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From yellow perch to round goby: A review of double-crested cormorant diet and fish consumption at Three St. Lawrence River Colonies, 1999–2013

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ABSTRACT

The number of double-crested cormorants (*Phalacrocorax auritus*) in the upper St. Lawrence River has increased markedly since the early 1990s. In 1999, a binational study was initiated to examine the annual diet composition and fish consumption of cormorants at colonies in the upper river. Since 1999, 14,032 cormorant pellets, collected from May through September each year, have been examined from St. Lawrence River colonies to estimate fish consumption and determine temporal and spatial variation in diet. Seasonal variation in diet composition within a colony was low. Prior to 2006 yellow perch was the primary fish consumed by cormorants in the upper St. Lawrence River. Round goby were first observed in cormorant diets in 2003 and by 2006 were the main fish consumed at two of the three colonies. The time interval it took from the first appearance of round goby in the diet at a colony to when goby were the dominant prey species varied by island, ranging from two to five years. Daily fish consumption at each cormorant colony increased significantly from the pre-round goby to post-round goby period. The mean annual biomass of yellow perch consumed decreased significantly during the post-round goby period at the three colonies. Reduced consumption of yellow perch by cormorants may alleviate suspected localized impacts on perch near some of the larger river colonies.

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Introduction

The increase and expansion of double-crested cormorant (*Phalacrocorax auritus*) (hereafter referred to as cormorants) populations throughout the Great Lakes region are well documented (Weseloh et al., 1995; Weseloh et al., 2002). The primary factors that have been attributed to the proliferation of cormorants include reduced levels of environmental contaminants, increased food availability, and reduced human disturbance (Weseloh et al., 1995). The establishment of alewife (*Alosa pseudoharangus*) in the Great lakes, a non-native species with high caloric value (Van Guilder and Seefelt, 2013), is thought to be an important factor in increased cormorant populations (Weseloh et al., 1995). Alewife have been shown to represent a large component of the diet of cormorants throughout the Great Lakes (Belyea et al., 1997; Johnson et al., 2002, 2010; Seefelt and Gillingham, 2006) and post-fledgling survival is thought to be higher in years when the alewife are abundant (Weseloh et al., 1995).

More recently, profound changes have occurred within the fish community in the Great Lakes, with another invasive species, the round goby (*Neogobius melanostomus*), now a dominant component of the benthic community in many lakes (Van Guilder and Seefelt, 2013). Besides having adverse effects on native benthic fish species (Dubs and Corkum, 1996; Janssen and Jude, 2001; Balshine et al., 2005), round goby have been shown to alter food web dynamics (Johnson et al., 2005; Dietrich et al., 2006). In the Great Lakes, round goby now contribute substantially to the diet of lake trout (*Salvelinus namaycush*) (Dietrich et al., 2006; Rush et al., 2012), yellow perch (*Perca flavescens*), largemouth bass (*Micropterus salmoides*), northern pike (*Esox lucius*) (Taraborelli et al., 2010), brown trout (*Salmo trutta*), (B. Weidel, USGS, pers. comm.) and walleye (*Stizostedion vitreum*) (Bowlby et al., 2010). Moreover, round goby has now become a major component of the diet of piscivorous birds including cormorants (Somers et al., 2003; Johnson et al., 2010; Van Guilder and Seefelt, 2013) as well as the Lake Erie water snake (*Nerodia sipedon insulurum*) (King et al., 2006).

Most studies that have examined the diet of cormorants in the Great Lakes have been carried out in lentic ecosystems. Only one other study has been conducted in a connecting corridor such as the St. Lawrence River (Coleman et al., 2012). Cormorants were first observed nesting in the upper St. Lawrence River at Strachan Island in 1991. Cormorants now nest at a number of islands in the Thousand Islands section of the river. Three of the larger colonies in the upper river are at Griswold, McNair and Strachan Islands. Although the size of cormorant colonies in the upper St. Lawrence River is smaller than those in the eastern basin of Lake Ontario, the river colonies are generally in closer proximity to each other than the larger lake colonies. Because of increasing

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numbers of cormorants in the upper St. Lawrence River, and possible impacts on fish populations, a fifteen year study was carried out from 1999 to 2013 to quantify cormorant diet and fish consumption at the three largest colonies. The duration of the study period also provided a unique opportunity to examine the response of cormorants in a river ecosystem to an abundant and novel invasive prey species, the round goby.

Methods

Cormorant pellets were collected at three upper St. Lawrence River island colonies annually over a fifteen year period from 1999 to 2013. All three colonies are located in Canadian waters. The location of the islands, Griswold Island (0.13 ha), McNair Island (1.36 ha), and Strachan Island (0.66 ha) represented a 101 km stretch of the St. Lawrence River corridor (Fig. 1). The three islands spanned most of the upper river before it enters Quebec and the size of the cormorant colony on each island was sufficient to ensure that an adequate number of pellets could be collected on each sample date to quantify diet. In 2010 and 2011 pellets were collected at Bergin Island (0.7 ha) (also in Canadian waters) instead of Strachan Island because of higher nest counts at the former. Strachan and Bergin islands are about 3.5 km apart. Cormorant diets can vary, depending on habitat conditions, even at colonies located in close proximity (Johnson et al., 2010; DeBruyne et al., 2012). The 101 km stretch of river spanned by the three colonies included a variety of habitats including fast flowing and reservoir type conditions that could influence fish assemblages at nearby colonies. Pellets are a cost-effective, representative, and non-intrusive means of assessing the diet of adult cormorants (Neuman et al., 1997; Johnson et al., 2010), but their use may underestimate the consumption of fish species with less robust otoliths because of digestive processes while in the stomach (Duffy and Laurenson, 1983). Although there was some annual variation in the terms of the date of collections, double-crested cormorant pellets were collected on multiple occasions from April through September at all three colonies. Previous examination of the diet of cormorants at Lake Ontario island colonies demonstrated seasonal variation in both diet composition and daily fish consumption during pre-chick (prior to chick hatch, generally through early June), chick (chicks present and being fed by adults, mid-June to late July), and post-chick (no adult birds feeding chicks, generally after late July) feeding periods (Johnson et al., 2002; Johnson et al., 2010). However, seasonal variation in the diet of cormorants at the St. Lawrence River colonies was not observed. A minimum target sample size of 85 pellets for each feeding period was set at each colony, although it was not always met. Illegal shooting of cormorants at Griswold Island in 2010 resulted in few birds nesting on the island such that diet and fish consumption could not be determined.

Pellets were frozen until examination in the laboratory. In the laboratory, diagnostic prey remains recovered from the pellets, were used to describe cormorant diets. Diagnostic prey remains included bones, otoliths, and scales. Eye lenses were also enumerated because, 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.

Annual fish consumption was estimated following the same procedure as Johnson et al. (2002) and Johnson et al. (2010). This method incorporated the life history based model developed by Weseloh and Casselman (1992) and assumed that (1) residence time for breeding adults, immature birds, and young-of-year (YOY) was 158, 112, and 92 days, respectively (2) number of immatures was about 10% of the adult population which was taken as twice the number of nests; and (3) the number of YOY cormorants is the product of the fledgling

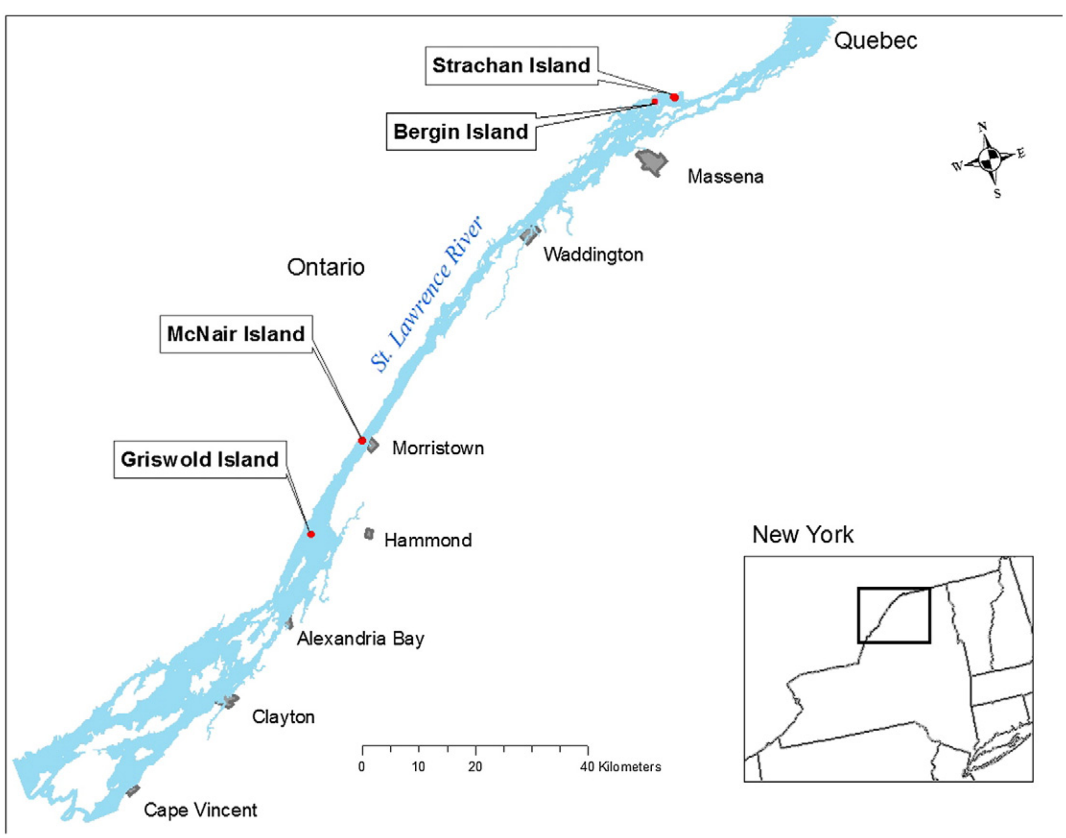

Fig. 1. Location of the islands that were sampled to examine double-crested cormorant diet and fish consumption in the St. Lawrence river.