The Double-crested Cormorant in Lake Michigan: A review of population trends, ecology and current management

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Introduction

The Double-crested Cormorant (*Phalacrocorax auritus*), or DCCO, is the most widely distributed cormorant of the six North American cormorant species (Hatch and Weseloh, 1999). The breeding range extends from the Pacific Coast (Alaska to Mexico) to the Atlantic Coast (Newfoundland to the Caribbean). The DCCO is the only species of cormorant to breed in large numbers in the interior of the U.S. and Canada (Hatch and Weseloh, 1999). These breeding interior populations are strongly migratory and mostly winter along the south-eastern Atlantic Coast and Gulf Coast (Root, 1988). In addition, large numbers also winter at inland lakes, rivers and impoundments in the south-eastern U.S., and have become more numerous at catfish and other aquaculture facilities (Stickley et al., 1992; Mott et al., 1998). The DCCO is the cormorant species most frequently cited as conflicting with sport and commercial fisheries in North America (Hatch and Weseloh, 1999).

There are six allopatric breeding populations of DCCOs, including the West Coast, Alaska, Bahamas, Florida, Atlantic, and Interior Populations (Hatch, 1995). Of these, the Interior Population, which includes the Great Lakes Basin, is the largest, with more breeding pairs than all other populations combined. Although this population is centered in the northern prairies, in the Great Lakes, cormorants

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are widely distributed and colonies can be found throughout the lakes and the St. Lawrence River. Large colonies can be found in eastern and western Lake Ontario, western Lake Erie, and across the Upper Lakes (Hatch, 1995; Weseloh et al., 2002). In Lake Michigan, the three major breeding areas are southern and northern Green Bay, and the Beaver Archipelago (Ludwig et al., 1989; Scharf and Shugart, 1998).

This work is an attempt to review and consolidate what is currently known about DCCOs in Lake Michigan. This includes an overview of the occurrence of DCCOs in the Great Lakes basin, as well as a discussion of both population trends and ecology of these birds in Lake Michigan. Finally, this work describes the recent changes in management legislation concerning DCCOs in the United States.

History of occurrence and population trends

DCCO populations have fluctuated greatly over much of their range throughout the past centuries. Early reports state that these birds were abundant across their range in the 1800s (Lewis, 1929), including in the Great Lakes Basin by the end of this century (Wires et al., 2001). However, by 1900, cormorants were not found breeding in the Lake Michigan Basin (Barrows, 1912; Ludwig et al., 1989). Yet, during the early 1900s, cormorant populations expanded again in the upper Great Lakes, with the first official breeding record in 1913, in western Lake Superior (Baillie, 1947). By the 1930s, several breeding colonies were active in northern Green Bay, Lake Michigan (Baillie, 1947; Ludwig, 1984). Due to persecution, commercial fishing practices and the general use of organochlorine chemicals, cormorant populations declined again from the 1940s through the early 1970s (Baillie, 1947; Ludwig, 1984; Craven and Lev, 1987; Ludwig et al., 1989). According to Ludwig (1984), waterbird surveys from 1959 through 1969, yielded no cormorant nests in Lake Michigan and the U.S. waters of Lake Huron, and by sometime between 1960 and 1962, DCCOs were completely extirpated as a breeding bird from Michigan.

After 1973, DCCOs began their most recent resurgence in the upper Great Lakes (Scharf, 1978; Ludwig et al., 1989; Scharf and Shugart, 1998), with at least a few pairs nesting on two islands and shoreline areas of southern Green Bay (Ludwig, 1984). This recovery has been attributed to the inclusion of DCCOs on the list of protected species under the 1918 Migratory Bird Treaty Act in 1972 (DEIS, 2001). Thus, a decline in human depredation, combined with a decline in both commercial fishing and chemical residue contamination levels (Ludwig, 1984), as well as changes in the fish communities (Hatch, 1995) may have provided new opportunities for cormorant recovery across the Great Lakes. The population expansion of non-native fish commonly found in their diet, including Alewife

(*Alosa pseudoharengus*), has also been linked to the cormorant population recoveries (Weseloh and Ewins, 1994). Overall, the number of breeding pairs in the Great Lakes has increased from 89 nests in 1970 to 38,000 by 1991 (Weseloh et al., 1995).

Formal nest count data for DCCOs in U.S. waters of the Great Lakes are available from 1977 (Scharf, 1978) and additional surveys were conducted in 1984 (Ludwig et al,. 1984), 1989-1990 (Scharf and Shugart, 1998), and 1997 (Cuthbert et al., 1997) (Table 1). The number of breeding DCCO colonies in the U.S. Great Lakes region has grown from four in 1977 to sixty-nine in 1997; in Lake Michigan this is paralleled by an increase from three in 1977 to twenty-seven active colonies in 1997 (Cuthbert et al., 1997). DCCOs have shown an overall population increase in the U.S. Great Lakes region, from 171 pairs in 1977 to 48,931 pairs in 1997. This same trend is true for Lake Michigan alone, where the number of breeding pairs increased from 75 pairs in 1977 to 28,158 pairs in 1997. Interestingly, in 1977 and 1989-1990, Lake Michigan cormorants comprised around 43% of the overall population nesting in U.S. waters of the Great Lakes. However, by 1997, the Lake Michigan DCCO population comprised over 57% of breeding pairs in the U.S. Great Lakes (Cuthbert et al., 1997).

The revival of cormorant populations has been no less pronounced in the Beaver Archipelago where, as of 1997, they were estimated to comprise almost 39% of the nesting DCCO pairs within Michigan waters of the Great Lakes (Cuthbert et al., 1997; Ludwig and Summer, 1997) and over 41% of the Lake Michigan breeding population (Cuthbert et al., 1997) (Table 2). Historically and more recently, there have been six active breeding DCCO colonies in the Beaver Archipelago, including Grape and Timm's spits (portions of Hog Island) and Pismire, Hat, Whiskey and Gull Islands. Overall, through 1997, the Beaver Archipelago breeding DCCO population has followed the general increasing trend seen lake wide. However, between 1997 and 2000, the population declined by 13.5%. In addition, between 2000 and 2001, the population size decreased by another 4.1% (Table 2). Colonies on Timm's Spit and Whiskey Island have disappeared, while both Pismire and Gull Islands experienced growth. The overall decline in the Beaver Archipelago may be indicative of a stabilizing population or changes in suitable nesting habitat due to lower lake levels. Lower lake levels may have allowed greater access to some colonies for mammalian predators, and has also increased the size of some small, more remote islands in the archipelago. Similarly, in Green Bay, DCCO populations also appear to be stabilizing, since there are few remaining unoccupied sites and existing colonies are probably approaching upper size limits (K. Stromborg, U.S. Fish and Wildlife Service, New Franklin, WI, U.S.A., pers. comm..).

Table 1. Lake Michigan and Great Lakes breeding Double-crested Cormorant population estimates beginning in 1977 and ending 1997. Both the number of breeding pairs and active colonies have increased substantially over this twenty year period. In 1997, the Lake Michigan colonies comprised 57.55% of the breeding cormorants in the U.S. waters of the Great Lakes.

	Lake Michigan Breeding Pairs	Lake Michigan Colonies	Great Lakes Breeding Pairs	Great Lakes Colonies
1977[a]	75	3	171	4
1984[b]	684	9	NA	NA
1989-90[c]	4743	18	11099	36
1997[d]	28158	27	48931	69

[a] Nest count data from Scharf, 1978.
[b] Nest count data from Ludwig, 1984.
[c] Nest count data from Scharf and Shugart, 1998.
[d] Nest count data from Cuthbert et al., 1997.

Table 2. Numbers of Double-crested Cormorant pairs breeding at colonies in the Beaver Archipelago, northern Lake Michigan beginning in 1984 and ending in 2001. Note that the number of breeding pairs increases until 1997, where after there is an overall population decline. Some colonies, such as Pismire and Gull, have continued to show an increase as the regional population declines, while Timm's and Whiskey colonies have dissolved.

	Pismire	Grape	Timm's	Hat	Whiskey	Gull	Total
1984[a]	57	0	0	54	0	139	250
1989[b]	35	291	0	294	0	260	880
1997[c]	383	3509	753	4617	560	1887	11709
2000	987	2431	277	4917	0	1532	10125
2001	1035	2146	0	4511	0	2013	9705

[a] Nest count data from Ludwig, 1984.
[b] Nest count data from Scharf and Shugart, 1998.
[c] Nest count data from Cuthbert et al., 1997.

Ecology

DCCOs are seasonal inhabitants of Lake Michigan, typically arriving in April in northern regions. In the Beaver Archipelago, egg laying and incubation begins in May or early June, chicks are hatched in mid to late June, and young birds fledge by late July or early August. Most birds leave the area by September; however it is not uncommon to see some DCCOs in October in the archipelago. There are also migrant birds that pass through the region in spring and autumn, and immature (non-breeding) birds that summer in the archipelago. Since the resurgence of the

DCCO population in the Beaver Archipelago, there has been a growing concern how this seasonal residency and the migration influx may influence local prey species.

DCCOs are opportunistic fish predators that often feed in shallow waters (Lewis, 1929; Birt et al., 1987). Information on prey taken by these birds has been widely gathered, but generally only in context of perceived fishery conflicts (Hatch and Weseloh, 1999). Seasonal variation in cormorant diet is evident in most studies, but simple lists and percentages do not reveal the ecological factors contributing to this predation pattern and the impact on fisheries. Since the local impacts on prey populations and ecosystem dynamics have remained unclear, it has been recommended that research efforts focus more closely on foraging behaviour and predator-prey interactions (Hatch and Weseloh, 1999). Currently, some areas in Lake Michigan, including the Beaver Archipelago, are being investigated to further understand cormorant-fish relationships.

Prey species and prey size are factors that may help determine the impact DCCOs have on fisheries (Ainley et al., 1981; Fowle, 1997). Because of the loss of large, native, piscivorous fish in the 1940s and an increase in salmonid stocking programs, prey fish populations have fluctuated across the region (Christie et al., 1987). In addition, introduced Alewife became abundant in all lakes, except Lake Superior, by the 1950s (Hatch and Weseloh, 1999). Other non-native forage fish, such as Rainbow Smelt (*Osmerus mordax*), have also become established.

Breeding cormorants remain relatively close to breeding colonies when foraging (Custer and Bunck, 1992). Although cormorants may have only small and localized effects on fish populations during migration (Kirsch, 1995), it has been demonstrated that these birds may deplete fish prey around breeding colonies in some areas (Birt et al., 1987). In Lake Ontario, for example, cormorants had a significant effect on specific age classes of Smallmouth Bass (*Micropterus dolomieui*) (Adams et al., 1999; Johnson et al., 1999; Schneider and Adams, 1999). However, most studies reflect that cormorant diets tend to include species that are of little commercial or sport value. Yet these species may be important in community trophic dynamics (Craven and Lev, 1987). Therefore, cormorants may have a secondary effect on sport fisheries by competing with desired species for forage fish and other prey such as crayfish. Although the effects on forage fish numbers may be limited and may only occur in localized areas (Madenjian and Gabrey, 1995), this combined with direct sport and commercial fish depredation may have some impact on some sport and commercial fish populations.

Historically, there have been several studies documenting the diet of cormorants in the upper Great Lakes, including Lakes Huron, Michigan and Superior (Craven and Lev, 1987; Ludwig et al., 1989; Ludwig and Summer, 1997; Maruca, 1997; Neuman et al., 1997). Ludwig et al. (1989) documented food items (n=8512) in the regurgitates of adults and chicks at several locations in Lakes Huron, Michigan

and Superior from 1986 to 1989. By number, Alewife and Nine-spine Stickleback (*Pungitius pungitius*) accounted for 41% of the diet. By biomass, the important species included Alewife (57%), Yellow Perch (*Perca flavescens*) (13%), Rainbow Smelt (8%), and White Sucker (*Catostomous commersoni*) (7%). Diet varied seasonally, and by August, the diet of cormorants in each study area surveyed contained 100% Alewife (Ludwig et al., 1989). In addition, Ludwig and Summer (1997) documented food items (n=6293) in the regurgitates of adults and chicks at nesting colonies in the Les Cheneaux Islands of northern Lake Huron in 1995. By weight, Alewife constituted 72% of the nestling diet. As part of the same study, Maruca (1997), using 373 stomachs, documented that adult cormorant diet contained approximately 48% Yellow Perch during the perch spawning season. In July, however, adults fed primarily on Alewife. Weseloh and Ewins (1994) have suggested that cormorant reproductive success may be intimately linked to Alewife population dynamics.

The Beaver Archipelago, and particularly the habitat around Garden and Hog Islands, has long been known for its excellent Smallmouth Bass fishing, and this evaluation has been published in the national media a number of times (Robinson, 1995). Recently, however, there have been numerous reports of a decline in the sport fishery by local anglers (Hooker, 1999a, 1999b, 1999c). In partial response to these reports, Central Michigan University (CMU) and the Michigan Department of Natural Resources (MDNR) initiated an intense population sampling in May of 1999. Compared to similar data gathered using trap nets by researchers at CMU nearly 20 years ago, not only is the Smallmouth Bass population down by an astounding 75-80%, but other fish species, including Brown Bullhead (*Ictalurus nebulosus*) and Rock Bass (*Ambloplites rupestris*) have declined by as much as 98% (D. Peterson, University of Georgia, Athens, GA, U.S.A., pers. comm.). It is therefore quite clear that there has been a recent and very rapid decline in the Beaver Archipelago fishery. The factors that have caused these declines have remained unclear. Present research is investigating whether the local DCCO breeding population could have played a role in the decline of local fish populations.

Most recent regurgitate and stomach content data suggest that DCCOs in the Beaver Archipelago feed primarily on Alewife during the breeding season. During 2000 and 2001, a total of 1128 regurgitate samples (10,600 individual prey items) were collected. When regurgitated food items are compared by mass, Alewife comprised 72.00% of the diet (57,073 g of 79,230 g) (Figure 1). Of the 150 stomachs (3363 individual prey items) analyzed in 2000 and 2001, Alewife mass comprised 72.83% of the diet (18,603 g of 25,550 g) (Figure 1). Other prey commonly found in the diet of Beaver Archipelago DCCOs are crayfish (*Orconectes sp*.), sculpin (*Cottus sp.*), Nine-Spine Stickleback, and White Sucker. Other miscellaneous prey include Spottail Shiner (*Notropis hudsonius*), Johnny

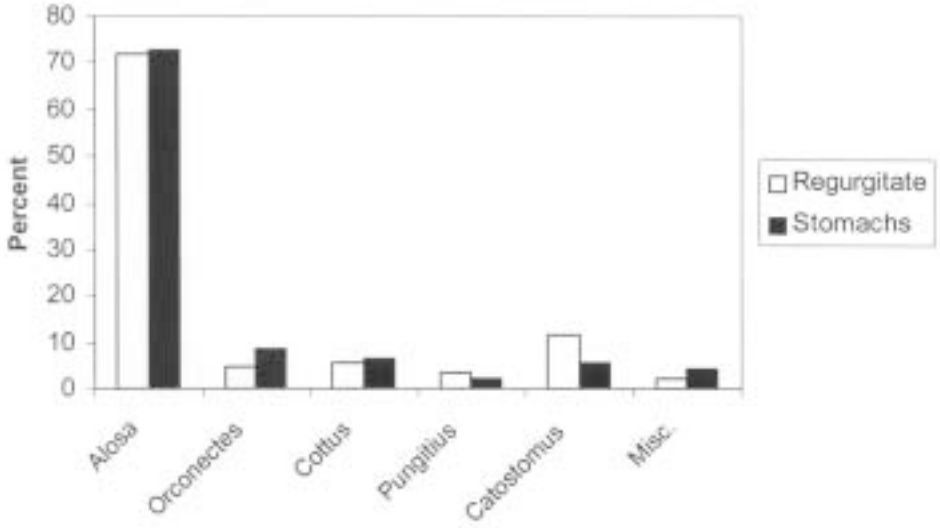

Figure 1. Diet of Double-crested Cormorants in the Beaver Archipelago, 2000 and 2001 combined, shown as percent mass for both regurgitate (n = 1128) and stomachs (n = 150). Alewife (*Alosa*) provide the most biomass in cormorant diets. For regurgitate samples, Alewife comprise 57,073 g of 79,230, while for stomach samples, Alewife comprise 18,603 g or 25,550 g. However crayfish (*Orconectes*), sculpin (*Cottus*), stickleback (*Pungitius*) and sucker (*Catostomous*) are also frequently taken.

Darter (*Etheostoma nigrum*), Trout-perch (*Percopsis omiscomaycus*) and Brook Stickleback (*Culaea inconstans*). Only one Smallmouth Bass was found in this investigation. No sample has yet yielded evidence of Rockbass or Brown Bullhead in the diet of archipelago DCCOs. As in previous studies in the Upper Great Lakes (Ludwig et al., 1989; Ludwig and Summer, 1997), Alewife became increasingly more important in the diet of Beaver Archipelago DCCOs as the breeding season progressed.

Current management

Cormorant-human conflicts are not a new phenomenon. Because of their perceived negative effect on aquatic communities, several studies have been conducted investigating cormorant influences on fisheries both in Europe (Suter, 1995; Warke and Day, 1995) and in the Great Lakes (Madenjian and Gabrey, 1995; Maruca, 1997; Neuman et al., 1997; Schiavone, 2001). Research suggests that waterbirds actually play central roles in marine food webs (Cairns, 1992), and this probably holds true in Great Lakes community dynamics. In order to get a realistic picture of the impact bird predators have on fish populations in Lake Michigan, it is

necessary to incorporate quantitative data on the diets, population size and energy requirements of the cormorant population. In addition, reliable data on the size of the fish populations, with the appropriate spatial and temporal scales, are necessary (Draulans, 1988). Currently, in the Beaver Archipelago, data of this sort are being collected in order to facilitate the reconstruction of fish communities and to determine the extent of the role the cormorant resurgence may have had in recent fishery declines in the region. Similar approaches have been successfully used in Lake Erie to assess the impact DCCOs have on fish populations (Madenjian and Gabrey, 1995; Hebert and Morrison, 2003).

Currently, there is no long-term management plan for DCCO populations in Lake Michigan. In the Wisconsin waters of Green Bay, a landowner has successfully deterred cormorants from nesting on his small island using devices designed to scare the birds. In addition, there has also been an isolated incidence of vandalism at a colony on a northern island in Green Bay (K. Stromborg, U.S. Fish and Wildlife Service, New Franklin, WI, U.S.A., pers. comm.). Yet, overall in Lake Michigan, there have not been actions to manage cormorant populations. Since the resurgence of DCCO populations, research has focused mainly on monitoring breeding colony size, diet and toxicology within this basin. However, there has been an aggressive DCCO management program in the Lake Ontario Basin. In 1992, the New York State Department of Environmental Conservation (NYSDEC) began focused research to determine the actual impacts DCCOs have on fisheries and other aspects of both the Lake Oneida and eastern Lake Ontario ecosystems (Farquhar et al., 2003). This research, although still ongoing, has led to the implementation of a five-year management plan for U.S. waters of the eastern basin of Lake Ontario beginning in 1999. Management practices have focused on using egg-oiling, nest removal, harassment and habitat modification to control DCCO numbers, without the implementation of lethal control of adults and chicks (Farquhar et al., 2003). Egg-oiling has proved successful at reducing reproductive success of DCCOs in U.S. waters of Lake Ontario. Within five years, the number of breeding pairs should be reduced to target numbers with continued annual oiling activities (Schiavone, 2003).

Resolving human-cormorant conflicts has become a focus of the U.S. Fish and Wildlife Service. In 1998, a Depredation Order (50 CFR 21.47) was enacted which authorized "commercial aquaculture producers in 13 states…to take DCCOs, without a federal permit, when found committing or about to commit depredations to aquaculture stocks" (DEIS, 2001). Since this original action did not allow for Federal management or population control of DCCOs, and did not take into account more recent concerns, it has been considered ineffectual.

In the fall of 2001, the U.S. Department of the Interior Fish and Wildlife Service in conjunction with the U.S. Department of Agriculture APHIS Wildlife Services released a Draft Environmental Impact Statement (DEIS) for DCCOs. The purpose

of that document was to describe and evaluate alternatives which focused on reducing conflicts between DCCOs and people (commercial, recreational and other issues) and to ensure the long-term health of cormorant populations (DEIS, 2001). Apparently, although most Americans were ambivalent with regard to DCCOs, there were many individuals concerned about the conservation and management of these birds. The DEIS categorized these concerned parties as follows: 1) animal protectionists that support non-lethal management; 2) individuals, including resource professionals, that favour conserving DCCOs and not scapegoating the birds; 3) others, including resource professionals, that emphasize conservative DCCO management; and 4) citizens who are directly affected by DCCOs, including aquaculturists, and favour more aggressive management. These differing viewpoints have added much emotion to the debate and the resolution of cormorant-human conflicts.

In order to facilitate both dialog and action, the DEIS proposed six alternatives ranging from no action (allowing current management plans to stand) to a cormorant hunting season. Each alternative outlined in the DEIS was analyzed as to how each would impact cormorant populations, fish, other birds, vegetation, federally listed Threatened and Endangered species, water quality, human health, economic issues and others (DEIS, 2001). The new "Proposed Action" favoured by the Services establishes "a new Depredation Order to address public resource conflicts." The new action would authorize "State, Tribal and Federal land management agencies to implement a DCCO management program, while maintaining Federal Oversight of DCCO populations via reporting and monitoring requirements" (DEIS, 2001). Participation of State agencies is strictly voluntary and these management plans will allow for local DCCO control with federal oversight. This new Public Resource Depredation Order will allow for some taking of cormorants at breeding and roosting sites, as well as egg oiling and destruction (DEIS, 2001).

In March 2003, the Department of the Interior, Fish and Wildlife Service released the proposed rule for DCCO management (50 CFR Part 21, 68 FR 12653). Then, in August 2003, the Final Environmental Impact Statement (FEIS) was released. According to the FEIS (2003), the Public Resource Depredation Order "will cause the estimated take of <160,000 DCCOs, which is not predicted to have a significant negative impact on…DCCO populations." In addition, it will minimize the local impact on other birds, reduce both fishery and vegetation impacts on a local scale and reduce depredation on both aquaculture and hatchery facilities. However, this new order "is not likely to significantly benefit recreational fishing economies or commercial fishing" (FIES, 2003). The final rule (50 CFR Part 21.48, 68 FR 25396) released on 08 October 2003, allows for local cormorant control in twenty-four states. It established not only a Public Resource Depredation Order, but also revised the original Aquaculture Depredation Order. In addition, the new rule also requires the monitoring of cormorant numbers and careful record

keeping to insure that populations remain sustainable. This final rule took effect 07 November 2003. Currently, it is difficult to comment on how this action will influence Lake Michigan populations of DCCOs.

Conclusion

The DCCO, an indigenous species, has shown a remarkable population recovery over the past three decades in Lake Michigan and other Great Lakes. Often perceived as depredating fish stocks, thus far, in northern Lake Michigan, these birds do not seem to have negatively impacted either sport or commercial fisheries. However, cormorant-fish relationships are still being investigated and soon more information may be available, especially with respect to the northern Lake Michigan ecosystem including the Beaver Archipelago. It will be interesting to see how this new information in combination with the new management rule will influence DCCO populations of Lake Michigan.

Summary

The Double-crested Cormorant (*Phalacrocorax auritus*), a colonial waterbird native to North America, has experienced a substantial population increase throughout the Great Lakes, including Lake Michigan, over the past thirty years. This resurgence in combination with a simultaneous decline in some sport and commercial fisheries has led to their implication in fishery depredations. Research in Lake Michigan has largely focused on monitoring breeding population numbers and investigating prey species in the diet. Currently in northern Lake Michigan, specifically the Beaver Archipelago, the most important prey item in the cormorant diet appears to be Alewife (*Alosa pseudoharengus*). However, research is still being conducted to investigate what impact these birds may have on this species and other fisheries in northern Lake Michigan. In addition, the U.S. Department of Interior's Fish and Wildlife Service, in conjunction with the U.S. Department of Agriculture's APHIS Wildlife Services, has released a rule change that will allow for more aggressive management of cormorants when they are in conflict with economic and ecological interests. How this new rule will influence the Lake Michigan cormorant population remains uncertain.

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