AVIAN CONSERVATION & ECOLOGY

**VOLUME 18, ISSUE 1, ARTICLE 1**

Ludwig, J. P., S. J. Cooke, and K. A. Hobson. 2023. On the lack of scientific evidence for the Ontario cormorant cull and other cormorant management actions: a response to Dorr et al. (2022). Avian Conservation and Ecology 18(1):1. https://doi.org/10.5751/ACE-02375-180101

**Erratum:** The original PDF of this article failed to give the correct copyright year, Volume, Issue, and Article numbers. The error was corrected on 8 March 2023.

# On the lack of scientific evidence for the Ontario cormorant cull and other cormorant management actions: a response to Dorr et al. (2022)

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## À propos du manque de données scientifiques relatives à l'abattage de cormorans en Ontario et d'autres activités de gestion des cormorans : une réponse à Dorr et al. (2022)

Key Words: *cormorants; diet; fisheries interactions; management; misconceptions; Ontario*

In their recent essay in *Avian Conservation and Ecology*, Dorr et al. (2022) were compelled to clear up apparent misunderstandings they felt were perpetrated by the separate editorials of Hobson (2021) and Cooke (2021) dealing specifically with the Ontario government's decision to allow a province-wide public cull of Double-crested Cormorants (*Nannopterum auritum*) in response to perceived conflicts with fisheries, conservation objectives, and human recreation. They claim to have addressed "misconceptions about cormorant and fishery interactions, summarize the current state of knowledge on the issue, and discuss a different approach based on collective experience in the United States." They further suggest that both editorials imply that "cormorants rarely, if ever, are an issue for any reason, and that management is rarely warranted." While we welcome the debate, it is clear to us (now including Ludwig, the senior author of this report) that such premises are simply not true; a more careful reading of our papers would have revealed a more dispassionate and scientific approach to the question and that we had very clearly focused almost entirely on the Great Lakes region vs. Double-crested Cormorants everywhere. Rather, the Dorr et al. (2022) response reflects the authors' long careers in cormorant "management" and an apology for the record of the US government (and various state agencies) with respect to cormorant fisheries concerns. The apparent need by Dorr et al. (2022) to defend cormorant management in light of the irrational Canadian province-wide hunt /cull by an ill-informed public is revealing. Readers will know that we clearly acknowledged that certain situations justify cormorant management and should be conducted by professionals (as in fact quoted by Dorr et al. [2022] from Hobson's editorial). Moreover, we never labeled cormorant management universally as "persecution." Indeed, Hobson (2021) devoted considerable summary background on the myriad of environmental issues involved in the health of the Great Lakes that obscures any direct linkage between cormorants and fisheries in this region. The obvious take-home message from the Hobson (2021) and Cooke (2021) essays was how complex these natural systems are and how such complexity has hitherto been ignored by public advocates for cormorant control, governments, and several fisheries biologists.

The Dorr et al. (2022) essay raises important issues but is afflicted by the same tunnel vision that has tainted many studies of fisheries and cormorants published by fisheries and wildlife biologists for decades. This included ignoring examples of any beneficial interactions of cormorants with game species, cherry-picking data sets to include only those data that suggest cormorants harm fisheries, creating models replete with unjustified or known false assumptions, the ignoring or outright misuse of published data, and a common tendency to assume the only important change in ecosystems where conflicts exist are changes in fish stocks (usually game fish) and cormorant numbers. The most egregious oversights are the implicit assumptions that the explosions of invasive species and their interactions with fisheries did not influence the observed declines of economically important fish species where cormorants were present (Bunnell et al. 2017). Early research on the Great Lakes indicated cormorants ate very few game fish (Eck and Brown 1987, Ludwig et al. 1989, Madenjian et al. 1995, MDNR Fisheries 17), but this research has been ignored by proponents of controls.

For example, consider the frequently quoted study by Fielder (2008) on the Les Cheneaux yellow perch (*Perca flavescens*) fishery on Lake Huron often used to condemn cormorants when Fielder concluded they were the cause of the perch decline. Fielder (2008) used netting data from different locations in different years and assumed these perch population data were comparable; he ignored the 2504% increase of northern pike (*Esox lucius*) in creel census data collected by his agency coincident with the decline (reported as Table 4.5 in Diana et al. 1997, MDNR Fisheries 17) that conforms to the timing of the decline of the local perch population far better than the local increase of nesting cormorants; he ignored a 1987 paper on the damage of alewife predation on perch eggs and larval-stage fish from Lake Ontario (Brandt et al. 1987) that found inter-annual variation of 1–30% in losses of perch year-classes owing to alewife predation; he assumed all locally nesting cormorants flew inshore from their local colonies to exploit perch when the data collected by Diana and others (MDNR Fisheries 17) found most birds did not feed inshore when nesting, with minimal predation on perch by cormorants (1% of the annual mortality of 45%) but heavy

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consumption of alewives (*Alosa pseudoharengus*) and nine-spined sticklebacks (*Pungitius pungitius*) during nesting; and he ignored the ecological turmoil in northern Lake Huron following invasions of the Zebra mussels (*Dreissena polymorpha*), Quagga mussels (*D. bugensis*), and round gobies (*Neogobius melanostomus*) after 1992 followed by collapses of the prey-fish food base for all predator species and the developing oligotrophication of Lake Huron. Many other variables besides cormorants including fluctuating climate, timing of breeding, water temperature, and water turbidity as well as predation have been shown to affect the breeding success of perch in both inland and large lakes (Bacheler et al. 2011, reviewed in Kestemont et al. 2015; Fetzer et al. 2016).

Other fisheries studies have made similar errors. For example, Tsehaye et al. (2015) created a model purported to project cormorant impacts on fish by assuming a normal feeding range of 40 kilometers from colonies when multiple published studies (Birt et al. 1987, Custer and Bunck 1992, Seefelt and Gillingham 2008, MDNR data of tagged fish in the Les Cheneaux region and weekly aerial overflights in 1994 and 1995) all found nesting cormorants fed very close to their colonies. These studies found a maximum feeding range of 12 km, with a typical foraging range of <7 km for almost all nesting birds. Similarly, studies in Lake Ontario (e.g., Lantry et al. 1999) that correlated declines in smallmouth bass (*Micropterus dolomieu*) to rising cormorant numbers between 1988 and 1995 failed to assess the impacts of the dreissenid mussel and goby invasions, especially the potential effects of goby and alewife predation on bass nests recently shown to follow within seconds when anglers removed bass from their nests (Tufts et al. 2019). A follow-up study (Johnson et al. 2015) reported a rapid switch by foraging cormorants from perch to gobies after the gobies invaded. A study in northern Lake Michigan by Kaemingk et al. (2012) that is cited rarely by those fisheries biologists who blame cormorants for smallmouth bass declines, found bass there prospered, grew more rapidly, and built larger populations when the locally nesting cormorants were at their highest population densities. This outcome may be owing to the birds targeting gobies and alewives as their principal foods when both cormorants and bass were nesting (Steinhart et al. 2004, Van Guilder and Seefelt 2013, Crane and Einhouse 2016, Tufts et al. 2019), thereby reducing predation on bass nests and larval stages.

In summary, large lake ecosystems (like the Laurentian Great Lakes) suffering repeated alien species invasions are complex unstable systems with rapidly changing interspecies relationships where cormorants may harm or benefit any particular game fish species (Madenjian et al. 2002). One of the key criteria for establishing a cause–effect relationship is *consistency upon replication by different researchers examining the same question* (Ludwig et al. 1995). In general, fisheries studies of cormorant fisheries relationships routinely fail this important criterion.

If the available fisheries data are selected to focus only on the presence of cormorants and a fish species in the same habitat, then one can reach any conclusion they wish. However, co-occurrence and correlation are never proof of a causal relationship of either harm or benefit among species occupying the same habitat unless all, or at least most, other potential causes for a fish population change are accounted for. None of the published papers by fisheries scientists have achieved this standard and most did not even attempt to reach it. Most have chosen to indict cormorants as the major guilty party based on co-occupancy of the same habitats. Bunnell et al. (2017) document the massive impacts of invasive mussels on nutrient availability across the Great Lakes and how these changes have resonated across all trophic levels of these ecosystems. All fish-eating predators in every taxon were affected in substantial ways, but most published data on the relationships of cormorants to fisheries have been ignored by fisheries scientists in favor of largely speculative opinions that cormorants always damage fisheries, if not by direct predation on game species, then by consuming prey that could sustain game species. Conclusions in the absence of replicated data from multiple studies are not valid science: Rather, it is speculation and, more often than not, over-generalization. Unfortunately, the list of papers cited by Dorr et al. (2022) in support of their premise provides little scientific evidence and consideration of alternative hypotheses that undermine the Fielder (2008) work, as described previously, for the Great Lakes region.

To date, there are no unbiased estimates of the economic benefits of cormorant control programs in the Great Lakes region. The most significant attempt to quantify the costs owing to cormorant pressure on fisheries was the analysis of economic impacts in the Finger Lakes region of New York state in 2008 (Shwiff and Kirkpatrick 2009). The stated premise of that research project was that *"*The major economic impact of cormorants was hypothesized to be a decrease in the number of non-resident anglers visiting Oneida Lake, due to decreased fish populations and negative media surrounding the cormorants at the Lake.*"* They attributed all local declines in fishing license sales (even out-of-state sales) and the local losses of jobs for the 15 years of 1990–2005 to the presence of cormorants. Depressed local economic conditions were far more likely connected to national trends of malls and big box stores competing with small businesses, the severe recession after the second Iraq War, and the housing crisis. Blaming cormorants for the economic conditions extant in central New York state and calculating the cost owing to cormorants at USD $500 million was an extreme example of APHIS (U.S. Department of Agriculture Animal and Plant Health Inspection Services) spin.

It is overdue to account for the costs of control measures and develop a defensible methodology to measure accurately the cost to local fisheries that can be attributed to cormorants. There is no question that cormorants can exploit the fisheries of shallow lakes and artificial ponds effectively and can cause economic losses (a point never disputed by us). In these situations, the high efficiency of cormorants as predators and the shallow nature of inland lake systems makes them vulnerable to exploitation by cormorants (well-documented examples include the Finger Lakes of New York State, Brevort Lake in Michigan, and catfish farms in the Mississippi Delta region of the southern U.S.). Defensible means to translate most of these real biological effects into real economic effects do not exist, especially for the fisheries of large lake ecosystems or coastal marine habitats.

Cormorants prefer to nest in trees where available and their nitrogenous droppings clearly cause tree mortalities or shifts in tree species composition (referred to by Hobson (2021) as "guilty as charged"). Typically, most conifers and hardwoods are killed within a few years of cormorant nesting, leaving only the feces-tolerant trees such as box elder maple (*Acer negundo*). Especially along shorelines and on islands in large lakes where unregulated water levels fluctuate widely, tree mortalities unrelated to bird species nesting are often excessive and far more extensive than tree kills caused by nesting cormorants, herons, or egrets. To date, there have been many observations of tree mortalities but little research to disentangle causes among nesting bird species, fluctuating water levels, drought, plant species competition, or damaging tree pests such as the invasive emerald ash borers (*Agrilus planipennis Farmaire*) or the native long-horned wood boring beetles (Coleoptera: Cerambycidae). Multiple sources of tree losses should be evaluated. For example, the Canadian islands of western Lake Erie hosted the northward extension of the Carolinian forest association that included many species of concern in Canada, especially the blue ash (*Fraxinus quadrangulata*). Great concern was voiced by the Pelee National Park and independent botanists about the threats cormorants posed to this species in the early 1990s, but it was the invasive emerald ash borer that killed off virtually all ash species in southwestern Ontario. Based on their own population data, the annual cull of adult nesting cormorants on Middle Island by Parks Canada has, through disturbance, conceivably reduced populations of other colonial waterbirds there such as Great Blue Herons (*Ardea herodias*), and prevented colonization by American White Pelicans (*Pelecanus erythrorhynchos*).

Since 2008, the efforts of the two national governments to census cormorants and other waterbirds have faltered across their breeding range. The size of the cormorant population and the current distribution are unknown. Further, few current data exist on the productivity of the cormorant population (i.e., fecundity, adult survival rates, fledging rates, etc.) that has been severely impacted by culls, egg oiling, greatly altered access to prey (i.e., the trophic structure in key ecosystems like the Great Lakes and Lake Winnipeg/Winnipegosis; Bunnell et al. 2017), increased predation by Bald Eagles (*Haliaeetus leucocephalus*), Newcastle's disease virus (NDV), avian cholera (Leighton et al. 2021), and the 2022 outbreak of $H_5N_x$ avian influenza viruses. The list of recent factors impinging on the productivity and survivorship of cormorants across North America is large and unquantified. Often, surprising relationships are revealed by diligent long-term research such as reported for a Saskatchewan cormorant colony where chicks of tree nesting birds were 14 times less likely to contract NDV or avian cholera than ground nesters in a 21-year time span when disease outbreaks occurred in 14 years and the colony was maintained only through recruitment from other sites (Leighton et al. 2021). In 2022, the $H_5N_x$ viruses killed cormorants at three Green Bay Lake Michigan colonies, a colony on an inland lake in Illinois, and in flocks of birds on migration in southern Lake Michigan. Similar, but unexplained, mortalities occurred at a western Lake Erie colony involving both American White Pelicans and cormorants. Simply put, the current status of the cormorant population (in Ontario and most of the Great Lakes region) is unknown and yet such basic information, all would have to agree, is needed urgently in light of current and planned management actions.

The ethical dimension of cormorant control policies and actions is rarely discussed by proponents of controls on cormorant populations in lieu of economic or perception arguments (Guillaumet et al. 2014). Cormorants are a native species that responded to human introductions of many invasive species, changes made to aquaculture, mismanagement of many different aquatic ecosystems across North America, and serious epizootic disease outbreaks since 1990. The conversion of cormorants into pests, or a species that harm some dimension of human activity, is a by-product of many decisions and changes that have been imposed or allowed by humans or that occurred naturally in North America. Before controls are continued based on productivity and survivorship data from the 1990s (MDNR Fisheries 17), new data on these parameters must be collected and understood or any decisions to continue the culls as "adaptive management" will proceed based on opinion and prejudice, not on a sound scientific database.

We acknowledge the modeling efforts by the USFWS and the USDA to better evaluate cormorant fisheries interactions as described by Dorr et al. (2022), but we are skeptical that such models could incorporate the kinds of complexity we have indicated above. Further, it is not clear to what extent the recent permitting changes in the United States regarding cormorant management (USFWS 2020) will adequately defuse the debate and result in less vigilantism in that country, and we can be forgiven if we remain skeptical given the track record of the USFWS and USDA on the permitting front when it comes to cormorants. Nor is it clear how much of the natural fisheries resources will be allotted to native non-human species like cormorants, as agreed to by multiple "stakeholders." Key authors of the Dorr et al. (2022) paper and their agencies (especially USDA/Wildlife Services and Michigan Department of Natural Resources) have played significant roles in the largest destruction of cormorants the continent has seen to date (Wires et al. 2014, 2015). As such, any "different approach" as described by Dorr et al. (2022) is, of course, welcome. Regardless, we argue that such issues have little to do with the objectives of the Hobson (2021) and Cooke (2021) editorials that Dorr et al. (2022) chose to target. The discourse in this series of papers further amplifies the complexity of the topic and the evidentiary voids that exist in drawing cause–effect relationships between cormorant populations and fish populations (e.g., Schultz et al. 2022).

There is one main area of agreement between Dorr et al. (2022) and our team: notably, a mutual recognition that there is zero evidence to support a province-wide public cormorant hunt (read as "cull") in Ontario, the fundamental basis of the essays by Hobson (2021) and Cooke (2021). That agreement is telling, despite other clearly disparate views as outlined. Evidence-based decision-making, when applied to natural resources and biodiversity, requires high quality evidence. In this case, the evidence to support such a province-wide cull is entirely absent or flawed. Given that the Ontario Ministry of Natural Resources and Forestry purports to be a "science based" organization, it is apparent that the decision by the provincial Conservative government to institute a cull was entirely political, which is inconsistent with contemporary evidence-based decision-making.

**Author Contributions:**

*JPL wrote a first draft and SC and KAH contributed writing and editing.*

**Acknowledgments:**

*We thank the three anonymous reviewers who commented on an early draft of this rebuttal.*

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