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Double-crested Cormorants and Fisheries in Florida

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Abstract.—Wintering and breeding populations of Double-Crested Cormorants (*Phalacrocorax auritus*) in Florida underwent declines in the middle of the 20th century, rebounding in the 1980s. Overall, little conflict occurs between cormorants and the food-fish and game-fish industries in Florida waters. Specific conflicts exist when wintering cormorants feed at inland hatcheries, grow-out ponds, and ornamental-fish ponds, where high-value tropical and pet fish crops may be completely lost to fish-eating birds. These ponds are small in acreage, such that exclusion (netting), scare devices (dogs), or a change in cultural practices (segregating fish by size classes) may be appropriate methods to reduce fish losses to piscivorous birds.

Key words.—Aquaculture, bird damage, Double-crested Cormorant, fisheries, fish predation, Florida, *Phalacrocorax auritus*, population.

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Awareness of issues associated with fish-eating birds in Florida is increasing because of recent growth of the aquacultural industry, publicity about fish-eating birds elsewhere, and fish losses at some local sites. The aquaculture industry in Florida has undergone dramatic changes in recent years (data from Florida Agricultural Statistics Service 1988, 1990, 1992). Aquaculture in Florida includes 6 main crops, listed in order of economic value: tropical fish, aquatic plants, alligators (*Alligator mississippiensis*), oysters and clams, catfish (*Ictalurus punctatus*), and sport/game fish. The total value of aquacultural operations increased more than 50% in Florida between 1987 and 1991, from $35 million to $54 million (US$). Nearly 450 producers were active in Florida in 1991 compared to 342 in 1987.

By far, the economically most important aquacultural crop is tropical fish production for the aquarium trade. Sales reached $32.8 million in 1991 compared to $21.7 million (US$) in 1987. The number of growers (193) was similar between 1987 and 1991. Total land and water surface area devoted to tropical fish increased only 10% during these years. Tropical fish production is centered in Hillsborough and Polk counties with some activity in Dade and Palm Beach counties.

Aquacultural food production includes catfish, oysters and clams, and crawfish. Birds have not been reported as problems in oysters, clams, or crawfish, so these crops will be omitted from discussion. The number of catfish growers increased slightly from 55 to 62 between 1987 and 1991. Food production of catfish increased from 0.7 million pounds to 1.8 million pounds, and $1 to $2 million (US$) between 1987 and 1991. Additional catfish were sold as fingerlings and "stockers". Catfish production is concentrated in northern Florida and the panhandle.

Sport and game fish facilities produce game fish such as Bluegill (*Lepomis macrochirus*), Largemouth Bass (*Micropterus salmoides*), hybrid Striped Bass (*Morone* spp.), and Red Drum (*Sciaenops ocellata*). In 1991, sport-game fish sales from 17 growers amounted to $0.8 million (US$). Comparable data were not available for 1987 to identify changes. Hatcheries and nurseries are located from central Florida to the panhandle.

Although the biology of wading birds is relatively well-studied in Florida, little scien-

tific attention has been paid to population ecology of Double-crested Cormorants (*Phalacrocorax auritus*), especially with respect to aquaculture. The objective of this case study is to provide an overview of the available data on cormorants and their relationship to aquaculture in Florida.

METHODS

Cormorant Population History

Breeding populations—Estimates of cormorant nesting populations in Florida were obtained from published and unpublished literature. Additionally, the 1966 to 1991 Breeding Bird Survey (BBS) database for Florida Double-crested Cormorants was obtained from the U.S. Fish & Wildlife Service (USFWS) in Laurel, Maryland. Routes with ≤10 years of data were excluded from analysis. The total number of breeding cormorants from the remaining routes was tallied each year.

Wintering populations—The numbers of Double-crested Cormorants identified in annual Audubon Christmas bird counts (CBC) were tallied from 1965 to 1991 for 10 routes. Routes were chosen if they were censused each year and if cormorants were present in most counts. In alphabetical order, CBC routes were: Cocoa, Coot Bay, Fort Myers, Jacksonville, Merritt Island, Naples, Saint Petersburg, Sarasota, South Brevard, and Tampa. Additionally, all CBC routes in Florida were tallied from 1985-86 to 1990-91 as an index to the current number of wintering cormorants.

Banding data—Published reports of cormorant banding data with reference to Florida were reviewed.

Cormorant-Human Interactions and Management Options

Telephone interviews were conducted with 38 biologists, extension agents, and growers in Florida to identify issues of concern and the geographic locations where Double-crested Cormorants might be in conflict with human activities. Individuals were questioned about methods to manage cormorant-human conflicts and their apparent effectiveness.

RESULTS

Cormorant Population History
Breeding populations

Double-crested Cormorants are year around residents in Florida, breeding in colonies throughout the state from December to September (Clapp *et al.* 1982). Little information is available to estimate historical population sizes of breeding Double-crested Cormorants in Florida. Early reports only offer qualitative estimates (e.g., "great numbers" of birds); few site-specific estimates are available. For example, Fargo (1929) estimated 1,800 nesting pairs (= 3,600 birds) at Indian Key near the mouth of Tampa Bay in 1925 and "fewer" in 1926 and 1927. Howell (1932) stated that "The Florida Cormorant is very abundant on the Gulf coast and less numerous on the east coast and on many of the lakes in the interior". Sprunt (1954) commented that "no change of any consequence has taken place in these birds since Howell wrote in 1932", perhaps referring to population size. However, Palmer (1962) suggested that breeding populations of cormorants in Florida were decreasing.

The current breeding population in Florida may be between 10,000 and 30,000 cormorants (Table 1), but it is difficult to interpret statewide survey data collected between March and July because Florida cormorants also breed in winter in south Florida (Runde 1991). From 1976 to 1979, the number of breeding cormorants on the Florida-east Atlantic coast was estimated to be ca. 8,630 and that on the Florida Gulf coast ca. 15,060 (H. W. Kale in Clapp *et al.* 1982) yielding a total of 23,690 individual birds. In June 1986, the middle of the breeding season, 2,346 nests (= 4,692 birds) were counted between Anclote Keys and Sanibel Island on the Gulf coast (R. Paul, pers. comm.). In a statewide survey conducted March to July 1976-78, more than 28,000 breeding cormorants were estimated from 77 colonies (Nesbitt *et al.* 1982). In March to July 1986-89, 16,430 cormorants (range: 8,898 to 23,980) were reported from 110 colonies (Runde 1991).

Between 1976-78 and 1986-89, Double-crested Cormorants appeared to expand their distribution to include six inland counties (Runde 1991). However, the total number of breeding cormorants in Florida apparently declined during this period. The frequency distribution of colony sizes differed between decades, with fewer large (>100 breeding cormorants) and more small colonies observed in 1986-89 compared to 1976-78 (Runde 1991). The presence of large nesting colonies conspicuously declined in the 1980s at latitudes less than 26°N.

Table 1. Estimates of the numbers of breeding Double-crested Cormorants in Florida, 1976 to 1989.

Year	Location	Number of birds	Source
Regional:			
1976-79	Florida-Atlantic coast	8,630	H. W. Kale in Clapp *et al.* 1982
1976-79	Florida-Gulf coast	15,060	H. W. Kale in Clapp *et al.* 1982
1986	Anclote-Sanibel	4,692	R. Paul, pers. comm.
Statewide:			
1976-78	Florida	>28,000	Nesbitt *et al.* 1982
1986-89	Florida	16,430	Runde 1991

In southern Florida, where the only long-term study of a local population has been conducted, aerial surveys of cormorants nesting and roosting in Biscayne Bay from 1980 to 1986 revealed stable breeding and wintering populations (Cummings 1987). From April to September nearly 1,300 breeding birds were counted; March and October censuses averaged 2,500; and counts from November to February averaged 3,500 birds (Cummings 1987).

The USFWS-BBS revealed little about breeding populations of Double-crested Cormorants in Florida between 1966 and 1991. Only 26 BBS routes were conducted for more than 10 years in Florida. One route, South Brevard County, consistently encountered cormorants; numbers ranged from 45 to 234, with >200 cormorants observed in 1971, 1982, and 1988. Fewer than 30 cormorants were observed on the remaining routes each year, yielding annual breeding estimates of less than 275 birds. Between 1966 and 1979, Florida averaged 4.2 Double-crested Cormorants per route, exceeded only by Saskatchewan (mean = 4.6) and New Brunswick (mean = 9.4) (Robbins *et al.* 1986).

Wintering populations

Migratory cormorants from northern states and provinces overwinter from October to May in Florida (Palmer 1962), concentrating in the southern-most regions of the state (Root 1988). Historical data suggest large wintering populations in Florida. Howell (1932) reported the sizes of individual flocks at the mouth of Tampa Bay: ca. 10,000 cormorants were seen at Passage Key on 4 December 1910, 5,000+ were seen at Terra Ceia Bay on 21 January 1919, and 2,000+ were observed at Pass-a-grille in February 1924. Fargo (1929) noted a decline from 3,000 to fewer than 1,000 birds near Pass-a-grille between 1925 and 1929.

The tally of Double-crested Cormorants from 10 consistently surveyed Audubon Christmas bird count locations revealed a trend of increased wintering populations from ca. 6,000 in 1965 to ca. 20,000 in 1989 (Fig. 1). When standardized by total party hours, the number of cormorants increased three-fold from about 45 to 130. The highest counts of this sample were along the Atlantic coast, from Merritt Island, Cocoa, and South Brevard County. The total counts of Double-crested Cormorants from all Florida Christmas bird counts between 1985-86 and 1990-91 ranged from 26,836 to 143,139 birds (Table 2). An unusual flock of about 100,000 cormorants was sighted in North Pinellas during 1988-89, greatly increasing the year's total (W. Biggs, pers. comm.).

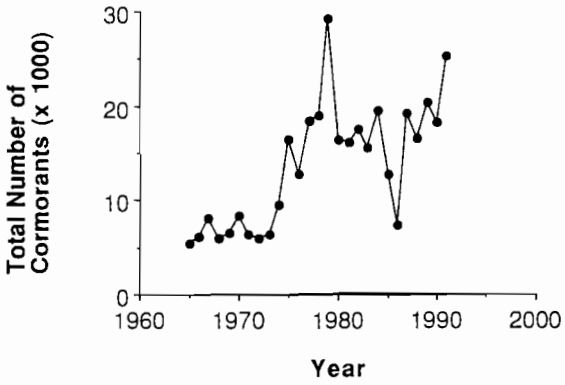

Figure 1. Total number of Double-crested Cormorants (*Phalacrocorax auritus*) recorded at 10 Audubon Christmas Bird Count locations conducted in Florida between 1965 and 1991.

Table 2. Annual totals of all Double-crested Cormorants recorded during Audubon Christmas Bird Counts conducted in Florida during the winters of 1985-86 to 1990-91.

Year	Total number of birds	Number of count locations
1985-86	26,836	45
1986-87	44,399	47
1987-88	40,671	49
1988-89	143,139	50
1989-90	46,294	52
1990-91	56,596	52

Banding data

Previous banding studies demonstrated that the origin of Double-crested Cormorants that winter in Florida include U.S. states and Canadian provinces east of the Great Lakes. Of 248 nestlings banded in Maine, 72% (N=169) of birds recovered in December to February were taken in Florida (Kury and Cadbury 1970). Of 93 returns found in south Florida (24° to 27.3°N, 80° to 83°W) from October to May, 98% were banded in Maine, Massachusetts, Michigan, Wisconsin, Ontario, or Quebec (Cummings 1987).

Cormorant-Human Interactions

Three major categories were identified for cormorant-human interactions in Florida, based on the telephone interviews: (1) impact of cormorants on fish at aquacultural operations, (2) impact of cormorants on domestic stock (disease vectoring) or protected species (interspecific competition for food), and (3) human harassment of cormorants. The following accounts suggest topics for further study.

Impact of cormorants on fish

Food fish.—Losses of food fish, primarily catfish, can be locally severe. Up to 50% mortality of fingerling catfish was sustained in open 0.125-ha ponds during 1991 at the University of Florida, and was attributed to Double-crested Cormorants (C. Cichra, pers. comm.). Losses of catfish in open ponds <1 ha in size were as high as 99% during 1986-87 at the Richloam Fish Hatchery (Rodgers 1988). Fifteen species of fish-eating birds were observed at the Richloam facility from November to June (Rodgers 1988), some of which are listed in Table 3.

Game fish.—Several hatcheries sustained high losses of fingerlings and stockers in recent years. Between 23% and 59% mortality due to causes such as bird consumption or cannibalism by other fish occurred in open 0.25-ha Striped Bass grow-out ponds in Richloam (Stout and Drda 1986). From 81.5% to 91.2% mortality was observed in 0.25-ha open ponds of hybrid Striped Bass fingerlings and was mainly attributed to accountable (seining, birds, bass) rather than background (oxygen depletion, pilfering) mortality (Stout and Drda 1987). At Port Manatee in 1991, more than 200,000 of 240,000 Red Drum fingerlings stocked in open 0.125-ha ponds were lost (>83% mortality), presumably to birds (C. Young, pers. comm.). This compares to 30% mortality in the previous year. Double-crested Cormorants and other birds were observed at the ponds (Table 3).

Sport fishermen recently voiced concern over cormorants as potential competitors for game fish in central Florida (B. Millsap, pers. comm.). However, no data are available from man-made lakes or conservation areas in Florida to document the food habits of Double-crested Cormorants to offer insight into the issue. The increased public awareness of Double-crested Cormorants in Florida could be associated with expansion of breeding colonies to inland counties or better understanding of the cormorant-aquaculture problem elsewhere in the United States and knowledge of cormorant population data.

Tropical fish.—Fish-eating birds were reported to be a problem to growers of tropical fish, ranking third in a survey of 35 potential problem areas (C. Watson, pers. comm.). Anecdotal reports suggest that other birds, frogs, turtles, and otters were the most serious fish predators (Table 3). The impact of vertebrate predation on the tropical fish industry is not known. Production data are not available in the tropical fish industry such that the effects of various management tech-

Table 3. Vertebrates implicated in damage to fish rearing facilities in Florida.

Common name	Scientific name	Industry type[1]		
		F	G	T
Pied-billed Grebe	*(Podilymbus podiceps)*	+		
Double-crested Cormorant	*(Phalacrocorax auritus)*	+	+	
Red-breasted Merganser	*(Mergus serrator)*	+	+	
Belted Kingfisher	*(Ceryle alcyon)*	+	+	+
Great Blue Heron	*(Ardea herodias)*	+	+	
Great Egret	*(Casmerodius albus)*	+	+	
Black-crowned Night Heron	*(Nycticorax nycticorax)*			+
Yellow-crowned Night Heron	*(N. violaceus)*	+		+
Green-backed Heron	*(Buteroides striatus)*		+	
terns	*(Sterna spp.)*			+
Bald Eagle	*(Haliaeetus leucocephalus)*	+		
Soft-shelled Turtle	*(Trionyx ferox)*			+
Snapping Turtle	*(Chelydra serpentina)*			+
Bullfrog	*(Rana catesbiana)*			+
River Otter	*(Lutra canadensis)*			+

[1]F = Food fish, G = Game fish, T = Tropical fish.

niques or causes of mortality cannot be determined.

Several features of tropical fish production generate potential for conflict with fish-eating birds. Proximity of ponds to fish-eating birds may be important: the industry is based east of Tampa Bay, less than 50 km distant from large breeding and wintering aggregations of waterbirds (C. Watson, pers. comm.). Small size of ponds and farms may be important factors owing to ease of access by fish-eating birds to a large proportion of a grower's stock: tropical fish are grown in outdoor ponds averaging 8 × 23 m on farms that average 5 ha. Stocking density may also be important, as stocking rates can reach 20,000 fish per pond making them potentially attractive sites for foraging.

High value of the crop is central to the issue of vertebrate damage in tropical fish facilities. Assuming a wholesale market value of $0.20US per fish, a single pond may hold a crop valued about $4,000US. If a fish weighs <5 g, and if a fish-eating bird eats 200 g fish/day (Schramm *et al.* 1987), then a single bird could eat $8.00US/day of tropical fish.

Fish diseases.—Several important parasitic diseases are transmitted through fish-eating birds and invertebrates to fish. Fish may serve as the definitive host or an intermediate host to a group of flatworms known as digenetic trematodes (Francis-Floyd 1991) and to nematodes of the genus *Eustrongylides* (Spalding and Forrester 1991). Trematodes impair gill function, which causes increased mortality due to poor respiration. Nematodes may not affect fish longevity, but they can make fish unmarketable owing to the unattractive worm masses that form in the fish. Unconfirmed estimates of losses up to $3.5 million (US$) occur in the tropical fish industry in Florida due to parasitism (R. Francis-Floyd, pers. comm.).

No estimates are available to quantify losses in the food or game-sport fish industries due to parasitism.

Impact of cormorants on other birds

Avian disease.—Cormorant-borne diseases that might be of concern to other avian species include an avian paramyxovirus (Newcastle's disease) and avian influenza, a disease that is considered to be foreign to United States bird populations. Either disease could infect migratory birds such as Double-crested Cormorants, and could be virulent to domestic stock or pet bird species if transmission via aerosol or contact with infected materials occurs (Harrison and Harrison 1986). Neither disease is known from Florida cormorants.

Interspecific competition for food.—Although no evidence is available to support the following hypothesis, several biologists suggested the idea as a possibility to consider with respect to declining breeding populations of waterbirds. Double-crested Cormorants and waterbirds may consume similar fish species and could thus compete for limited resources during critical periods of the year. For example, cormorants in Biscayne Bay, south of Miami, feed on demersal fish in the families Balistidae, Batrachoididae, Haemulidae, Scaridae, and Scorpaenidae, in amounts nearly proportional to those available (Cummings 1987). It would be valuable to compare feeding ecology of sympatric waterbirds during breeding and nonbreeding periods and to identify relative availability of prey species in order to assess whether interspecific food competition exists.

Human harassment of cormorants

Human activity (boats or jet skis) in Double-crested Cormorant breeding colonies could reduce breeding success by causing abandonment or renesting or may force cormorants to feed at aquaculture sites if normal feeding sites are degraded or the source of harassment. Data are lacking in Florida to assess the importance of this problem to cormorant population dynamics or selection of foraging sites.

Management Options

Interviews with biologists, extension agents, and fish growers revealed five categories of management options that could be available to aquaculturalists to address problems of fish-eating birds feeding in ponds: frightening devices, barriers, altering aquacultural practices, management of cormorant behavior, and cormorant population control. Many methods have been tried in Florida, however, data are lacking to evaluate the effectiveness of any of these methods at local aquacultural facilities.

Frightening devices—Visual and audio scare-devices (scarecrows, reflecting tape, sound cannons, pistol "screamers") were used by many growers, with limited success. Growers thought that birds responded briefly to frightening devices, but became used to them over time. The presence of dogs or people frightened birds only briefly.

Barriers—Wire-grid systems and netting were used at some facilities, again with limited success. Growers thought that wire-grid systems might work if only a few birds were present and if wires were put up prior to the onset of bird problems.

Netting may be appropriate for small ponds, if cost-effective. Concerns were expressed about the longevity of netting, maintenance requirements, and whether farm laborers could gain access to these ponds for frequent feeding, care, or special treatment. It should be noted that netting caught and killed birds at several facilities. Tropical fish growers might be especially suited to use exclusion as a method to reduce vertebrate damage (C. Watson, pers. comm.). It also is feasible to build and support a structure over small tropical fish ponds, whereas it may not be feasible to place support posts in larger ponds.

Aquacultural practices—The business of growing fish should include a planning component that recognizes fish-eating birds or other vertebrates as potential sources of crop loss. Segregation of fish by size class and protection of the vulnerable ponds may reduce losses in some areas. Stocking fish after the main migration from Florida or stocking with respect to an annual cycle of bird activity may reduce losses. The use of plastic liners may make it difficult for wading birds to maintain footing in ponds. Designing ponds with steep sides may reduce access to ponds by wading birds such as herons or egrets that prefer to feed in shallow water. Regular activity around ponds may reduce losses.

Cormorant behavior—Modification of cormorant roosting or feeding locations through dispersal or hazing was recommended as the most cost-effective method to reduce numbers of fish-eating birds at ponds (Rodgers 1988), compared to the cost of installing nets ($30,000US per acre).

Population control—Lethal control of fish-eating birds is limited to shooting cormorants under federal permit, except in the case of Herring Gulls (*Larus argentatus*), for

which Avitrol is registered in Florida. No depredation permits are in use in Florida. No information was available to identify whether Avitrol had been used at aquacultural facilities in Florida. Because of restrictions associated with the issuing of permits and the concern about hazards to nontarget species, Avitrol may not be ideal for use at fish hatcheries.

DISCUSSION

Essentially nothing is known about population ecology of Double-crested Cormorants in Florida, despite the fact that cormorants are one of the species of colonial waterbirds monitored by state biologists (Florida Game and Fresh Water Fish Commission 1988). The few population estimates available suggest currently stable resident and potentially increasing winter populations. Winter migrants originate in U.S. states and Canadian provinces surrounding and east of the Great Lakes, thus winter populations of Double-crested Cormorants in Florida may grow in relation to those in northeastern North America. Fragmentation of large coastal breeding colonies may be occurring in Florida, resulting in dispersal of birds to new inland breeding sites. Consequently, the general public may become increasingly aware of Double-crested Cormorants at inland fish-rearing facilities and recreational waters.

Four recommendations for research and management emerged from this case study of Double-crested Cormorants in Florida:

(1) Population database for Double-crested Cormorants and fish-eating birds.—To better understand and monitor population changes of Double-crested Cormorants and fish-eating birds in Florida, regular estimates of the sizes of breeding and wintering populations are needed. Such a study could focus on geographic regions where economic impacts are likely to be high, for example in the tropical fish-growing areas of Hillsborough and Polk counties. Increased banding of cormorants in wintering populations may contribute to our understanding of their migration patterns in North America and the Caribbean.

(2) Bird damage survey of aquacultural producers.—Since existing information indicated that Double-crested Cormorants were not the major fish-eating species at aquacultural facilities, a questionnaire could be constructed and mailed to producers and extension agents to establish baseline data. These data could then be used to identify the nature of the problem and research needs.

(3) Monitoring program at fisheries/hatcheries.—A scientific program to monitor the sources of fish mortality is needed to identify the role of fish-eating birds in harvest loss. Ideally, multi-year monitoring should be undertaken to develop a long-term perspective on the relative impacts of fish-eating birds at each kind of facility. Cormorants and other birds could be marked with color or USFWS bands to identify movement patterns of individuals at aquacultural facilities.

(4) Methods evaluation, development and training.—A cost-benefit evaluation of current methods in bird control is needed to identify the most successful techniques to reduce bird damage to aquacultural crops. Continued development of methods would improve the number of techniques available to producers. A comprehensive training project is reasonable, given the number of producers (<500) in Florida in 1991. Perhaps an instructional pamphlet entitled "Managing Bird Damage to Aquaculture in Florida" should be prepared and distributed to all producers to mitigate the bird-aquaculture problem.

Presently, Double-crested Cormorants are not an obvious pest to aquaculture in Florida. Damage to some fish-rearing facilities may occur in selected areas, such as the tropical fish industry near Tampa Bay. However, only limited information is available from Florida about population ecology of Double-crested Cormorants and the nature of cormorant-human interactions. If in future years Double-crested Cormorants are perceived as a species of interest by scientists or the general public, then considerable more research is needed to improve our understanding of the autecology of these birds and methods to alleviate problems associat-

ed with Double-crested Cormorants and fisheries in Florida.

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