DOUBLE-CRESTED CORMORANT IMPACTS TO COMMERCIAL AND NATURAL RESOURCES

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Abstract: The North American population of double-crested cormorants (*Phalacrocorax auritus*) has increased at an annual rate of 6.8% since 1966, with regional growth exceeding 20%/year since 1990 in Ontario and states bordering the Great Lakes. Population numbers, though operating under biological carrying capacity, have exceeded acceptance capacity with several wildlife stakeholder groups throughout Canada and the United States. Stakeholder concerns predominantly focus around social, ecological, and economic values associated with habitat destruction, changes in recreational fisheries, and loss of production at aquaculture facilities. We describe perceptible impacts to these commercial and natural resources, and discuss current research and management efforts focused on reconciling discrepancies between stakeholders acceptance and biological carrying capacities.

Key words: aquaculture, biological diversity, carrying capacity, double-crested cormorant, *Phalacrocorax auritus*, recreational fisheries

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INTRODUCTION

Anthropogenic impacts to the North American landscape are linked to local, regional, and complete extinction of numerous flora and fauna. Conservation awareness and cooperation between citizens, private organizations, and state and federal agencies have championed successful efforts that have restored viable populations to their historic ranges throughout the continent. However, many species are terminally affected by large-scale habitat alteration and continue to decline despite intensive management efforts. Natural resource managers rarely are challenged with controlling over-abundant populations, but rather plan for maintenance or recovery of populations. Ironically, one waterbird in North America has drawn a tremendous amount of attention in the last 40 years for its ability to respond positively to environmental changes and increase in the presence of human population growth, urban expansion, and extensive habitat alteration.

The double-crested cormorant (hereafter, cormorant) is the most numerous and widely distributed of the 6 North American cormorants (Hatch and Weseloh 1999). Human persecution in the nineteenth and early twentieth centuries, coupled with environmental contamination through the early 1970s (Hatch 1995; Hatch and Weseloh 1999), severely reduced population levels of cormorants throughout North America (Ludwig 1984; Hatch and Weseloh 1999; Wires et al. 2001). Response to increased human environmental awareness (i.e., reduction of environmental contaminants and regulatory protection) over the past 3 decades facilitated a population resurgence of cormorants in North America, particularly in the interior region, with numbers in some areas doubling in < 5 years (Hatch and Weseloh 1999, Glahn et al. 2000). Changes in fish communities on the breeding (Hatch and Weseloh 1999) and wintering grounds (Glahn et al. 2000) also may have contributed to an increase in cormorant numbers. Conservative estimates of the total population of cormorants in the United States and Canada are > 1 million individuals (Tyson et al. 1999), but a true population estimate is likely closer to 2 million (Hatch and Weseloh 1999).

While the overall rate of growth in North American cormorant populations slowed during the early 1990s (Tyson et al. 1999), significant population increases occurred in some areas. In the Great Lakes, where cormorants reached a low of around 200 nesting pairs between 1968 and 1973 (Ludwig 1984), nesting pairs of cormorants increased from 38,000 in 1991 (Weseloh et al. 1995), to 93,000 in 1997 (Tyson et al. 1999) and to 115,000 in the 2000 breeding season (D.V.C. Weseloh, unpublished data).

STAKEHOLDER PERCEPTIONS

Social Values

For centuries, cormorants have been associated with unpleasant things and have taken the common names "crow duck", "eel crow", "lawyer", "shark", and "water turkey" (Lewis 1929). Conniff (1991) reported use of the word "cormorant" in classical literature representing greed and gluttony. Yet despite their aversion to some, cormorants remain aesthetically pleasing to others. Lewis (1929) estimated 26,586 breeding cormorants throughout North America. During that era, cormorants provided a sense of wilderness and fascination and were welcomed at summer cottages and near scenic tourist areas (Lewis 1929). Today, facing a continental population approaching 2 million birds (Hatch and Weseloh 1999), people in general are perhaps more aware and less tolerant of cormorants. However, birders represent a stakeholder group still interested in viewing cormorants in their natural environment (Vermeer 1970, Conniff 1991, Bédard et al. 1995) and which consider such observations positive events.

Reports of cormorant guano destroying vegetation and cormorant colonies having an unpleasant odor are not new events (Lewis 1929). However, Lewis (1929) reported that cormorants dwelled in secluded places and had no effect on those who did not seek them. Today, some homeowners and business owners in the Great Lakes region may find the sight and smell of cormorant colonies offensive and aesthetically unpleasing (J. Henke, Oneida Lake Association, unpublished report). Some outdoor enthusiasts in the Great Lakes region and private land owners along the St. Lawrence Estuary also are aesthetically opposed to cormorants roosting in wooded areas (e.g., Presqu'ile Provincial Park, Ontario) due to the unsightly loss of native flora (Ontario Parks 2002, unpublished).

Ecological Values

Environmentalists, naturalists, natural resource managers, and scientists perceive ecological value in cormorants. As with all living organisms, cormorants are intrinsically valuable as members of a complex food web. They fill a niche as consumers of small fish in marine and freshwater environments, generally taking fish at depths ≤ 8 m (Hatch and Weseloh 1999). In natural waters, cormorants may support maintenance of aquatic species diversity and stabilize the relationship between predatory fish and their prey (Glahn et al. 2000). Conversely, cormorants may decrease local avian diversity on the breeding grounds through direct competition for nesting sites (Jarvie et al. 1999, Shieldcastle and Martin 1999). Cormorants also may decrease local plant diversity at breeding colonies (Weseloh and

Ewins 1994, Bédard et al. 1995, Jarvie et al. 1999, Shieldcastle and Martin 1999) and winter roost sites (G. Ellis, Wildlife Services, personal communication) through deposition of excreta.

Economic Values

During the 19th and early 20th centuries, cormorants were a subsistence item in the Great Lakes region and generous bounties were paid for their meat (Lewis 1929). Near the north shore of the Gulf of St. Lawrence, cormorant eggs were collected and eaten, whereas young cormorants were killed and used to feed dogs and captive foxes (Lewis 1929). On occasion, cormorant meat was eaten by local inhabitants, explorers, and settlers (Lewis 1929).

Today, cormorants are protected by federal and international laws as migratory birds and there is no evidence that cormorants possess a positive economic value for food or subsistence. Rather, cormorants are most often associated with economic loss. In fact, most impacts associated with cormorants can be viewed from socioeconomic perspectives.

CORMORANT IMPACTS

Habitat Destruction

Cormorants are notoriously destructive on the breeding grounds. During nest building, cormorants defoliate tree canopies by stripping leaves and breaking branches. Throughout the breeding season, cormorants deposit vast amounts of guano in and around nest sites. Ground-nesting cormorants prevent establishment of ground cover and woody growth, while tree-nesting cormorants cause death to upper and mid-canopy vegetation as well as ground flora. The resulting habitat destruction is highly visible (Weseloh and Ewins 1994, Bédard et al. 1995, Jarvie et al. 1999, Shieldcastle and Martin 1999), resulting in an array of social, ecological, and economic impacts perceived differently by stakeholder groups.

The noise and smell of cormorant breeding colonies, coupled with the appearance of dying trees, distract from the appearance of an area, resulting in potential abandonment by recreational users and loss of profit by business owners. Destruction of tree nesting cover and competition for space in traditional breeding colonies impacts other colonial birds such as black-crowned night herons (*Nycticorax nycticorax*) [Jarvie et al. 1999, Shieldcastle and Martin 1999], great blue herons (*Ardea herodias*), great egrets (*Ardea alba*), and snowy egrets (*Egretta thula*) [Shieldcastle and Martin 1999]. Given their ability to switch to ground nesting once trees are destroyed, cormorants may competitively exclude other colonial waterbirds from traditional sites in the absence of control efforts.

Catfish Production

In a national survey of catfish producers, 69% reported wildlife-caused losses of catfish with cormorants as the most frequently cited predator (Wywialowski 1999). Glahn and Brugger (1995) predicted wintering cormorants in the Delta region of Mississippi required an average of 504 g/bird/day (22% of their body mass) from November to March, resulting in an annual loss of $2 million (US$) in replacement costs for 1989-90 and 1990-91. With winter roost counts in Mississippi more than doubling from 1990 to 1998, Glahn et al. (2000) projected economic losses due to cormorant predation on catfish at $4.8 and $4.9 million in 1997-98 and 1998-99, respectively. Total estimated cost of losses to all North American catfish producers in 1996 was $12 million, though the added costs of wildlife damage prevention may have increased total cost to >$17 million or 4% loss of total sales (Wywialowski 1999).

Economics of the catfish market are more complicated than offsetting catfish loss with fingerling replacement cost, because production is largely a function of total biomass at harvest (Tucker et al. 1992). Using enterprise budgets, Glahn et al. (2002) estimated net returns on a commercial-scale pond using a single-batch cropping system ranging from $1189.29/ha without cormorant predation to $-132.12/ha with predation. Calculations by Glahn et al. (2002) including compensatory growth of surviving catfish, suggested that previous estimates of catfish production loss in the Mississippi Delta region may have been underestimated 5-fold. Thus, impacts of cormorant predation on catfish production in 2000 were approximately $25 million or 8.6% of total sales (Glahn et al. 2002). While 4-9% loss may seem low, production loss is not dispersed equally among catfish producers (Duffy 1995) and varies spatially with respect to cultural practices (i.e,, stocking density, size class of fish, and cropping system) and adjacency to cormorant roost sites (Mott et al. 1992, King et al. 1995). Impacts also vary temporally, with 50% of catfish losses projected to occur in February and March in the Mississippi Delta (Glahn and Brugger 1995).

Recreational Fisheries

Perceived impacts of cormorants on recreational fisheries pre-date those of aquaculture (Lewis 1929, Mendall 1936), though they also vary spatially and temporally. Food habits studies on the breeding grounds in the Great Lakes region revealed that cormorants forage primarily on small forage fish such as alewife (*Alosa pseudoharengus*), emerald shiners (*Notropis atherinoides*), gizzard shad *(Dorosoma cepedianum*), sculpins (*Cottus* spp.), and sticklebacks (*Gasterosteus* spp. and *Pungitius pungitius*) [Lewis 1929, Craven and Lev 1987, Ludwig et al. 1989, Weseloh et al. 1995, Bur et al. 1999, Ross and Johnson 1999]. Furthermore, Bur et al. (1999) and Ross and Johnson (1999) found that cormorants did not impact game fish on Lake Erie and Lake Ontario, respectively. However, cormorants have been shown to impact fisheries during stocking, when small fish are released into rivers and lakes (Blackwell et al. 1997, Derby and Lovvorn 1997, Ross and Johnson 1999).

Further research in the Great Lakes region revealed that cormorants may impact recreational fisheries by reducing specific size classes of sport fish. Schneider et al. (1999) found that cormorant diets in the eastern basin of Lake Ontario included 3- to 5-year old smallmouth bass (*Micropterus dolomieui*) when alewife and other prey species populations were low. VanDeValk et al. (2002) estimated that cormorants consumed 49% of age-1, 26% of age-2, and 13% of age-3 and older yellow perch present in Oneida Lake, New York in 1997. Furthermore, they reported that cormorant depredation of sub-adults (ages 1 and 2) was a larger source of mortality than angler harvest, while depredation of adults ($\geq$3 years) was comparable to angler harvest (VanDeValk et al. 2002).

Concern over depredation of recreational fisheries in the cormorant's winter range is overshadowed by concern over impacts to aquaculture; however, 2 studies have examined food habits of cormorants in natural waters of the southern United States. In a Texas study of 8 public reservoirs, shad (*Dorosoma* spp.) and sunfishes (*Lepomis* spp.) accounted for 90% of the total food items by number in 420 cormorants sampled. Similarly, Glahn et al. (1998) found shad and sunfish to be the most common food items in 142 and 51 cormorants feeding on lakes in Mississippi and Alabama, respectively.

MANAGEMENT OF IMPACTS

Breeding Grounds

Measures to control cormorants on the breeding grounds are applied locally to reduce local impacts and usually consist of multiple techniques. Common combinations of control include egg-oiling, nest removal, harassment, and culling (killing adults and/or chicks).

Egg-oiling is an effective technique for reducing reproductive success in cormorants while preventing or delaying re-nesting attempts within breeding seasons (Bédard et al. 1995, Farquhar et al. 2002, Dorr et al. 2003); however, nests must be oiled multiple times throughout the breeding season to ensure successful management. Nest removal also may reduce reproductive success, though adults often re-nest immediately in the same vicinity. Thus, to be effective, management must be extended throughout the breeding season to remove successive nests. Moreover, egg-oiling and nest destruction must reduce local impacts (e.g., number of fish eaten, number of trees killed) and be cost effective; however, no published studies have evaluated their efficacy in reducing impacts.

We found no published studies that quantified the effects of breeding season harassment on reducing impacts of cormorants and speculate that it may be cost-prohibitive in many circumstances. Furthermore, cormorants often breed in close proximity to less abundant bird species, which may be negatively affected by harassment events. Chipman et al. (2000) successfully used combinations of boat chases, pyrotechnics, mylar ribbon, human effigies, propane cannons, and electronic scare devices to harass post-breeding and migrating cormorants from Oneida Lake, New York. Harassment was conducted in September (Chipman et al. 2000), following natural dispersal of common terns (*Sterna hirundo*), a species of concern in New York.

Adult mortality affects reproductive output of cormorants more than nest treatments (Ewins and Weseloh 1994, Blackwell et al. 2002). Culling of cormorants on the breeding grounds also may have the most immediate effect on reducing local impacts; however, it is generally the least socially acceptable method of control. Unlawful shooting of cormorants on the breeding grounds is well documented (Hobson et al. 1989, Ewins and Weseloh 1994, Keith 1995), though the effects on impact reduction and population growth are unknown.

Bédard et al. (1999) initiated a 5-year culling/egg-oiling program in 1989 to halt the population increase of cormorants in the St. Lawrence River Estuary and reduce damage to unique forest habitat. This lethal/non-lethal combination exceeded expected goals and reduced populations numbers faster than model predictions, likely due to a greater vulnerability of males (203:100) to shooting (Bédard et al. 1999). Nevertheless, the efficacy of the program on impact reduction to forest habitat was not reported.

Wintering Grounds

Measures to control cormorants on wintering grounds focus almost exclusively on reducing local impacts on catfish aquaculture facilities in the southeastern U.S. Ironically, the least-used methods on breeding grounds are the most used on wintering catfish ponds: harassment and shooting. Physical barriers are a management option for small-scale fish production (e.g., tropical fish) or hatcheries where fish are grown in raceways (Parkhurst et al. 1987, Brugger 1995, Pitt and Conover 1996); however, exclusion devices such as nets and wires are not practical for large-scale aquaculture operations (Mott and Boyd 1995, Price and Nickum 1995, Littauer et al. 1997).

Many of the same harassment tools available for breeding cormorants are used during winter. Harassment programs must be aggressive and consistent to be effective (Littauer et al. 1997). They also must be adaptive and use multiple techniques to prevent habituation (Reinhold and Sloan 1999). The most common method of delivery on southeastern catfish farms is via harassment patrols (Wywialowski 1999, Wires et al. 2001), whereby farmers and employees actively scare birds when not involved in other farm duties (e.g., feeding, harvesting, repairing equipment). Patrols use vehicles and pyrotechnics to disperse birds away from their facilities, thereby reducing immediate impacts. Farmers occasionally stage unmanned vehicles on pond levees to deter bird use of nearby ponds.

In 1986, the U.S. Fish and Wildlife Service (USFWS) began issuing depredation permits to catfish farmers, which allowed them to shoot cormorants on their facilities. In 1998, USFWS issued a standing depredation order (USFWS 1998; 50 CFR 21.47) that allows commercial freshwater aquaculture producers in 13 states to take cormorants without a permit, when found committing or about to commit depredations to aquaculture stock. These events allow catfish producers to reinforce harassment with lethal control (Mott and Boyd 1995, Reinhold and Sloan 1999). Wywialowski (1999) found that shooting to harm or kill under USFWS permits was the most frequently cited loss prevention method (57%) used by catfish producers. Similarly, Stickley and Andrews (1989) found that 60% of producers surveyed patrolled their ponds and shot at cormorants. Neither survey differentiated shooting to harass from shooting to kill, though it is suspected that firearms are used in some instances to scare birds instead of pyrotechnics.

Killing cormorants on catfish ponds to reduce local or regional populations has not been a management goal nor has it been investigated with scientific rigor. Keller et al. (1998) used lethal control in Bavaria, Germany to reduce local populations of great cormorants (*Phalocrocorax carbo*), and thereby reduce local fish depredation. However, they found that despite killing the equivalent of 50-100% of the mean cormorant population in Bavaria, cormorants killed on Bavarian lakes were quickly replaced by migrating cormorants. Thus, they concluded that shooting was an inappropriate management tool for reducing impacts on fish during cormorant migration (Keller et al. 1998).

One technique of non-lethal control with merit among southeastern catfish producers is roost dispersal. Producers in Mississippi use roost dispersal more than other catfish producing states to prevent depredation (Wywialowski 1999) and the USDA Wildlife Services Program coordinates that effort in Mississippi at the request of the producers (Reinhold and Sloan 1999). Numbers of cormorants observed visiting catfish ponds may be reduced by 70-90% when nearby roosts are disturbed (Mott et al. 1992, 1998). Thus, producers participating in a night roost dispersal program spend less money to control cormorants than those that do not (Mott et al. 1998).

FUTURE MANAGEMENT OF CORMORANTS

Perceptions of perceived and realized impacts to natural resources are likely to remain polarized by stakeholder groups. Given the extent of perceived impacts, it is possible that a numerical decrease in cormorant populations caused by density-dependent factors and/or wildlife damage management may go unnoticed by some groups. Moreover, there are logistical problems associated with quantifying the effects of management on impacts caused by cormorants. For example, breeding cormorants that eat freshwater fish and breed on Lake Ontario will continue to eat fish despite nest destruction or egg-oiling. Furthermore, age at first breeding in cormorants is generally year 3 and most sub-adults do not return to their natal site until sexual maturity (Hatch and Weseloh 1999). Thus, there is a time lag ($\geq$2 years) in population response to treatments by cormorants (Bédard et al. 1999) and the fishery.

Recently proposed changes to cormorant management (Barras and Tobin 2004; 50 CFR Part 21, Volume 68) may further task natural resource managers and expand their roles spatially and temporally in reducing impacts by cormorants. Nevertheless, managers must work closely with research scientists throughout these processes and quantify the effects of local management activities throughout the range of cormorants.

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