Why is the Double-crested Cormorant a Problem? Insights from Cormorant Ecology and Human Sociology

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Abstract.—Cormorants Phalacrocoracidae have a long history of conflict with fishermen and more recently with fish-farmers. Cormorant species tend to be opportunistic, adaptable, and highly attracted to concentrated food sources. At the population level, there is little evidence to suggest that cormorants seriously deplete commercial food sources, although at small scales, individuals or small numbers of cormorants may cause problems, especially at fish farming operations or hatcheries. On the other hand, despite a high potential rate of population increase, cormorants are among the more sensitive seabirds to human disturbance during breeding. Control measures would be very effective at breeding sites, but it is not clear that such efforts would remove the proportion of the population likely to be in direct conflict with humans, except at colonies adjacent to fish farms.

Key words.—Double-crested Cormorant, disturbance, pest species, *Phalacrocorax auritus*, population dynamics, wildlife management.

Colonial Waterbirds 18 (Special Publication 1):25-32, 1995

This paper tries to set conflicts between cormorants and fishermen in the framework of the biology of cormorants and how we humans deal with problem species. It then makes some recommendations, based both on biology and on human attitudes, in the context of ecological problem-solving. It is not designed to be a review of the literature, but rather to highlight why the cormorant can be a problem, how we can evaluate that problem, and how we can take advantage of the species' biology to reduce the problem.

In wildlife management, only part of the process is scientific. We can measure populations, life history parameters, diet, energetics and behavior of the wildlife and not touch on the source of the problem. Most problems and solutions involve human attitudes and actions which serve as a filter for the science, so, in dealing with the problem of the Double-crested Cormorant (*Phalacrocorax auritus*) competing with fishermen, we have many scientific facts, but there are differing opinions about the problem and what can be done about it. At the extremes, some say that there is in fact no biological problem; that cormorant predation is minor compared to other losses at fish farms. Others, animal-rights advocates, would claim that the cormorants have a right to fish and that we have no right to stop them. Finally, there are those who fish or farm who believe that their right to make a living is impaired by cormorants so they should have free rein to deal with the problem. Most of us fall somewhere in the middle of all this.

Whatever our differing viewpoints, we accept that there is a conflict. I and other cormorant investigators can talk about the science, but I think we scientists need to keep in mind that our science can take us only so far. On the other hand, I would ask non-scientists to examine what the science has to say with an open mind. It may contradict their experience or their impressions, but that is what exactly what science is designed to do, separating our preconceptions from the cold reality of hard data. Things are not as they appear or as we may wish them to be when dealing with cormorants (Bayer 1989).

The Perception of Pest Status

Pest status of animals is inherently a subjective and political judgement (Berryman 1986). This classification is based on a determination that the animal is "a health hazard, causes economic damage or is a general nuisance to one or more persons" (Salmon and Lickliter 1984) or prevents "optimization of the resource under management" (Stark 1977) or has a "negative impact on human survival or well-being" (Berryman 1986). There appear to be few efforts to establish objective standards of pest status, taking into account the positive and negative effects of species in communities at different times and places, or of differing views within the human population. A species is a pest when someone says it is, whether that someone is a homeowner, a fish farmer or a scientist. If the one person feels strongly enough, they do something about the problem, ranging from the legal such as putting up a scarecrow or obtaining a nuisance permit, to the illegal such as harassing animals or attacking breeding sites. If enough people agree that there is a problem, reach a consensus on a solution, and have the political power, then maybe something gets done at a larger scale, such as a government program (Wagner and Seal 1992).

Problem species involve perceptions and perceptions change (cf. Kellert 1985). For example, wolves were once viewed as pests in Yellowstone National Park, so they were exterminated. Now we are re-introducing wolves at great cost back into the same park. The wolf has not changed at all; public attitude has (McNaught 1987). Wolves still kill livestock on occasion, but the public has reached a consensus that wolves in the Yellowstone ecosystem are more important than the costs of wolf predation to livestock and the opposition of many livestock owners.

For less charismatic species, such as cormorants, no such consensus exists. As this collection of papers illustrates, there are many areas where cormorants are considered pests, taking free-ranging or farmed fish, yet at the same time the Double-crested Cormorant has been listed as endangered in Illinois and as of special concern in Michigan (Blokpoel and Scharf 1991). We have the illogical result that some states are trying to protect and increase cormorant populations, while the same cormorants are being harassed or shot when they reach other states. Until such time as a national or bi-national (United States and Canada) consensus emerges on whether the Double-crested Cormorant is a problem, this piecemeal management can treat local symptoms, but it is unlikely to achieve much of a solution, no matter how good the scientific advice or the management expertise.

The Science of Pest Species

Species' characteristics

Seabird biologists and managers are more accustomed to dealing with problems of rarity in seabirds than of pest species. The low intrinsic rate of population increase and vulnerability to nest disturbance and predation of many species of seabirds have led to major population decreases (cf. Croxall *et al.* 1984; Croxall 1991; Nettleship *et al.* 1994), so that 15 percent of all species in the seabird families are threatened or endangered and, in some families, as many as 30-40% (Duffy 1992). Even among cormorants, 11% of the species are at risk (Duffy 1992). Biologists are thus cautious about adding to this problem through population manipulations that might backfire; afterall, some of today's pest species were endangered less than a century ago. For example, Double-crested Cormorants and Great Black-backed Gulls (*Larus marinus*) were almost extirpated in the United States at the turn of this century; now both species are common and cause problems (Buckley and Buckley 1984). The species have not evolved, human behavior has changed and we have ceased hunting, reduced pollutants, and restricted disturbance at nest sites.

While definition of a pest species depends on human decisions and economics, there are several biological criteria that may point to species than can obtain population levels and exploit suitable environments in sufficient abundance to be considered pests by humans.

Population.—Population size or density alone are poor indicators of pest status. For example, the Double-crested Cormorant population in the Great Lakes is now estimated at approximately 27,000 pairs in an area of 244,000 km^2 (Hatch 1995), or a density of one bird for every 4.5 km^2. The latest estimates for the North American breeding population are 330,000 pairs (Hatch 1995) in an area of 19 million km^2, or a density of one bird per 25 km^2.

Population growth.—While population size in itself may not identify problem species, population trends may be more useful. Double-crested Cormorants have shown astounding rates of population increase, such as 20% per year in southern New England (Hatch 1984), 40.4% per year in the Canadian lower Great Lakes between 1976 and 1990 (Blokpoel and Tessier 1991), 44% per year during 1973-1981 for the entire Great Lakes (Ludwig 1985), and 56% per year in Lake Ontario during 1974-1982 (Price and Weseloh 1986). In contrast, the Guanay Cormorant (*Phalacrocorax bougainvilli*) living in the highly productive waters of the Peruvian upwelling had a mean annual rate of increase of only 18% (Duffy 1983).

Population dynamics are determined by the relative contributions of reproduction, mortality, and migration. Reproduction includes clutch size, breeding success, and age at first breeding. Cormorants have relatively large clutches compared to other seabirds (Duffy 1980) and have asynchronous hatching that facilitates survival of different numbers of young, based on food supply (Williams and Burger 1979). Price and Weseloh (1986) report reproductive success for Lake Ontario cormorants of 1.7-3.2 young per nest and they suggest a mean of 2.8 young per nest is possible for this population. Drent *et al* (1964) reported 2.4 young per nest over three years at Mandarte Island; rates of 2.1-2.4 were reported by Pilon *et al.* (1983a) for the Magdalen Islands, Quebec. These rates appear high relative to other cormorants (Johnsgard 1993) and are certainly high compared to most seabirds (Lack 1967).

The age of first breeding for Double-crested Cormorants is unknown for the Great Lakes, but Van de Veen (1973) found that over 20% of breeders of a slowly increasing (8% per year) Pacific coast population were only one to two years of age. That the species can breed this early is itself remarkable, compared to most seabirds which may wait three years or more (Lack 1967). If the Great Lakes population has a much higher percentage of young birds breeding than in the Pacific population, this would also help explain the rate of increase (Price and Weseloh 1986).

Turning to mortality, Price and Weseloh (1986) reviewed data that suggest that stable populations of Double-crested Cormorants suffer a 70% pre-breeding mortality and 15% annual adult mortality. In a Pacific population increasing at 8% per year, Van de Veen (1973) reported mortality during the first two years (here assumed to be the same as prebreeding) to be 64.5% and adult mortality to be 15.1%. To fit Great Lakes estimates of nest productivity and population increase, Price and Weseloh (1986) suggest a prebreeding mortality of only 31% and an adult mortality of 10%. It is interesting to speculate that the high rate of immature survival may be linked to food on the wintering grounds, such as at fish farms.

The last aspect, immigration, may be important locally. Price and Weseloh (1986) argue that annual population increases up to 56% on Lake Ontario could be produced by the breeding colonies themselves, but that in three of their nine study years, immigration was responsible for 10%, 31%, and 55% of the population increases of up to 171%. However, it remains unclear where such migrants come from, as there seem to be few colonies that are decreasing in the United States and Canada (Vermeer and Ranking 1984). There may however be a pool of nonbreeding birds that recruit into colonies during exceptional years.

Taking these aspects together, at least in the Great Lakes, Double-crested Cormorant reproduction seems to have more in common with rabbits than with most seabirds.

The species is undergoing a remarkable increase in population. This suggests that problems between cormorants and humans will only increase.

Foraging.—Problem species have relatively wide habitat and food tolerances, and the ability to adapt to locally abundant food resources when these become available. At first glance, cormorants do not appear to fill these criteria. Cormorants as a family are relatively limited in how they can forage. Although other cormorant species have been reported feeding by plunge-diving (Duffy *et al.* 1986) and feeding on trawler offal (Blaber and Wassenberg 1989), most cormorants catch their prey by underwater diving in pursuit of live prey (e.g., Ainley *et al.* 1981).

Cormorants may locate a suitable feeding area from the air, while flying, using the presence of fish (Vogt 1942, Barlow and Bock 1984), prior knowledge, or other foraging birds as clues (Duffy 1987). Palmer (1962) reported a foraging range of 8-16 km for Double-crested Cormorants. Others, tracked by airplane at two breeding colonies in Wisconsin, had maximum foraging ranges of 11.6 km and 40 km but mean distances of only 2.0 km and 2.6 km (Custer and Bunk 1992). On the other hand, in the Farallon Islands off California, Ainley *et al.* (1990) found that breeding Double-crested Cormorants travelled 30-80 km to feed in shallow waters over smooth substrates inshore, because suitable nesting places were not available closer to the fishing grounds. Such a long commute would require that the food resource be consistently available and abundant and, in fact, Double-crested Cormorant nesting success was more consistent than that of other species that fed closer to the Farallones, on less predictable prey (Boekelheide *et al.* 1990).

Pennycuick's (1989) analysis of wing shape indicated that the species forages most efficiently only at short distances from the colony. Ainley (1977:678) has argued that these flight constraints restrict diving seabirds such as breeding cormorants to areas with "reliable food sources relatively close to the breeding site" and to "regions of high biological productivity and standing stocks of organisms". Fish farms fit these requirements superbly.

Once a foraging site is chosen, cormorants search for prey underwater and lunge at them with their beaks (Owre 1967). While most foraging seems to take place in shallow waters, Double-crested Cormorants have been reported foraging in water 15-22 m (Palmer 1962, Knopf and Kennedy 1981, Johnsgard 1993). As cormorants are visual hunters (Owre 1967), their hunting efficiency may be reduced at lower visibilities.

On the other hand, although the foraging methods of Double-crested Cormorants are limited to surface diving, their choices of foraging areas and prey are very broad and they appear very adaptable to local conditions (Ludwig *et al.* 1989). For example, Ainley *et al.* (1981) reported this species foraging on mid-water schooling fish in the eastern Pacific, while Robertson (1974) found them feeding on inshore benthic species on Mandarte Island, British Columbia. They fed on "small, shallow water, bottom species" in Lake Superior (Craven and Lev 1987), while elsewhere in the Great Lakes Ludwig *et al.* (1989) found them feeding both on benthic species and on shallow-water schooling fish, when the later moved inshore to spawn.

Prey size ranges from 3 cm to 30 cm, basically anything cormorants can catch and swallow (Mitchell 1977, Pilon *et al.* 1983b). Socially, their foraging is also very adaptable. Double-crested Cormorants are solitary feeders on the Atlantic coast (pers. observ.) and Great Lakes (Craven and Lev 1987), but social feeding is common in the Pacific (Bartholomew 1942).

Cormorants spend a great deal of time searching for prey (flight to foraging site, then diving) relative to actual feeding which may take less than a second for small fish. In terms of foraging theory (MacArthur and Pianka 1966), such a predator should take virtually any edible prey it encounters and can eat, rather then being selective, because handling and consuming the prey costs little in terms of time and energy relative to the energy or time expended before encountering another prey. In practical terms this means cormorants will probably feed on almost anything edible they encounter while diving.

Effects of Abundant Species

We can examine competition between fisheries and avian piscivores through a series of measurments that are simple in theory, no matter how complex their logistics.

If we know the mass or weight of a bird, we can calculate its energy consumption based on allometric equations or direct observations of consumption. For example, Schramm *et al.* (1987) used allometric equations to determine that at a mass of 1,800 g, the Double-crested Cormorant required a food consumption of 208-247 g d^{-1} (11.5-13.7% of body weight) in Florida. Based on field observations that cormorants ate 19 channel catfish (*Ictalurus punctatus*) per day (length 7-16 cm), Schramm *et al.* (1984) suggested an individual consumption of 304 g d^{-1} (16.9% of body weight) at fish ponds in south Florida.

If we know the number of birds feeding at the site, we can calculate total consumption by multiplying daily food needs in grams of fish per cormorant by the number of individual cormorants present. For example, the 13 cormorants resident at the same Florida pond consumed 246 fish per day or approximately 3.9 kg d^{-1} (Schramm *et al.* 1984).

These figures make sense only in relation to the number of fish present and to the growth of the fish. For example, the same pond was stocked in August with 75,000 fish of 3-8 cm. Consumption by 13 cormorants was 246 fish per day which works out to 7,380 per month or 89,790 per year, or 20% more fish than the initial stocking. At first this looks terrible, but we need to take into consideration not just standing stock (the number of fish at any one time), but the production or growth of the fish (Duffy and Schneider 1994). Basically, catfish grow, but the mass of food (304 g $d^{-1}bird^{-1}$) of food consumed per cormorant per day remains the same, so the number of fish needed to satisfy the cormorant's daily food requirements would drop continuously. We also need to consider size of fish in models of consumption by cormorants with losses from other sources (Parkhurst *et al.* 1987). Glahn and Stickley (1995) estimate that cormorants consume 4% of catfish fingerlings each year. Is this the largest source of mortality? If not, then perhaps funding and research should be focused elsewhere to achieve greatest return per research dollar.

Point and Non-point Sources of Problem Birds

From an ecological point of view, it is often helpful to think of problems, such as pollution, as originating either from point or non-point sources (Odum 1989). A point source for nitrogen entering a bay might be a sewage outfall; non-point sources would be hundreds of lawns being fertilized and the subsequent surface and groundwater runoff at a thousand different locations. In a point source it is easy to go after the problem at the source; for a non-point source, it may be easier to protect against the problem than to solve it at its myriad sources.

In terms of fish farms or other problem areas, is there one roost or colony within efficient foraging range (2-5 km?) that is the source of the birds? Or are there many roosts or small colonies? Or are there hundreds of migrating birds that stop to feed in passage? In the first case, the point source, perhaps the roost or colony, can be relocated by removing nesting or roosting trees during the non-breeding season or by judicious harassment as the colony or roost members first arrive? In the latter case, protecting the fish farm would appear more practical.

THE SPECIES' WEAKNESSES

Knowing something of the ecology of cormorants in general and of the Double-crested Cormorant in particular may give us management options for reducing the problems associated with fishery operations. The list that follows includes some such options, but does not address either their effectiveness or their drawbacks. The cures could be worse than the problems, so their use should be considered with care.

Nesting

Nesting Double-crested Cormorants are extremely sensitive to disturbance and resulting predation by Fish Crows (Grant 1970, Post 1988) and gulls (Kury and Gochfeld 1975, Siegel-Causey and Hunt 1981), whether the disturbance results from vandalism (Weseloh and Sturger 1985, Ludwig *et al* 1989), investigator disturbance (Ellison and Cleary 1978), or nuisance abatement programs (DesGranges and Reed 1981). However, such disturbance does not always translate into population reductions (DesGranges and Reed 1981).

Foraging

Cormorant foraging is less vulnerable to disturbance than is nesting. Cormorants can always feed elsewhere until the disturbance disappears. However, there may be a number of ways to make foraging more difficult. Barlow and Bock (1984) suggest that lower stocking densities of fish make it difficult for cormorants to locate fish from the air, so that fewer birds land, consume fewer fish, with fish productivity possibly ending up greater than with a higher stocking rate.

Because of their heavy bodies and small wings, cormorants need a clear runway for takeoffs. Restricting runway space for takeoff might discourage birds, perhaps with some small-scale equivalent of the barrage balloons that the British used in the Second World War to discourage low-level bombers. For another species of cormorant, Barlow and Bock (1984) suggested steep sides to fish ponds so that the cormorants cannot walk easily in and out of the water.

Barlow and Bock (1984) noted that crustaceans could be used to dilute the prey cormorants encountered in Australian fish ponds. If a noncommercial prey is available as a sacrifice, then predation on the commercial species would be reduced. Similarly, Morrisey (1976) suggested that reducing visibility in farm ponds can restrict foraging efficiency.

Finally, if cormorants can not travel long distances efficiently to forage, then it may be feasible to discourage or remove nesting colonies or roosts only within a certain radius of fish farms.

DISCUSSION

Cormorants are the most visible piscivores and there is a long standing tendency to blame them for mortality of commercially important fish (Bayer 1989). On the other hand, we have only begun to do the hard science and to measure how much cormorants actually eat, much less to consider the role of cormorants in the ecosystems that are fish ponds. We hear little about how cormorant predation compares to other losses, or whether by reducing the stocking level, cormorants might actually cause the remaining fish to grow faster, because of increased rations for the survivors. We do not know whether cormorants pick on weaker or sick fish, reducing the risk of disease in fish farms or whether cormorants are vectors for fish diseases. Finally, we have only an initial idea of whether harassment programs pay for themselves in terms of increased survival or production at the local pond level (Parkhurst *et al.* 1987, Stickley *et al.* 1992). Would such programs really pay for themselves at a regional or national level?

Double-crested Cormorants are undoubtedly a problem for fish farmers, but these problems are local. Solutions to these problems should also be local, at least on the basis of present knowledge. Some of the solutions suggested above could reduce predation, but they would not eliminate it. At a larger scale, since we know that wintering cormorants that cause problems come from many different breeding colonies (Dolbeer 1991), we would need to 'down-size' all current North American nesting cormorant populations through a massive harassment program at breeding sites. We wiped out Double-crested Cormorants in the United States once; we can do it again. This would kill hundreds of thousands of birds, even though only a few tens of thousands (3%) are actually the problem (Glahn and Stickley 1995). This is unacceptable. Harassment might also have unintended consequences, such as disturbance to endangered species like Bald Eagles and Brown Pelicans (Bayer 1989) or it might trigger boycotts of aquaculture products, as happened with tuna and Japanese whaling. Finally, we should keep in mind that our grandchildren might find themselves reintroducing cormorants into Mississippi sometime in the future, much as we are reintroducing wolves to Yellowstone National Park.

ACKNOWLEDGMENTS

I would like to thank B. Coblentz, M. Erwin, J. Hatch, J. Johnsgard, J. Ludwig, D. N. Nettleship, K. Vermeer, C. Weseloh for help with the literature and discussions about cormorants.

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