoliths were not considered for measurement. To estimate the weight of these species consumed by cormorants we used length-weight regressions for eastern Lake Ontario populations (unpublished data).

Spatial and temporal variation in diet composition for the Griswold, McNair and Bergin 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 ( $C\lambda$ )  $\geq$  0.60 are considered biologically significant (Zaret and Rand 1971).

## **Results**

A total of 525 pellets were used to describe the feeding ecology of cormorants from Griswold (174 pellets), McNair (176 pellets), and Bergin (175 pellets) Islands in 2011 (Tables 1-3). Too few pellets were collected during the post-chick feeding period at all colonies to quantify diet. Over the entire season the number of fish per pellet was highest at Bergin Island (24.2) and was similar at McNair (17.3) and Griswold (17.1) islands (Tables 1-3).

### Diet Composition

Round gobies were the primary prey of cormorants at Griswold Island (63.3%) and yellow perch (18.5%) were the second ranked prey (Table 1). Round gobies dominated the diet during the

two feeding periods that were sampled. Rock bass (12.1%) were the only other species that contributed at least 10% of the diet of Griswold Island cormorants. For the entire season, panfish (i.e., yellow perch, rock bass, pumpkinseed, ictalurids) contributed 35.0% of the diet, forage fish (round goby, cyprinids, darters) composed 64.6%, and gamefish (mainly smallmouth bass and esocids) comprised 0.4% of the diet of Griswold Island cormorants.

Round goby (70.6%), pumpkinseed (10.7%), rock bass (10.5%) and yellow perch (6.2%) were the dominant prey in the diet of cormorants at McNair Island (Table 2). For the season, panfish made up 27.8% of the diet of McNair Island cormorants, forage fish 71.6%, and gamefish (mostly smallmouth bass) 0.6% (Table 2).

Round goby (58.0%), yellow perch (22.6%), and rock bass (11.0%) were the main prey of Bergin Island cormorants (Table 3). Pumpkinseed (5.3%) and ictalurids (1.1%) also contributed to at least 1% of the diet. Panfish made up 40.0% of the seasonal diet, forage fish 59.9%, and gamefish 0.1% at Bergin Island in 2011 (Table 3).

### Diet Overlap

Diet overlap for the entire season among all three upper St. Lawrence River colonies in 2011 ranged from 0.88 to 0.95 (Table 4). Diet was the most similar between cormorants from Griswold and McNair Islands ( $C\lambda=0.95$ ). There was little temporal variation in diet composition between the two feeding periods at any of the three colonies (Table 5).

### Fish Consumption

Based on nest counts of 346 on Griswold Island, 833 on McNair Island, and 627 on Bergin Island, and fledgling productivities of 1.8 chicks per nest (pers. comm. James Farquhar, NYSDEC, Watertown), we estimated 0.18, 0.44 and 0.32 million cormorant feeding days for Griswold Island, McNair Island, and Bergin Island, respectively, in 2011. Fish consumption for the Griswold Island colony was estimated at 3.0 million fish and 0.18 million pounds, for the McNair Island colony at 7.6 million fish and 0.44 million pounds, and for the Bergin Island colony

at 7.4 million fish and 0.32 million pounds (Table 6).

We estimate that during 2011 cormorants from Griswold Island consumed 1.04 million panfish (including 0.55 million yellow perch, 0.36 million rock bass and 0.09 million pumpkinseed), 1.91 million forage fish (including 1.87 million round goby and 0.04 million cyprinids) and 0.01 million gamefish (smallmouth bass) (Figure 1). We estimate that cormorants from McNair Island consumed 2.00 million panfish (mainly 0.77 million pumpkinseed, 0.75 million rock bass, and 0.45 million yellow perch), 7.13 million forage fish (including 5.05 million round goby and 0.05 million cyprinids), and 0.04 million gamefish (primarily smallmouth bass). Cormorants from Bergin Island consumed 2.95 million panfish (including 1.67 million yellow perch, 0.81 million rock bass, 0.39 million pumpkinseed, and 0.08 million ictalurids), 4.43 million forage fish (mainly 4.30 million round goby and 0.04 million cyprinids), and 0.02 million gamefish (smallmouth bass) (Figure 1). The size of fish consumed at Bergin Island was smaller than at the other two colonies (Table 7).

### **Discussion**

Of the six double-crested cormorant colonies (3 eastern Lake Ontario, 3 St. Lawrence River) where diets have been examined, Griswold was the last colony to have round goby be the main fish prey. Since 2009 round gobies have become the dominate prey of cormorants at Griswold Island. Prior to 2009, yellow perch (55.5%) were the main prey of cormorants at Griswold Island (Johnson et al. 2010). Since 2009 round goby have contributed 61.9% and yellow perch 21.4% of the diet of cormorants at Griswold Island.

Round gobies first appeared in the diet of cormorants nesting at these three colonies in 2003 when they contributed about 2% of the diet of birds at McNair Island (Johnson et al. 2004). In 2004, cormorants at all three colonies consumed round gobies with the diet contribution at McNair increasing to 15% and the contribution at Griswold Island and Strachan Island being 1.2% and 1.7%, respectively. In 2005, gobies were

almost non-existent (0.1%) in the diet of cormorants at Griswold Island but were the second most consumed prey and represented 24.3% and 19.6% of cormorant diets at McNair and Strachan Island, respectively. Since 2004, when round gobies first appeared in cormorant diets at all St. Lawrence River colonies, they have comprised 43.2% of the fish consumed at Strachan (through 2009), 45.1% at McNair and 30.2% at Griswold. Round gobies made up 60.4% of the diet of cormorants at Bergin Island in 2010 and 2011. The possible halo effect relative to yellow perch populations surrounding Strachan Island observed by Klindt (2007) has not been evident since round goby became abundant in the diet (Klindt and Gordon 2010).

From 1999 to 2004, panfish composed 78.6% and forage fish only 19.3% of cormorant diets at the three St. Lawrence River colonies. Since 2004, panfish have made up 47.0% and forage fish 52.1%, of cormorant diets in the upper St. Lawrence River. Over the past 12 years game fish have made up 1.1% (range 0.04% to 2.9%) of cormorant diets at these three river colonies (Johnson et al. 2005, 2006, 2007, 2008, 2009). The contribution of gamefish in cormorant diets in 2011 (0.4%) matched the record low observed in 2010. As noted for panfish, reduced consumption of gamefish could be related to the dominance of round gobies in cormorant diets at these colonies.

Since 1999, we estimate that cormorants from these colonies have consumed 115.3 million fish (Figure 2). This includes 36.3 million yellow perch (31.4%), 40.2 million round goby (35.0%) 16.2 million rock bass (14.0%), 9.8 million pumpkinseed (8.5%), 6.3 million cyprinids (5.4%) and 0.9 million smallmouth bass (0.8%) (Figure 2).

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**Table 1. Seasonal and total percent diet composition by number of double-crested cormorants from Griswold Island, 2011. Pre-chick feeding period includes pellets collected on 6/13/11, and chick feeding period includes pellets collected on 7/19/11. No pellets were collected during the post-chick feeding period.**

	<u>Pre-chick</u>	<u>Chick</u>	<u>Total</u>
No. of pellets	89	85	174
Fish/pellet (adjusted x 1.042)	18.4	15.7	17.1
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Round goby	58.1	68.1	63.3
Yellow perch	27.8	10.0	18.5
Rock bass	10.0	14.0	12.1
Pumpkinseed	1.9	3.8	2.9
Ictalurid	1.0	2.0	1.5
Cyprinid	0.9	1.7	1.3
Smallmouth bass	0.3	0.3	0.3
Esocid	---	0.1	0.1
Total	100.0	100.0	100.0

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**Table 2. Seasonal and total percent diet composition by number of double-crested cormorants from McNair Island, 2011. Pre-chick period includes pellets collected on 6/13/11 and chick feeding period includes pellets collected on 7/19/11. No pellets were collected during the post-chick feeding period.**

	<u>Pre-chick</u>	<u>Chick</u>	<u>Total</u>
No. of pellets	90	86	176
Fish/pellet (adjusted x 1.042)	21.0	13.4	17.3
Round goby	76.8	62.9	70.6
Pumpkinseed	5.4	17.3	10.7
Rock bass	8.6	12.9	10.5
Yellow perch	7.2	5.0	6.2
Cyprinid	0.6	0.9	0.7
Smallmouth bass	0.7	0.3	0.5
Ictalurid	0.2	0.6	0.4
Darter	0.1	---	0.1
Alewife	0.2	---	0.1
Catostomid	0.1	0.1	0.1
Esocid	<u>0.1</u>	<u>---</u>	<u>0.1</u>
Total	100.0	100.0	100.0

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**Table 3. Seasonal and total percent diet composition by number of double-crested cormorants from Bergin Island, 2011. Pre-chick feeding periods includes pellets collected on 6/15/11 and chick feeding period includes pellets collected on 7/19/11. No pellets were collected during the post-chick feeding period.**

	<u>Pre-chick</u>	<u>Chick</u>	<u>Total</u>
No. of pellets	90	85	175
Fish/pellet (adjusted x 1.042)	33.8	14.1	24.2
Round goby	68.3	39.1	58.0
Yellow perch	16.5	34.1	22.6
Rock bass	8.8	15.0	11.0
Pumpkinseed	4.3	7.1	5.3
Ictalurid	0.6	2.1	1.1
Catostomid	0.3	1.9	0.9
Cyprinid	0.5	0.5	0.5
Banded killifish	0.4	0.1	0.3
Darter	0.1	---	0.1
Smallmouth bass	0.1	0.1	0.1
Trout perch	0.1	---	0.1
Esocid	<0.1	---	<0.1
Walleye	<0.1	---	<0.1
Total	100.0	100.0	100.0

**Table 4. Spatial diet overlap among three St. Lawrence River cormorant colonies, 2011.**

<u>Feeding period</u>	<u>Colonies</u>		
	<u>Griswold I.-McNair I.</u>	<u>Griswold I.-Bergin I.</u>	<u>McNair I.-Bergin I.</u>
Pre-chick	0.92	0.97	0.96
Chick	0.97	0.82	0.79
Average	0.95	0.90	0.88

**Table 5. Temporal diet overlap at each of the three St. Lawrence River cormorant colonies, 2011.**

<u>Feeding period</u>	<u>Griswold I.</u>	<u>McNair I.</u>	<u>Bergin I.</u>
Pre-chick feeding-Chick feeding	0.95	0.97	0.85

**Table 6. Fish consumption estimates in millions for cormorants at each of the three St. Lawrence River colonies, 2011.**

<u>Period</u>	<u>Griswold Island</u>		<u>McNair Island</u>		<u>Bergin Island</u>	
	<u>Number</u>	<u>Pounds</u>	<u>Number</u>	<u>Pounds</u>	<u>Number</u>	<u>Pounds</u>
Pre-chick feeding	0.9	0.05	2.3	0.11	2.8	0.08
Chick feeding	0.9	0.06	1.9	0.14	1.5	0.11
Post-chick feeding	<u>1.2</u>	<u>0.07</u>	<u>3.0</u>	<u>0.17</u>	<u>3.1</u>	<u>0.13</u>
Total	3.0	0.18	7.2	0.42	7.4	0.32

**Table 7. Estimated mean total length (TL, inches), weight (Wt., pounds), and number of otoliths examined (No.) for yellow perch, rock bass, and pumpkinseed consumed by double-crested cormorants during the pre-chick and chick feeding periods on Griswold, McNair, and Bergin Islands in 2011. (SD = standard deviation).**

	<u>Griswold</u>			<u>McNair</u>			<u>Bergin</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>
	Pre-chick								
Yellow perch	4.1(0.9)	0.03	100	4.6(1.0)	0.04	100	3.7(1.2)	0.02	100
Rock bass	4.2(1.1)	0.05	100	4.6(1.1)	0.07	100	4.1(1.2)	0.05	100
Pumpkinseed	3.5(1.1)	0.03	38	3.6(1.4)	0.03	91	3.3(1.0)	0.03	100
	Chick								
Yellow perch	4.1(1.1)	0.03	100	4.0(1.0)	0.02	58	3.6(1.0)	0.02	100
Rock bass	4.6(1.2)	0.07	100	4.7(1.1)	0.07	100	4.1(1.3)	0.05	100
Pumpkinseed	4.4(1.3)	0.07	74	4.6(1.5)	0.07	100	3.1(0.8)	0.02	100

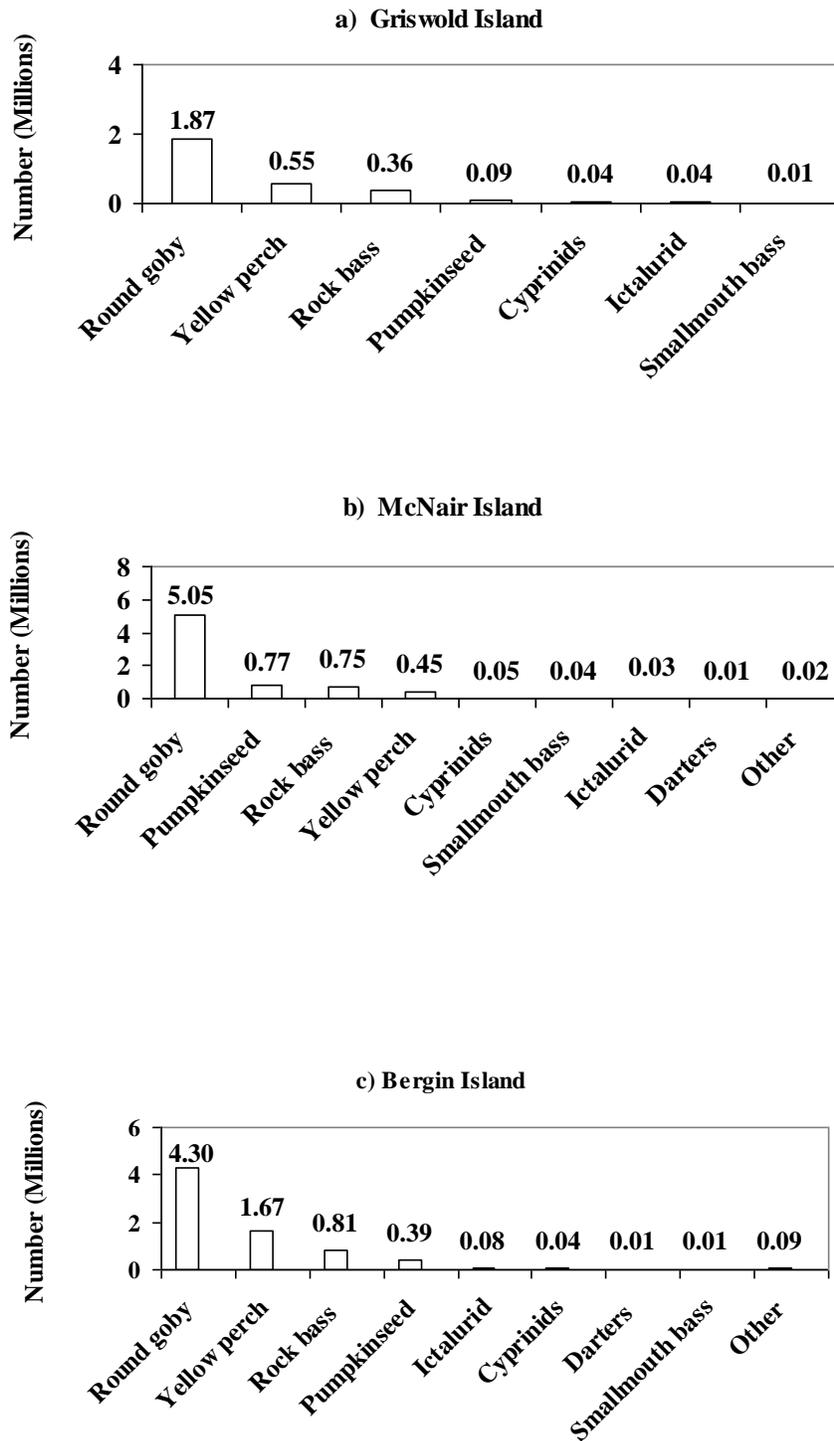
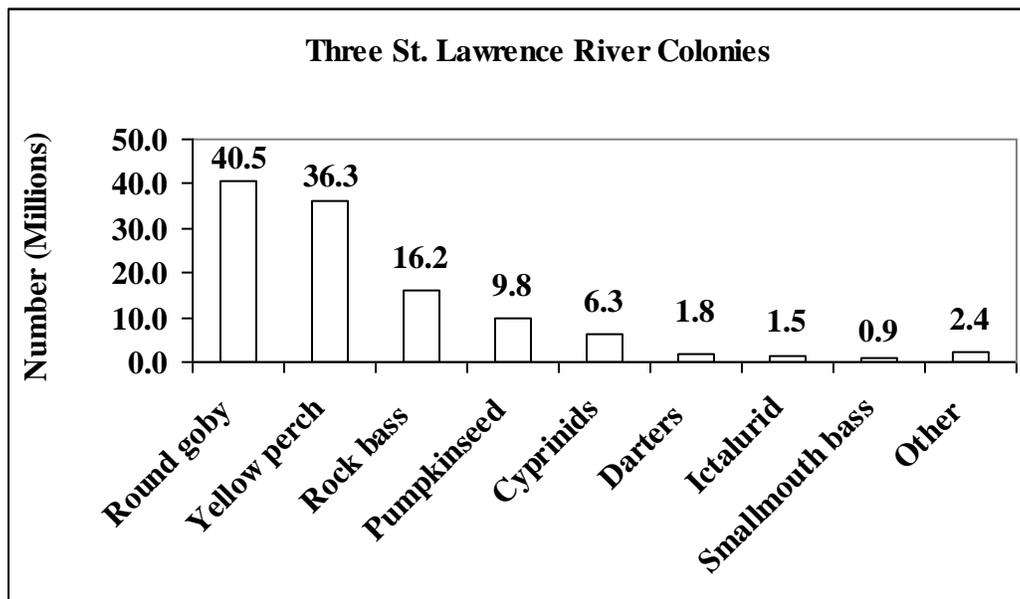


Figure 1. Estimated number of fish, in millions, consumed by cormorants from colonies at (a) Griswold, (b) McNair and (c) Bergin Islands in the St. Lawrence River in 2011.



*Figure 2. Estimated number of fish, in millions, consumed by cormorants at the three St. Lawrence River colonies 1999 to 2010.*