CHAPTER 4: ENVIRONMENTAL CONSEQUENCES

4.1 Introduction

The "environmental consequences" section of an EIS "forms the scientific and analytic basis for the comparison [of alternatives]" (40 CFR 1502.16). This chapter provides information needed for making informed decisions in selecting the appropriate alternative for meeting the purposes of the proposed action as stated in section 1.2, Purpose of Action. The chapter analyzes the environmental consequences of each of the five alternatives in relation to issues identified in Chapter 3, AFFECTED ENVIRONMENT, and in comparison to the No Action alternative to determine if impacts would be greater, lesser, or the same. Thus, the No Action alternative is the baseline for the analysis. Details of the alternatives are laid out in Chapter 2, ALTERNATIVES.

NEPA requires disclosures of direct, indirect, and cumulative effects as well as mitigation measures. If a management activity greatly changes the amount or quality of an environmental factor (i.e., those issues identified in Chapter 3), the effect qualifies as significant. Significant effects of some management activities may be unavoidable, have different short and long-term consequences or involve irreversible changes. Some effects may be mitigated to a level of insignificance. Significant effects may be positive or negative.

Management Activities

1. Shooting
2. Oiling or destruction of eggs
3. Nest destruction
4. Harassment (may include pyrotechnics, scarecrow devices, propane exploders, live ammunition, vehicle horns, etc.)

Environmental Factors

5. DCCO populations
6. Fish
7. Other birds
8. Vegetation
9. Threatened and Endangered species
10. Water quality and human health
11. Economic conditions (aquaculture and recreational fishing economies)
12. Hatcheries and Environmental Justice
13. Property losses
14. Existence and aesthetic values

4.2 Alternative A: No Action

4.2.1 Impacts to Double-crested Cormorants

Current management practices have not significantly impacted either regional or continental DCCO populations. The Breeding Bird Survey trend (mean percent change per year) for DCCOs in the U.S. and Canada from 1990-2000 was a statistically significant 9.91 percent (Sauer et al. 2001). Tyson et al. (1999), using a different survey technique, estimated that the overall mean percent annual change for the continental population of DCCOs from 1990-1994 was 2.6 percent although regional DCCO trends varied, from an estimated 22.0 percent mean annual increase in the Great Lakes, where numbers of nesting pairs doubled from 1991-1997, to a 2.6 percent mean increase in the Southeast population, a 6.5 percent mean decrease in the Atlantic population, and a 7.9 percent mean decrease in the West Coast-Alaska population (Tyson et al. 1999). (The two populations with negative mean percent annual changes, Atlantic and West Coast-Alaska, experience limited mortality from permitted take and no take under the Depredation Order.)

Despite the take of greater than 200,000 DCCOs in the U.S. since 1987, neither numbers of wintering birds nor of breeding birds appear to have been adversely impacted. Belant et al. (2000) documented lethal control at aquaculture facilities in the southeastern U.S. (including Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee) to evaluate the effects of these control activities on winter DCCO populations. Based on depredation permit data for 1987-1995, they estimated that 35,332 DCCOs were taken under 847 permits, which represented less than 0.5 percent of the estimated continental population of DCCOs. The authors concluded that lethal control at aquaculture facilities did not adversely impact regional winter or continental breeding populations. Additionally, Glahn et al. (2000a) concluded that the reported take of 9,557 DCCOs under the Depredation Order by Mississippi aquaculture producers had no apparent impact on DCCOs wintering in the Delta region.

Average annual estimated take under the Depredation Order and depredation permits in recent years (1998-2000) is 47,128 DCCOs. With the total estimate, including breeding and non-breeding birds, of the continental DCCO population being 2 million (based on Tyson et al.'s [1999] estimate of 372,410 total breeding pairs and personal communication with D.V. Weseloh [Canadian Wildlife Service], Linda Wires [University of Minnesota], and John Trapp [USFWS]), this represents a take of approximately 2.4 percent of the continental population.

Table 12. Annual Estimated Take Under No Action Alternative

Year	Number of permits	Reported take under permits	Estimated take under Depr. Order (MN)	Estimated take under Depr. Order (southern)	Total take (does not include eggs)	Percentage of estimated continental population
1998	~270	12,484	2100	29,634	44,218	2.2%
1999	~270	12,385	1600	38,098	52,083	2.6%
2000	276	10,493	2200	33,990	46,683	2.3%

Table 13. Permits Issued by Region

USFWS Region	Number of Permits (percent of total) - 1999
1 (CA, ID, NV, OR, WA)	20 (7.2%)
2 (AZ, NM, OK, TX)	3 (1.1%)
3 (IA, IL, IN, MI, MN, MO, OH, WI)	24 (8.7%)
4 (AL, AR, FL, GA, KY, LA, MS, NC, SC, TN)	199 (72.1%)
5 (CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VA, VT, WV)	15 (5.4%)
6 (CO, KS, MT, ND, NE, SD, UT, WY)	15 (5.4%)

The New York State Department of Environmental Conservation oiled 19,862 eggs on islands in eastern Lake Ontario in 1999 and 15,118 eggs there in 2000. The Vermont Department of Fish and Wildlife oiled 9,569 eggs on islands in Lake Champlain in 1999 and 4595 eggs there in 2000. Johnson et al.

(2000a) found egg oiling to be “an effective technique to reduce the reproductive success of [DCCOs]” on Little Galloo Island in Lake Ontario and estimated that, due to egg oiling efforts, 8,300 fewer chicks were produced there in 1999. Farquhar et al. (2001) concluded that 1999-2000 egg oiling efforts on Little Galloo Island resulted in an estimated 98 percent reduction in DCCO reproductive success. Egg oiling activities under the No Action alternative are currently limited to Lake Champlain, Vermont, and Eastern Lake Ontario, New York, and these localized efforts are not considered to be a threat to the health of regional or continental DCCO populations.

4.2.2 Impacts to Fish

Among natural resource agencies, a survey conducted by Wires et al. (2001) indicated that DCCO predation was perceived to be of major importance to sport and/or commercial fish in three States (Arkansas, Tennessee, and Texas), and of moderate importance in eight States (Alabama, Connecticut, Louisiana, Maine, Massachusetts, New York, Rhode Island, and Virginia). The APHIS/WS MIS database reveals that, from 1995-1997, of the 29 States reporting losses to natural resources, 27 reported losses to wild fish species. During scoping, letters received from the following States indicated some concern about possible impacts to sport fisheries: Arkansas, Georgia, Illinois, Kansas, Kentucky, Louisiana, Maine, Michigan, Nebraska, New York, North Dakota, Ohio, Oklahoma, Oregon, Texas, Vermont, Wisconsin, and Wyoming.

The role of predation on the dynamics of prey populations, even within scientific circles, is a controversial question (Banks 2000, Krebs 1995). The information necessary for determining impact, or lack of impact, in even the simplest cormorant-fishery systems is complex and difficult to acquire (Wires et al. In Press). Furthermore, because of the many ecological variables that potentially influence different fisheries, it is difficult to apply conclusions about DCCO predation from one location to another. Davies et al. (2001) noted that the findings of a study on a fishery in England to determine the relationship between Great Cormorant and fish populations were uncertain because of: 1) the complex nature of these systems, 2) difficulties in relating cormorant predation to changes in fishery performance, and 3) separating the effects of piscivorous birds from other factors affecting fish populations.

The degree of the effects of DCCO predation on fish in a given body of water is dependent on a number of variables, including the number of birds present, the time of year at which predation is occurring, prey species composition, and physical characteristics such as depth or proximity to shore (which affect prey accessibility). Environmental and human-induced factors affect aquatic ecosystems as well. These can be classified as biological/biotic (overexploitation, exotic species, etc.), chemical (water quality, nutrient and contaminant loading, etc.) or physical/abiotic (dredging, dam construction, hydropower operation, siltation, etc.). Such activities may lead to changes in species density, diversity, and/or composition due to direct effects on year class strength, recruitment, spawning success, spawning or nursery habitat, and/or competition (USFWS 1995). In the Wires et al. (2001) survey of natural resource agencies, the following factors, aside from predation, were considered to be potential contributors to reported fish declines: overfishing and habitat degradation, exotics (e.g., white perch invasion and zebra mussel infestation), global and local environmental change, recruitment failures, lack of zooplankton, weather, temperature, and the natural cycle.

Based on a review of the DCCO diet literature, Trapp et al. (1999) concluded that, relative to other biotic and abiotic factors, DCCOs have only a minor impact on sport fisheries, with localized exceptions noted. In Europe, impact studies showing negative effects of Great Cormorant predation in natural water bodies appear to be rare also (van Eerden et al. 1995). The effect of avian predation on European fish stocks was reviewed by Suter (1991 in van Eerden et al. 1995) who found no evidence for significant impacts in natural ecosystems. Although, on the whole, increasing DCCO populations do not appear to be causing *widespread* negative impacts to fish populations, it would be simplistic to conclude from this that DCCO predation never negatively impacts fisheries. Such impacts are typically site-specific and thus the nature of DCCO-fish conflicts tends to be highly localized. In Europe, direct effects associated with Great Cormorant predation have been reported in fish ponds or in rivers or small, artificially-stocked lakes where high densities of fish are raised (van Eerden et al. 1995). Russell et al. (In Press) found that the proportion of trout in the diet of Great Cormorants on river trout fisheries, one in northwestern England and another in southeastern England, varied considerably. In the former, trout represented 85 percent of the diet by weight; in the other, trout represented only one percent of the diet by weight. They concluded that there is a "need to assess potential impact on a case by case basis."

In the U.S., Derby and Lovvorn (1997) found that the percentage of sport and commercial fish in the diets of DCCOs in a Wyoming river varied widely, from 0.6 percent to 93 percent, and appeared to depend on local food availability. Although they were unable to determine whether cormorant predation rates were compensatory or additive, they concluded that "piscivorous birds can substantially affect fish stocks, depending on bird densities and availability of alternative prey." Additionally, research efforts in New York's Oneida Lake and eastern Lake Ontario have examined both DCCO diet and fish population data and found evidence that cormorant predation is likely a significant source of fish mortality (Adams 1999, Rudstam 2000, Lantry et al. 1999).

The following statements about DCCO feeding habits and fisheries impacts can be concluded with confidence from the available science:

15. DCCOs are a generalist predator whose diet varies considerably between seasons and locations.
16. The present composition of cormorant diet appears to have been strongly influenced by human-induced changes in the natural balance of fish stocks.
17. "Impact" can occur at different scales, such that ecological effects on fish populations are not necessarily the same as effects on recreational or commercial catches, or vice versa.
18. Cormorant impact is generally most significant in artificial, highly-managed situations.
19. While most studies show that cormorant diet does not typically consist of high percentages of sport fish, conclusions about fisheries impacts cannot be based on diet studies alone.
20. Because ecological conditions vary locally, conflicts with cormorants will vary locally.

In keeping with recommendations to examine DCCO-fish interactions on a site-specific basis, we do so here for four specific areas (and one region) where both fish and DCCO data is sufficient to analyze potential interactions: Oneida Lake, New York; eastern Lake Ontario, New York; Les Cheneaux Islands, Lake Huron, Michigan; Lake of the Woods, Minnesota; and southeastern lakes, ponds, and reservoirs. In this section, we present conclusions; further details on these specific areas can be found in Appendix 5.

Oneida Lake. DCCOs are an important fish predator in Oneida Lake with the potential to alter the lake's fish populations (L. Rudstam, Cornell Univ., pers. comm.). Cormorants consume older yellow perch and walleye targeted by anglers, intermediate size or pre-recruitment perch and walleye, and smaller age-0 to age-1 perch and walleye–important prey items for walleye. Cornell University biologists Rudstam and Adams (cited in Wires et al. 2001) based their conclusion of effect on perch and walleye on the following: 1) the timing of the disappearing adults coincides with the increase in DCCOs; 2) the size of the fish eaten by DCCOs coincides with the size of the fish that have increased mortality; and 3) at least for walleye, the number of fish missing is comparable to the number estimated to be consumed by DCCOs.

Eastern Lake Ontario. The predatory effect of DCCOs was addressed in a report by the special Task Group of the Lake Ontario Committee in the early 1990s. Bioenergetic simulations estimated that DCCOs consumed 1,650 metric tons of pelagic prey fish annually (as compared to a demand of 64,500 metric tons of prey from all salmonid predators), while the available biomass of rainbow smelt, alewife, and other prey fish in Lake Ontario was estimated at 418,000 metric tons. Thus, DCCOs accounted for 2-3 percent of the total annual predation of pelagic prey fish and did not appear to be a major contributor to lakewide predation effects at that time (USFWS 1995). However, DCCO populations have increased considerably since the early 1990s and, furthermore, the effects of DCCO predation in a large lake such as Lake Ontario are more likely to be localized than lakewide, warranting examination of potential site-specific population impacts. In 1999, the New York State Department of Environmental Conservation's Bureau of Fisheries and the USGS Biological Resources Division prepared an extensive report assessing the impact of DCCO predation on smallmouth bass and other fishes of the eastern basin of Lake Ontario. They found that, based on gill net sampling, dramatic declines in smallmouth bass abundance have occurred there since the early 1990s. The main results reported by Lantry et al. (1999) in this report were: 1) the mortality of age-3 to 5 smallmouth bass increased substantially after 1988; 2) loss rates of this magnitude could severely limit numbers of adult smallmouth bass recruited to the fishery; and 3) DCCO predation on 3-5 year old bass was significant enough to cause the observed declines in the smallmouth bass population.

Les Cheneaux Islands, Lake Huron. Fisheries investigations carried out concurrently with DCCO diet investigations in the Les Cheneaux Islands area found that DCCOs removed only 2.3 percent of the available yellow perch biomass and accounted for less than 20 percent of the total annual mortality of perch. Overall, cormorants accounted for 0.8 percent of the mortality of legal-sized perch (178 mm), whereas summer sport fishing accounted for 2.5 percent. The conclusion was that DCCOs had minimal impact on the local perch population (Belyea et al. 1999).

Lake of the Woods. For the last decade, there has been no clear upward or downward trend in year class strength for either walleye or sauger. Preliminary evidence from Minnesota Department of Natural Resources fisheries reports does not indicate that DCCOs are impacting game fish populations, as various population indices have indicated strong populations of walleye, sauger, perch, and northern pike in the lake. However, specific modeling that factors all types of juvenile fish predation, including DCCOs, has not yet been done in this lake (K. Haws, MDNR, pers. comm.).

Southeastern lakes, ponds, and reservoirs. Two of the studies examined (Glahn et al. 1998, Campo et al. 1993) did not find evidence of significant impact to fisheries caused by DCCO predation. A third study (Simmonds et al. 2000), using modeling, found that at particularly high levels of predation, fisheries could be negatively impacted. It is difficult to make broad conclusions about the impacts of DCCOs on fisheries at ponds, lakes, and reservoirs across such a broad geographical area. Generally, the lower availability of prey refugia often found in smaller waterbodies, especially artificial ones, will make prey more susceptible to predation. But, as noted earlier, the actual effect of DCCO predation depends on a number of variables and should be examined locally where necessary.

Impacts of current management activities, if they effectively reduce DCCO predation on fish populations, should be positive, although this can vary from site to site depending on the movement of DCCOs and how significant a limiting factor predation is on the specific fishery. Using information on average DCCO consumption, it is possible to estimate the amount of fish that were not consumed due to control efforts, but without associated DCCO foraging data and fisheries data, it is difficult to accurately predict the long-term impacts to specific fish populations. Johnson et al. (2000a) determined that DCCOs from the Little Galloo Island (Lake Ontario, New York) colony consumed approximately 13.25 million fewer fish in 1999, the first year of extensive egg oiling activities, than in 1998. They estimated that 8,300 fewer DCCO chicks were produced on the island in 1999, which reduced fish consumption by 348,000 kg (766,000 lbs).Two species, alewife and smallmouth bass, were believed to have benefitted the most since their contribution in the diet was known to be substantially greater during the chick-feeding period than during the pre-chick feeding period. Additionally, they found that fish consumption in 1999 was only 45 percent by number and 58 percent by weight of the mean of the previous seven years for Little Galloo Island DCCOs.

4.2.3 Impacts to Other Birds

The significance of impacts to other birds varies with scale. While large-scale impacts on regional or continental populations of other birds have not been documented, DCCOs may have negative impacts on other bird species at a local, site-specific level. For example, during scoping, the Ohio Department of Natural Resources stated that increases in DCCO numbers “have caused extensive damage to terrestrial island habitats in Lake Erie that are important to several species of rare Ohio birds” and noted that the “habitat alteration/competition problem [from DCCOs] is quite discouraging given the lack of alternative nesting sites for colonial waterbirds.” Additionally, the Vermont Department of Fish and Wildlife expressed concern that habitat on Young Island in Lake Champlain, which was “once a mix of trees and herbaceous vegetation that supported breeding populations of black-crowned night-heron, cattle egret, snowy egret, black duck, mallard, goldeneye, and common merganser,” had been completely destroyed by cormorants (and gulls) so that the other species had left.

The New York State Department of Environmental Conservation also commented, during public scoping, that they are concerned about “the impacts that cormorants have on other colonial-nesting species [such as Common Terns, a State-listed threatened species].” Blokpoel and Weseloh (unpubl. data) further stated that Great Egrets “may suffer from nest site competition, or takeover, from cormorants, especially on East Sister Island (Lake Erie) and Chantry and Nottawasaga Islands (Lake Huron).” Additionally, one independent researcher concluded that “The disastrous effects of the cormorant colony on Home Pond [Gardiner’s Island, New York] are unequivocal. Cormorants and their profuse guano...have denied the ‘right to life’ of a heron/egret/ibis colony of several species; eight-plus pairs of nesting ospreys; nesting black ducks and gadwall...” (P. Spitzer, unpubl. data).

4.2.3a Impacts Associated with Cormorants

As befits this highly social and gregarious species, DCCOs almost always nest in close association with a variety of other species of colonially-nesting birds, both ground- and tree-nesters. In the United States Great Lakes, for example, 97 percent of all active DCCO colonies (between 1976 and 1999) were associated with other species of colonially-nesting waterbirds (Scharf and Shugart 1998, USFWS unpubl. data).

Is there evidence to suggest that increases in recent years in the number of nesting DCCOs at multiple-species breeding colonies have had a direct effect on the numbers of other colonially-nesting waterbirds? To answer this question, we examined data from the U.S. Great Lakes for three time periods: 1976-1977, 1989-1991 (Scharf and Shugart 1998), and 1997-1999 (USFWS unpubl. data). Because many factors other than DCCO abundance can and do affect colonial waterbird numbers and distribution, this information should be viewed as correlational and not necessarily evidence of cause-effect relationships until further scientific evidence indicates such.

Herons and Egrets. The Great Blue Heron is a frequent nest associate of the DCCO. Because of similar nest-site requirements (e.g., tops of mature trees), competition between these two species might be predicted to occur relatively frequently. Over the approximately 25 years that comprehensive surveys of the U.S. Great Lakes have been conducted, Great Blue Herons are known to have nested at 26 colony-sites. The number of colony-sites known to have been occupied increased from 13 (1976-1977), to 18 (1989-1991), to 19 (1997-1999). Over the same time periods, the mean number of nesting pairs per occupied colony-site increased slightly: 27, 30, and 34. One might conclude from this analysis that DCCOs have had minimal, if any, impacts on Great Blue Herons at the scale of the U.S. Great Lakes.

An examination of site-specific observations between DCCOs and Great Blue Herons is also warranted. There were 29 site-specific instances in which cormorants nesting in association with Great Blue Herons increased between adjacent time periods. Trends of Great Blue Herons with respect to cormorant increases was about equally mixed: in 16 instances Great Blue Herons also increased (mean of 16 pairs), while in 13 instances they declined (mean of eight pairs). The mean net changes per colony-site in these 29 instances were gains of 261 pairs of cormorants and two pairs of Great Blue Herons. Nesting populations of Great Blue Herons were not correlated with nesting populations of DCCOs, nor were changes in populations between adjacent time periods correlated with increasing populations of cormorants.

The Black-crowned Night-heron has frequently been mentioned as a species that might be negatively affected by DCCOs in the Great Lakes (Jarvie et al. 1999, Shieldcastle and Martin 1999). Night-herons are known to have nested at 26 colony-sites in the Great Lakes. The number of colony-sites known to have been occupied increased from 12 (1976-1977), to 15 (1989-1991), to 23 (1997-1999). Over the same time periods, the mean number of nesting pairs per occupied colony-site declined steadily: 24, 18, and 13. One might conclude from this analysis that DCCOs have had minimal, if any, impacts on Black-crowned Night-herons at the scale of the U.S. Great Lakes.

An examination of site-specific observations between DCCOs and night-herons is also warranted. There were 29 site-specific instances in which cormorants nesting in association with night-herons were documented to increase between adjacent time periods. In 12 of those instances, night-herons also increased (mean of seven pairs), and in 17 instances they declined (mean of 11 pairs). The mean net changes per colony-site in these 31 instances was a gain of 677 pairs of DCCOs and a loss of four pairs of night-herons. Nesting populations of Black-crowned Night-herons were not correlated with nesting populations of cormorants, nor were population changes between adjacent time periods correlated with increasing populations of cormorants.

A NYSDEC biologist provided the following example of evidence of direct displacement of Black-crowned Night-herons by DCCOs. Gull Island is a one acre site situated on the edge of Henderson Bay, within the greater eastern basin of Lake Ontario. Black-crowned Night-herons have been sporadically documented as a nesting species on this island. A more “permanent” presence began to develop in the late 1980s, presumably from birds displaced from Little Galloo Island, where DCCO numbers were increasing. By 1993, 30 pairs of Black-crowned Night-herons were breeding on the island. In 1993, DCCOs also established an arboreal colony of about 150 nests there. Larger trees were removed from the island late in 1993 to deter DCCO from maintaining the newly established colony in future years. Since 1994, the NYSDEC has annually removed DCCO nests from the island in order to maintain shrubby vegetation for use by night-herons. Count data for Black-crowned Night-herons from 1995-1999 have revealed a stable number of nests ranging from 41-46 each year. In 2000, DCCO re-established a breeding colony on the island beginning in late April. Attempts to displace the cormorants did not begin, however until 15 May, at which time 478 nests were occupied (and removed). One hundred and ten (110) of the nests were arboreal, either in box elder or directly above night-heron nests in the tops of dogwood shrubs. Night-heron nest numbers dropped by about half under these conditions, and remained at this level through the breeding season in spite of cormorant removal. Based on field observations and professional judgment, it was hypothesized that direct guano deposition by DCCOs resulted in the observed abandonment by night-herons. Although Gull Island was apparently partially abandoned by Black-crowned Night-herons due to the direct effects of DCCOs, suitable nest sites were utilized on nearby Bass Island, where numbers increased from 6-12 annual nests over the past three years (1997-99) to 35 in 2000. On Bass Island, DCCO usage was not in proximity to night-heron nesting sites (J. Farquhar, NYSDEC, unpubl. data).

Additionally, recent research on potential impacts of DCCOs on Black-crowned Night-herons in the Canadian Great Lakes found that 28 percent of night-heron sites visited in 2000 had been abandoned "in light of increasing cormorant numbers or were in imminent danger of being overrun by cormorants" (Weseloh and Havelka, Canadian Wildlife Service, unpubl. data). They concluded that night-herons may be leaving historical nesting areas and establishing new colonies because of DCCOs. Specifically, Black-crowned Night-herons appear to have abandoned colonies in Lake Ontario on Scotch Bonnet, Pigeon, and Snake Islands and at Hamilton Harbor after DCCOs became established at these sites (Blokpoel and Weseloh, Canadian Wildlife Service, unpubl. data).

Conflicts between DCCOs and Great Egrets are possible but depredation permits for dealing with such conflicts have not currently been issued. Localized concern about displacement of Snowy Egrets by DCCOs has led to the issuance of depredation permits for enhancing avian diversity in New York and Vermont.

Gulls and Terns. The impact of DCCOs on ground-nesting terns and gulls appear to be minimal, at least in the Great Lakes (USFWS 1999a). Herring Gulls are the most ubiquitous of the colonial waterbirds nesting in the U.S. Great Lakes, where they are known to have nested at 74 colony-sites. The number of colony-sites known to have been occupied increased from 56 (1976-1977), to 63 (1989-1991), to 70 (1997-1999), while the mean number of nesting pairs per occupied colony-site varied over these same time periods: 148, 247, and 114. There were 88 site-specific instances in which DCCOs nesting in association with Herring Gulls increased between adjacent time periods. Changes in Herring Gulls numbers in relation to cormorant increases were about equally mixed: in 42 instances they increased (mean of 172 pairs) and in 46 instances they declined (mean of 54 pairs). The mean net changes per colony-site in these 88 instances was a gain of 253 pairs of cormorants and a loss of 4 pairs of Herring Gulls.

Ring-billed Gulls are known to have nested at 30 colony-sites in the U.S. Great Lakes. The number of colony-sites known to have been occupied increased from 15 (1976-1977), to 20 (1989-1991), to 22 (1997-1999), and the mean number of nesting pairs per occupied colony-site increased over these same time periods: 374, 1328, and 1786. There were 35 site-specific instances in which DCCOs nesting in association with Ring-billed Gulls increased between adjacent time periods. In 18 of those instances, Ring-billed Gulls also increased (mean of 343 pairs), and in 16 instances they declined (mean of 598 pairs). The mean net changes per colony-site in these 35 instances were gains of 338 pairs of cormorants and 18 pairs of Ring-billed Gulls. Nesting populations of Ring-billed Gulls were positively correlated with nesting populations of cormorants, but population changes between adjacent time periods were not correlated with increasing DCCO populations.

Caspian Terns are known to have nested at nine colony-sites in the U.S. Great Lakes. The number of colony-sites known to have been occupied increased from 3 (1976-1977), to 5 (1989-1991), to 7 (1997-1999), and the mean number of nesting pairs per occupied colony-site remained fairly stable over these same time periods: 537, 437, and 566. There were 11 site-specific instances in which DCCOs nesting in association with Caspian Terns increased between adjacent time periods. In eight of those instances, Caspian Terns also increased (mean of 198 pairs), and in three instances they declined (mean of 249 pairs). The mean net changes per colony-site in these 11 instances were gains of 1440 pairs of DCCOs and 27 pairs of Caspian Terns. Nesting populations of Caspian Terns were positively correlated with nesting populations of DCCOs, and population changes between adjacent time periods were likewise positively correlated with population increases of DCCOs.

Numbers of Caspian Terns on Little Galloo Island, eastern Lake Ontario, New York, were higher in 2001 than in previous years, after three years of intensive DCCO egg oiling activities. Great Black-backed Gull numbers on Little Galloo Island had increased in 2001 compared to previous years. Ring-billed Gull and Herring Gull numbers had declined somewhat but this was not believed to be associated with recent egg oiling efforts on the island since the egg oiling activity was removed from most of the gull nesting areas and since declines in these two species had apparently started before the egg oiling program began in 1999 (J. Farquhar, NYSDEC, pers. comm.).

The Common Tern is considered to be endangered, threatened, or a species of special concern in six Great Lakes States and Ontario, as well as being a USFWS species of management concern in the U.S. Great Lakes. Competition with Ring-billed Gulls is considered a major factor in their decline in the Great Lakes (Scharf et al. 1992) although displacement by DCCOs may also occur (USFWS 1999a).

Cormorants and Anhingas. Populations of Pelagic and Brandt's Cormorants, species which nest in association with DCCOs on the Pacific coast have fluctuated in response to El Niño conditions but, overall, their numbers have remained stable or increased (Carter et al. 1995a). Great Cormorant populations in North America appear to have increased dramatically and expanded their range southward in recent decades (Kaufman 1996). Populations of Neotropic Cormorants appear to be increasing and spreading geographically (C. Hunter, FWS, pers. comm.). Populations of Anhingas appear to be stable except for a decline in Texas numbers (BBS trend for 1990-98 was a statistically significant mean annual decline of 17.98 percent).

Food Competition. A review of the vast literature on DCCO food habits and foraging behavior revealed little information about potential food competition with other birds. DCCOs are opportunistic in their foraging habits, feeding on a large variety of fish species. In any given situation, individual DCCOs can be expected to prey on those species that are most abundant and most easily captured (Trapp et al. 1999, Wires et al. 2001).

The DCCO is one of at least 73 bird species found in freshwater or saltwater habitats of the United States whose diet consists primarily of fish. Food competition between these species is reduced by differences in foraging techniques that are used and the substrates in which prey are hunted. By defining specific foraging techniques and substrates, DeGraaf et al. (1985) categorized these 73 species into no fewer than 17 different foraging guilds or categories. DCCOs and six other species were placed in the "water diver" guild (species that dive from the surface to pursue underwater prey, and that forage in brackish, freshwater, and saltwater habitats). The most likely food competitors of the DCCO are loons, grebes, pelicans, other species of cormorants, and mergansers, although there is no evidence supporting the idea that competition for food has negatively impacted these species.

The DCCO's range overlaps broadly with those of the Pelagic Cormorant and Brandt's Cormorant along the Pacific Coast. Ainley et al. (1981) compared and contrasted the diets and feeding habitats of these three species. They found that DCCOs fed primarily on schooling fish (66-67 percent compared to 22-60 percent for Pelagic and Brandt's) that occurred at relatively shallow depths (22-33 percent ranged from the water surface to mid-depths compared to 11-14 percent in that range for Pelagic and Brandt's) over flat bottoms (63-67 percent compared to 20-38 percent for Pelagic and Brandt's).

Ecological differences and limited geographic overlap between DCCOs and Neotropic Cormorants helps restrict foraging competition between the two species (Johnsgard 1993). Limited foraging competition may exist between Anhingas and DCCOs in areas where they both occur, such as in Florida, but this is poorly documented. Owre (1967 in Johnsgard 1993) suggested that different fish-catching strategies of the two species in southern Florida may reduce competition for food, even though both fed on slow-swimming centrarchids.

Kirsch (1995) concluded that DCCOs were not competing for food with herons and egrets along the Upper Mississippi River, where forage fish (especially gizzard shad) were not limited. Cormorants forage differently and in different habitats than herons and egrets, further reducing the potential for competition.

In July 1985, densities of fish species preyed on by DCCOs were determined in four bays on Prince Edward Island that were located at varying distances from two large cormorant colonies (Birt et al. 1987). All bays were similar except for the presence or absence of foraging DCCOs. Fish densities were significantly (83 percent) lower in two bays used by cormorants for feeding than in two bays outside their foraging range (i.e., 3.6 versus 21.0 fish/transect). These findings provide evidence of prey depletion, and suggest the possibility of prey competition between DCCOs and other fish-eating diving birds. However, Engström (1997) found no evidence of prey depletion within 10 km of a Great Cormorant breeding colony in Sweden. Most fish-eating birds are adept at exploiting patchily distributed prey, and would probably quickly respond to areas of temporary prey depletion by seeking out concentrations of prey elsewhere.

Disease Transmission. The disease most often associated with DCCOs is Newcastle disease, which is chiefly a disease of the central nervous system and is caused by infection with a type of avian paramyxovirus. Newcastle disease was first identified as a source of mortality in DCCOs in Quebec in 1975 (Kuiken et al. 1998). Some of the largest epizootics of Newcastle disease have occurred in western Canada in 1990, where at least 5,000 DCCOs died, and in 1992 in western Canada, the Great Lakes area, and the north central U.S., where some 20,000 DCCOs died. In all cases, most, if not all, of the dead birds were juveniles (Kuiken 1999, Kuiken et al. 1998, Glaser et al. 1999). A 1995 epidemic in Saskatchewan, Canada, led to a 32-64 percent mortality rate among juvenile DCCOs (Kuiken et al. 1998). In 1997, Newcastle disease was diagnosed in juvenile DCCOs from breeding colonies at Salton Sea (CA), the Columbia River estuary (OR), and Great Salt Lake (UT) by the National Wildlife Health Center. Mortality of juveniles varied from “not abnormal” to greater than 90 percent (Kuiken 1999).

In a survey conducted by Wires et al. (2001), two out of 49 respondents reported documented cases of disease transmission involving DCCOs. This involved the outbreak of Newcastle disease in Michigan in 1992 (mentioned above). While Newcastle disease is considered a serious threat to poultry, there has been only one reported incident in ten years directly linking DCCOs to an outbreak of the disease in domestic poultry (Mixson and Pearson 1992, Kuiken 1999). Evidence suggests that Newcastle disease is not an important cause of mortality in other wild bird species that nest in close association with DCCOs (Kuiken et al. 1998, Kuiken 1999).

4.2.3b Impacts Associated with Management Actions
Carney and Sydeman (1999) noted that nesting colonial waterbirds, when disturbed by humans, often flush from their nests, during which time nest contents can be spilled, exposed to predation, or harmed by

exposure to the elements. Nest abandonment may also occur. These authors emphasized “the varied responses of individual species and populations to...disturbance,” while also noting that in many cases “significant impacts on reproductive performance of colonial waterbirds” has occurred. However, there is no evidence indicating that current management practices are a threat to the population viability of other species of colonial waterbirds.

Benefits to Other Species. Depredation permits have been issued to the States of New York and Vermont for the purpose of enhancing avian diversity, including Black-crowned Night-herons. The USFWS Environmental Assessment for the take of cormorants on Lake Ontario Islands, New York predicted that night-herons would benefit from reduced DCCO recruitment caused by egg oiling (USFWS 1999a), but it is too early to evaluate this prediction. Habitat manipulation and DCCO nest removal efforts on Gull Island in eastern Lake Ontario are presumed to have contributed to the stable night-heron population on that site (NYSDEC 2000).

Gull species that nest in association with DCCOs may benefit from the presence of cormorants due to the increased availability of food on the islands, including fish remains and chick regurgitates. Gulls also routinely prey on cormorant eggs and young nestlings when nests are left unattended (J. Trapp, FWS, pers. comm.).

It is believed that the Common Tern could benefit from reduced DCCO recruitment where suitable island nesting sites are limited. Thus, from 1995-1999, the Service issued a permit to Vermont to destroy DCCO nests and eggs on five islands in Lake Champlain, in order to reduce competition with Common Terns. Additionally, permits have been issued since 1999 to Vermont and New York to oil DCCO eggs and destroy nests to benefit Common Terns.

Take of Look-alike Species. Under the Depredation Order, it is likely that some incidental take of Neotropic Cormorants and Anhingas occurs in southern States (where their range overlaps with that of DCCOs), but this is not considered to be a threat to either species. In particular, it can be difficult to distinguish juvenile DCCOs from Neotropic Cormorants, while Anhingas are much more distinguishable because of their bill structure. One National Fish Hatchery manager in Texas estimated that approximately 10 percent of their take is made up of “either juvenile DCCOs or Neotropic Cormorants” (in 2000 this amounted to ~30 birds). The declining trend for Anhingas in Texas started well before the Depredation Order came into effect and is not believed to be related to by-kill. Take of other cormorant species under depredation permits is believed to be insignificant.

4.2.4 Impacts to Vegetation

DCCOs destroy their nest trees by both chemical and physical means, due to accumulation of guano, which is highly acidic, and removal of foliage for nesting material (Palmer 1962, McNeil and Leger 1987, Scharf and Shugart 1981, Weseloh and Ewins 1994, Weseloh and Collier 1995). Cormorant guano, or excrement, disturbs the ionic equilibrium in forest soils (Haynes and Goh 1978), thus killing ground vegetation and eventually the nest trees. Furthermore, DCCOs damage vegetation by stripping the leaves from trees and even breaking branches due to the combined weight of the birds and their nests (Weseloh and Ewins 1994).

Some specific examples of conflicts between DCCOs and vegetation/habitat in Ontario, New York, Connecticut, Michigan, Ohio, Quebec, and Rhode Island are described here. Weseloh and Ewins (1994) observed that, up until 1980, all DCCO nests on eastern Lake Ontario’s Little Galloo Island were in trees. They noted that several large willow and hackberry trees, which were “alive and in relatively good health in 1978-79, have simply died or crumbled.” Consequently, the number of ground nests on Little

Galloo Island increased significantly after the early 1980s (Weseloh and Ewins 1994). Moore et al. (1995) reported that DCCOs began nesting in cottonwood trees at Hamilton Harbor, Lake Ontario in 1986, and that since that time the trees have gradually died, with only 24 percent remaining alive by 1993.

Lemmon et al. (1994) observed extensive damage to trees containing DCCO nests on the Norwalk Islands off the coast of Connecticut. They noted that, "branches above and within a six to eight foot radius of cormorant nests were stripped of their foliage... [while]... lower limbs extending beyond the nests had normal foliage... [and]... the ground cover and lower sections of the trees below the cormorant nests were whitewashed with guano."

The State of Michigan expressed concern about "the impact of large cormorant nesting colonies on the underlying vegetation" and noted that "many well-vegetated Great Lakes islands have been drastically impacted by these cormorant colonies, often reducing them to barren landscapes." Shieldcastle and Martin (1999) reported that the Ohio Division of Wildlife and the Service are concerned, biologically and aesthetically, about the arrival of nesting DCCOs on West Sister Island National Wildlife Refuge and other islands in Lake Erie. Additionally, on Pilot Island in Lake Michigan's Green Bay, evidence exists of DCCOs colonizing and killing all of the white cedars there (as well as displacing the herons that were using the trees). These islands experienced a "major loss of mature trees" due to guano accumulation and defoliation caused by nesting and roosting DCCOs (Shieldcastle and Martin 1999). Vegetation on other Great Lakes islands (Hat and Spider Islands in Lake Michigan, for example), some of which are managed as national wildlife refuges, has also been changed significantly by DCCOs (S. Lewis, pers. comm.).

In Rhode Island, a DCCO nesting area on an Audubon Society of Rhode Island preserve in the upper Sakonnet River, which once constituted a mature deciduous forest of beech, oak, and hickory, has been observed to be "rapidly losing all its tall vegetation and may eventually become unsuitable for wading birds" (M. Lapisky, pers. comm.). In Canada, damage to island vegetation in the St. Lawrence River estuary of Québec was described by Bédard et al. (1995) as "severe, ecologically measurable and aesthetically real" and led the Québec Ministère de l'environnement et de la faune to initiate a DCCO population control program. Additionally, Korfanty et al. (1999) reported that DCCO-induced habitat destruction on Carolinian islands in western Lake Erie is a major problem and that DCCO colonies have killed trees and shrubs on several islands in Lake Ontario, Lake Huron and at Lake of the Woods. Although the long-term ecological effects of this destruction are unclear, it is clear that large DCCO colonies, on a localized scale, can conflict with habitat management goals. Depredation permits have been issued to the States of Vermont and New York for the purpose of enhancing habitats on islands in Lake Champlain and the eastern basin of Lake Ontario. The effects of these local control activities on habitat have not been thoroughly examined but we would expect them to contribute in a positive way to the reduction of DCCO damage.

4.2.5 Impacts to Federally-Listed Threatened and Endangered Species

Pacific salmonids. In 1980, DCCOs were first documented nesting in the Columbia River Estuary on pilings in Trestle Bay (Carter et al. 1995b). Nesting on East Sand Island at the mouth of the estuary was first documented in 1987. The site supported 91 active nests in 1989 (D. Bell, pers. comm.). In 1988, DCCOs also established a nesting colony on Rice Island, 14 miles upstream in the estuary. By 1999, the total estuary population was estimated at 7,900 breeding pairs, all located on the East Sand Island colony and nearby pilings and channel markers (K. Collis and D. Roby, pers. comm.). This is the largest known DCCO breeding colony on the West Coast (Wires 2001). Other species of piscivorous birds nesting in the estuary (Caspian Terns and Glaucous-winged/Western Gulls) also experienced rapid population expansion during this time period.

The population growth of estuary-nesting colonial waterbirds in the last decade prompted the National Marine Fisheries Service (NMFS) to issue a 1995 Endangered Species Act (ESA) Biological Opinion on the Operation of the Federal Columbia River Power System to the U.S. Army Corps of Engineers (ACOE) requiring that they initiate research to estimate the number of smolts consumed by Caspian Terns and DCCOs in the estuary. In 1999, NMFS issued a second ESA Biological Opinion to ACOE on the Columbia River Channel Operation and Maintenance Project requiring management actions to relocate a breeding colony of Caspian Terns as a means to reduce predation on listed smolts, and to modify pile dikes in the Columbia River Estuary to reduce use of these structures by DCCOs as resting, loafing, or feeding platforms. Annual research activities continued to refine estimates of the number of smolts consumed by cormorants and terns in the estuary through 2001.

The best estimate of total consumption of juvenile salmonids by DCCOs nesting in the Columbia River Estuary in 1998 was 4.6 million (range 2.2 - 9.2 million) or 4.7 percent of the estimated number of smolts reaching the estuary (Collis et al. 2000). This represents about 2.3 percent of the approximately 200 million smolts annually produced throughout the entire Columbia River Basin. Cormorants foraged on hatchery and wild smolts in proportion to their availability, thus the majority of smolts taken were hatchery-reared stock, and steelhead smolts were preferred in comparison to coho or chinook (Collis et al. 2000). In 1998, DCCO diet differed between the two nesting colonies in the estuary. Cormorants nesting on East Sand Island near the mouth of the Columbia River had fewer salmonids in their diet (14.7 percent of identified prey items) as compared to those nesting further up-river at Rice Island and on channel markers (53.1 percent of identified prey items)(Collis et al 2000).

Multi-disciplinary science reviews have found no compelling scientific evidence that predation has been a *primary* cause for recent Pacific salmonid declines (USFWS 2000b), although that does not mean that they are an insignificant part of overall mortality on salmonid smolts. While the role of avian predation and the relationship of increasing survival of listed salmonid smolts in the estuary to numbers of adult returns is relatively unknown, numerous initiatives are underway throughout the Columbia River Basin to decrease in-river smolt mortality as a means to aid the recovery of listed salmonid stocks. These include control of predatory northern pikeminnows (a native fish known to prey on salmonid smolts), relocation of a large Caspian Tern colony to a new location at the mouth of the estuary, and modifications of extensive systems of estuary pile dikes to preclude use by DCCOs as foraging platforms. Management actions to reduce avian predation, primarily focused on Caspian Terns, have resulted in substantial reductions in smolt losses to avian predation in the estuary (Collis et al. 2000). Research and monitoring activities are continuing to further refine estimates of DCCO smolt consumption and to determine the need for further management actions (BPA 2001).

Atlantic salmon. The DCCO was first documented as a breeder in Maine in the late 1800s. Maine has the largest number of breeding DCCOs in New England with at least 17,100 pairs estimated at 117 colonies in 1994-95 (Wires et al. 2001). Blackwell et al. (1995) examined foods of nestling DCCOs at ten colonies in Penobscot Bay, Maine and found that sculpins, sand shrimp, wrymouth, rock gunnel, and cunner were consistently among the highest ranking prey. Atlantic salmon smolts were not an important prey item. But it was found that Atlantic salmon were an important component of DCCO diet on the Penobscot River in the spring. No conclusions were drawn about the impacts of this predation on fisheries (Blackwell et al. 1997).

Today, the largest effort in the U.S. to restore the Atlantic salmon is occurring in the Penobscot River, Maine (Krohn and Blackwell 1996). Like many New England rivers, the Penobscot has undergone 200 years of development, including the construction of numerous hydroelectric dams (Baum 1983, Moring 1987, and Moring et al. 1995 in Blackwell 1997). Additionally, many biologists feel that changed oceanic conditions may be affecting salmon during their time in the North Atlantic (Krohn and Blackwell 1996). Blackwell et al. (1997) suggested that smolt losses to DCCO predation are made worse by springtime discharge rates at dams inhibiting smolt passage and escapement. Loss of smolts to DCCOs foraging on New England rivers is perceived by some as a potential limiting factor to the recovery of Atlantic salmon populations (Moring 1987 and Moring et al. 1995 in Blackwell et al. 1997).

Current DCCO management activities do not appear to be a threat to populations of any federally-listed threatened and endangered species.

4.2.6 Impacts to Water Quality and Human Health

Currently, depredation permits have only been issued for the control of DCCOs that are a direct source of water pollution (e.g., birds roosting over a water storage area). None have been issued for indirect pollution of groundwater, since it can be difficult to show a direct relationship between DCCOs and compromised water quality. The organochlorine contaminants found in many fish and birds were (and many continue to be) introduced into the environment by human activities. There is little scientific discussion of the relationship between bird abundance, contamination of ground water, and associated human health impacts. We were unable to locate any references in the literature or elsewhere of elevated bacterial counts or contaminant levels caused by DCCOs threatening human health.

Clearly, DCCOs, by virtue of being a top predator, harbor contaminants that are found in the Great Lakes ecosystem and convey these to the waters that they inhabit. While there is a great deal of literature examining the levels and effects of various contaminants in DCCOs (cf. Elliott et al. 1989, Bishop et al. 1992a, Powell et al. 1997, Rattner et al. 1999, etc.), there is no documentation of effects on humans caused by direct contamination from DCCO excrement, feathers, or carcasses. Thus, it is difficult to predict the potential human health impacts associated with DCCOs and water quality. In 1999, testing by a New York State-accredited environmental laboratory (Chopra-Lee, Inc.) found no chemical contaminants in either of two residential groundwater wells near Little Galloo Island (home of a large DCCO colony in eastern Lake Ontario) that were sampled, although elevated bacterial counts were measured (Anon. 1999).

DCCOs are not considered to be a significant threat to groundwater supplies, although they may be a direct source of contamination in cases where they nest or roost near water supplies.

4.2.7 Economic Impacts

4.2.7a Aquaculture

In 1996, roughly half (53 percent) of U.S. catfish farmers considered DCCOs to be a problem, with farmers from Mississippi (77 percent), Arkansas (74 percent), and Alabama (50 percent) most likely to have DCCO conflicts (Wywialowski 1999). In the Mississippi Delta, 87 percent of catfish farmers surveyed felt that they had a bird problem and losses to birds (harassment costs plus value of fish lost) were estimated at $5.4 million, or 3 percent of total sales (Stickley and Andrews 1989). A survey conducted by Wires et al. (2001) found that DCCO predation at aquaculture facilities was perceived as a "major" problem by 6 States (Alabama, Arkansas, Louisiana, Mississippi, Tennessee, and Texas). It was perceived as a "moderate" problem in the States of Connecticut, Florida, Illinois, Maine, Massachusetts, Oklahoma, and Rhode Island.

Price and Nickum (1995) concluded that the aquaculture industry has small profit margins so that even a small percentage reduction in the farmgate value due to predation is economically important. Bioenergetics modeling on the impact of DCCOs on the Mississippi Delta catfish industry estimated that in 1989-90 and 1990-91, losses approximated 20 million and 18 million catfish fingerlings (10 to 20 cm), respectively (Glahn and Brugger 1995). This was equivalent to approximately 4 percent of the fingerling class during the November to April study periods, representing approximately $2 million in fish losses. Although losses were documented over a six-month period, the majority (about 64-67 percent) occurred in February and March (Glahn and Brugger 1995). Glahn et al. (2000) used this same model to predict current predation rates on fingerling catfish in the Delta region based upon the recent doubling in the wintering DCCO population, with estimated losses resulting in the removal of 49 million fingerlings valued at $5 million. Glahn et al. (1999) stated that as much as 75 percent of the diet of DCCOs in certain roosting areas of the Mississippi Delta consisted of catfish, and according to bioenergetic models cormorants can exploit as much as 940 metric tons of catfish per winter.

Controlled experiments by Glahn et al. (In Review) investigating predation losses by DCCOs confirm previous estimates of cormorant damage and have started to examine output parameters at harvest with and without predation. Using sampling weights of fish inventoried from captive cormorant trials, they calculated a 19.6 percent biomass production loss from DCCO predation. At a commercial pond scale the 20 percent loss in production would correspond to a loss of 6800 kg (15,000 lbs) valued at $10,500 or almost 5 times the value of the fingerlings lost. Using this ratio, catfish production losses to Mississippi Delta catfish farmers may currently approach $25 million or 8.6 percent of all catfish sales in Mississippi. Furthermore, they examined the economic effects of cormorant predation on net returns in an enterprise budget for an average130 hectare (13,000 acres) catfish farm using data collected from captive cormorant trials and standard budgeting techniques. Enterprise budgets resulted in a 111 percent loss of profits based upon a 20 percent production loss observed at harvest from simulating 30 DCCOs feeding at a 6 hectare (600 acre) catfish pond for 100 days (Glahn et al. In Review).

Additionally, the APHIS/WS Management Information System (MIS) database reveals that, from 1995-1997, aquacultural resource losses to DCCO predation were reported in 33 States with catfish and trout being the mostly commonly identified fish species. Of $8.8 million in losses reported in MIS resource categories of aquaculture, property, and natural resources, aquaculture represented over 97 percent (approximately $8.5 million) of the reported losses.

The magnitude of DCCO-related economic impacts to the aquaculture industry can vary dependent upon many different variables, including the value of the fish stock, the time of year the predation is taking place, and the number of depredating birds present. The frequency of occurrence of DCCOs at a given aquaculture facility can be a function of many interacting factors, including: (1) size of the regional cormorant population; (2) the number, size, and distribution of ponds; (3) the size distribution, density, health, and species composition of fish populations in the ponds; (4) the number, size, and distribution of "natural" wetlands in the immediate environs; (5) the size distribution, density, health, and species composition of "natural" fish populations in the surrounding landscape; (6) the number, size, and distribution of suitable roosting habitat; and (7) the variety, intensity, and distribution of local damage abatement activities.

DCCOs clearly respond in a positive way to the presence of shallow-water ponds stocked with high densities of easy-to-capture prey fish. For example, within two weeks of stocking two ponds in Florida with fingerling catfish, twelve DCCOs were feeding in the ponds and roosting on nearby poles. A nearby pond, stocked with 75,000 fish in August 1980, had attracted thirteen DCCOs by September. These birds continued to feed at the pond throughout the fall and winter, and in spring 1981 they nested in a nearby cypress dome. By November 1981, about fifty cormorants were feeding in the pond (Schramm et al. 1984). The positive response of DCCOs to these ponds appears to be a contributing factor to the dramatic increase in the wintering population of cormorants in the fish producing regions of the southern U.S. (Glahn et al. In Press; Reinhold and Sloan 1999; Glahn et al. 1999; Jackson and Jackson 1995).

Additionally, because DCCOs are adept at seeking out the most favorable foraging and roosting sites, they are rarely distributed evenly over a given region, but rather tend to be highly clumped or localized. For example, in 27 weekly surveys at 50 catfish ponds in Humphreys County, Mississippi, 1987-1988, DCCOs were observed at only 9 of the 50 ponds and only on 14 occasions (Hodges 1989). Thus, it is not uncommon for some fish farmers in a region to suffer little or no economic damage from DCCOs, while others experience exceptionally high losses.

Much of the bird depredation to baitfish and the tropical fish industries have been associated with wading birds (Avery et al. 1999; Hoy 1994; Hoy 1989; USDA-APHIS 1997a). Impacts of cormorants on baitfish and tropical fish are unclear and not known (Brugger 1995; Glahn et al. (In Press). Similar wading bird impacts are seen within the crayfish industry with White Ibis, Yellow-crowned Night-herons, and Great Egrets being the main predatory bird species (Price and Nickum 1995). Cormorants have been documented eating crayfish on their northern breeding grounds (Blackwell et al 1997; Lewis 1929; Ludwig et al. 1989; Neuman et al. 1997; Weseloh and Collier 1995) and depredation has been observed on crayfish farms in Louisiana (USDA-APHIS 1997a; Huner and Jeske In Review). Based on available scientific studies the impacts of cormorants on commercial crayfish production are unclear (Glahn et al. In press), Huner and Jeske In review). DCCOs have been documented as a predator on farm raised trout and salmon, although in limited circumstances.

See section 4.3.7 for discussion of the impacts of non-lethal control techniques on aquaculture production. Shooting to kill birds is another means of controlling DCCO depredation at commercial freshwater aquaculture facilities. The 1998 Aquaculture Depredation Order authorizes the unlimited take of depredating DCCOs at aquaculture facilities in 13 States (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Minnesota, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas). In other States, depredation permits are issued by the Service Regional Migratory Bird Permit Offices for significant economic impacts to aquaculture facilities. Glahn et al. (2000a) estimated that without such lethal damage control programs, the impact of DCCO depredation on the catfish industry would likely have more than doubled in the late 1990s compared to earlier years.

4.2.7 b Recreational Fishing Economies

Current depredation practices do not authorize DCCOs to be taken to benefit public, open water fisheries or communities whose economies are closely coupled with the quality of recreational fishing. Trapp et al. (1999) surveyed the States asking, "Is there documented evidence that increased DCCO populations have affected local economies associated with the sport fishing or tourism industries?" Of the 12 responding States, none reported any *documented* evidence that DCCOs had affected local economies associated with the sport fishing or tourism industry.

We do not doubt the reality or disregard the importance of the economic changes occurring in communities whose economic health is closely tied to recreational fishing. However, analyzing the relationship between DCCO predation, fishery impacts, angler participation, and economic effects is very complex and, at this point, is limited to qualitative predictions. The Oregon Department of Fish and Wildlife, in reply to the survey conducted by Trapp et al. (1999), commented that "[while] we can document the economic effect of decreased salmon populations through closure of commercial fisheries and formerly popular sport charter fisheries, and declining sales of salmon harvest tags...we believe that DCCO predation is only one of a number of causative factors which in total are responsible." In areas where DCCOs may be impacting fisheries and associated recreational catch (e.g., eastern Lake Ontario and Oneida Lake, New York), they may also be having negative impacts on economics associated with recreational fishing in surrounding communities. To the extent that DCCO control activities contribute to the recovery of fisheries in these communities, and if angling participation increases subsequently, local economies will likely benefit.

4.2.8 Impacts to Hatcheries and Environmental Justice

DCCO impacts to hatcheries are generally related to predation, stress, disease, and financial losses to both hatcheries and recipients of hatchery stock. Hatchery fish are stressed by the presence of DCCOs, wounds from strikes, and noisemakers used to scare away DCCOs. This stress leads to a decrease in growth factors as feeding intensity decreases. Additionally, disease and parasites can be spread more easily by the presence of fish-eating birds. For example, some parasites, such as trematodes, complete their life cycle only after an infected fish is consumed by the birds (K. Flanery, USFWS, pers. comm.). Research from the Czech Republic and Mexico has linked cormorants to fish diseases (Moravec et al. 2000, Moravec and Scholz 1994, Vidal Martinez et al. 1994).

In a 1990 survey sent to the fisheries chiefs of each State, 33 percent of States reported an increase in DCCO predation in hatchery ponds and raceways (Erickson 1990). During public scoping, the Illinois Department of Natural Resources wrote that their LaSalle Fish Hatchery along the Illinois River has had problems with increasing predation pressure from migrating DCCOs in the late summer and fall. They stated that, in 1997, "production of muskellunge at this hatchery was severely impacted by cormorant predation." The Georgia Department of Natural Resources also reported that their hatchery personnel in southern Georgia "continue to report significant losses of fish to cormorant predation, especially in the fall and winter months." Also during the public scoping period, the States of Kansas, Ohio, Texas, and Wyoming indicated that DCCO predation on hatchery fish has been a problem. Reported instances of cormorant damage to hatchery fish in Texas include the loss of 90 percent of the smallmouth bass 2-year-old brood stock and 13,000 rainbow trout at the Jasper facility (Dukes 1987). Texas Parks and Wildlife Department fish hatchery managers reported that DCCO depredation at six installations increased during 1982-87 and that cormorant depredation had greatest impact on largemouth bass brood stock, goldfish brood stock, and rainbow trout rearing stock (Thompson et al.1995).

Parkhurst et al. (1987) found that human patrols were considered highly successful or better by 30 percent of hatchery managers, of limited success by 60 percent, and not successful by 9 percent. Spencer (1996) reported that two State fish hatcheries in Georgia used whistlers and cracker shells, and both techniques were considered partially effective against birds in general at each facility. Neither technique was considered effective against "resident" DCCOs however. The manager at Inks Dam National Fish Hatchery (Texas) described attempts at controlling DCCO depredation with non-lethal harassment alone as follows:

In years past cormorants have rested on dead limbs of a large cottonwood tree in our picnic area right along Lake LBJ. We were unable to shoot birds in this tree because there are houses directly across the lake, a distance of about 150 yards. Although we could not shoot these birds, we always tried to keep them scared off. At first all we had to do was drive by and the cormorants would fly. After a few days it became necessary to drive up to the tree and honk the horn. When this failed to work, I would drive up to the tree in a rapid manner, slam on the brakes as I honked the horn. Once the vehicle was stopped, I would step out of the vehicle and slam the door as loudly as I could. Once again this only worked for a few days. As a last resort, I began to throw rocks and sticks at the cormorants. The cormorants have started roosting in several trees along Lake LBJ. I have been driving down there after dark and scaring them with a spotlight. Each evening it is getting harder to run them out of the trees. During the daytime these same birds swim up and down Lake LBJ. Early in the season they would fly off every time a vehicle drove through the picnic area. Now most of them refuse to fly even when they are harassed with cracker shells (R. Lindsey, USFWS, pers. comm.).

Reports of habituation such as this are typical as DCCOs quickly learn to ignore noisemakers and other scare tactics. Shooting a few birds, on the other hand, has been shown to reinforce harassment efforts.

Covering ponds and raceways with netting is another management option. This has helped reduce depredation at some hatcheries but is not a panacea due to drawbacks such as lack of funding to install and maintain nets (e.g., the manager at Inks Dam National Fish Hatchery estimated that netting their ponds would cost $400,000) and the fact that it makes it considerably more difficult to feed, clean, aerate, and harvest ponds (K. Flanery, USFWS, pers. comm.).

Several managers of National Fish Hatcheries have expressed concern about problems with DCCO predation and not being able to use lethal control on birds at Federal facilities because of Director's Order 27, which states that "kill permits will be issued for use at [federal] facilities only when it has been demonstrated that an emergency or near emergency exists and an [APHIS/WS] official certifies that all other deterrence devices and management practices have failed." For example, the manager at Genoa National Fish Hatchery in Wisconsin expressed concern about DCCO predation on largemouth bass and walleye that are used as host fish for the endangered Higgins Eye mussel. In 1999, this facility experienced "complete loss" in their advanced walleye rearing pond and 50 percent mortality in their largemouth bass rearing pond due to DCCO predation (T. Turner, USFWS, pers. comm.). At Natchitoches National Fish Hatchery in Louisiana, 30,000 channel catfish fingerlings were reduced to less than 1,000 in two days by a flock of cormorants in the late 1980s (K. Kilpatrick, USFWS, pers. comm.). In 1996, Tishomingo National Fish Hatchery in Oklahoma lost 140,000 seven-inch catfish to approximately 400 cormorants, although they typically lose 5,000-10,000 annually (K. Graves, USFWS, pers. comm.).

Additionally, at Inks Dam National Fish Hatchery in Texas, where largemouth bass and channel catfish are raised for distribution to Federal and Tribal waters of the southwestern U.S., concern has been expressed about depredation problems caused by more than 100 resident DCCOs leading to "total loss of production" (N. Kaufman, USFWS, pers. comm.). During 1999-2000, Uvalde National Fish Hatchery in Texas averaged a 93 percent loss in 3 ponds of channel catfish due to cormorant predation. This level of loss caused several last-minute cancellations of scheduled fish deliveries (S. Jackson, USFWS, pers. comm.).

When hatcheries experience losses of this magnitude, they cannot fulfill their trust responsibilities to Native American Tribes. Representatives from Service Region 2 (Arizona, New Mexico, Oklahoma, Texas) are concerned that, at National Fish Hatcheries in Region 2, excessive losses of fish destined for stocking on Tribal lands may result in a significant direct economic impact for Native American Tribes.

4.2.9 Impacts to Property Losses

The APHIS/WS Management Information System database reveals that, from 1995-1997, losses to property were reported in 18 States with trees and shrubs most commonly reported. Respondents to a survey conducted by Wires et al. (2001) reported damages to private property in four States: Connecticut, Maine, Massachusetts, and South Carolina. For example, in a February 1, 2000, letter to the Service, the Maine Department of Inland Fisheries and Wildlife stated that "lower property values at major roosts and large nesting colonies" are an important issue in Maine.

In some cases, depredation permits have been issued for DCCOs taking fish from privately-owned and stocked fish ponds. For example, the Hiawatha Sportsmen's Club in northern Michigan, has been issued a permit to reduce DCCO predation on trout, walleye, and perch in stocked ponds. In Texas and Oklahoma, the Service has also issued permits to private stock ponds where DCCOs were having economic impacts.

Little attention has been given to complaints of fouling vessels or buildings in the literature (Hatch and Weseloh 1999). However, this issue was raised during the public scoping process and has been the subject of requests for depredation permits. For example, the Massachusetts Division of Fisheries and Wildlife noted problems with "small numbers of [DCCOs] perching and defecating on docks and moored boats."

As discussed in Section 4.2.4, DCCOs are capable of killing trees and other vegetation. Lewis (1929) considered the killing of trees by nesting cormorants to be very local and limited, with most trees he observed to have no commercial timber value. However, vegetation damage may be perceived as a problem if the species is rare, or is aesthetically or commerically valued by the landowner (Hatch and Weseloh 1999).

4.2.10 Impacts to Existence and Aesthetic Values

To some people, any killing of DCCOs or their eggs represents a loss of maximized existence value and therefore anything more than a non-lethal approach compromises this value. Under this alternative, however, a very large population of DCCOs still exists and it could be argued that as long as sufficient local, regional, and continental DCCO populations exist, even though individuals would be killed, existence value would not be seriously affected.

While many individuals commented during the public scoping process that DCCOs and their colonies are ugly, there are also those to whom the sight of a cormorant engaging in natural behaviors is viewed as beautiful. Nonetheless, certain species, particularly abundant ones, may be seen as a nuisance, thereby losing much of their aesthetic value. Several people also indicated during the scoping process that DCCOs have turned verdant islands or waterfront areas into wastelands through their killing of trees and this has compromised the natural beauty of the areas where they live, work, and/or recreate.

4.3 Alternative B: Non-lethal Management

4.3.1 Impacts to Double-crested Cormorants

We predict that a completely non-lethal approach to cormorant damage management will not threaten DCCO populations on a regional or national scale. The main effect on populations would be spatial (i.e., moving birds to different areas where they may be more or less of a problem).

In Lake Champlain, Vermont (USFWS 1999b), and eastern Lake Ontario, New York (USFWS 1999a), the goal of preventing colonization on specific islands by DCCOs was achieved through nest removal activities. Harassed birds may be prevented from reproducing during a specific breeding season or suffer reduced reproductive success because of time and energy expenditures involved in finding new nesting areas, but this technique is generally believed to have negligible impacts on local populations when practiced on a relatively small scale (USFWS 1999a,b). If prevention of colonization is practiced intensely, annually, and over a large enough area, it may be effective at managing regional populations (Bregnballe et al. 1997). However, such a level of intensity may not be logistically or financially feasible.

4.3.2 Impacts to Fish

Non-lethal management techniques to benefit fisheries involve temporarily moving DCCOs away from a specific fishery (e.g., harassment), altering fish release practices, or physically separating DCCOs from fish. In certain cases, techniques such as altered stocking practices have proven useful in reducing cormorant depredation. Van Dam and Asbirk (1997) predicted that continuous roost disturbance and efforts to prevent the establishment of new breeding colonies could benefit local fisheries in the vicinity, especially at inland sites, but this would likely require highly intensive harassment efforts. Moore (2001) noted that increasing the size of trout stocked and varying the timing of stocking were effective in improving angler success and reducing the proportion of fish taken by Great Cormorants at two still-water trout fisheries in the United Kingdom. Additionally, in 1996, to address concerns over DCCOs feeding on stocked fish, the New York State Department of Environmental Conservation made additional improvements in stocking methods to include stocking fish further offshore, stocking streams earlier in the spring before DCCOs return from wintering areas, and stocking nearshore areas at night so that fish can disperse before daylight. These efforts were considered to be effective in reducing predation on recently-stocked fish (J. Farquhar, NYSDEC, pers. comm.).

In response to DCCO predation on fish in Oneida Lake, New York, during fall migration, USDA-WS (under contract from the New York State Department of Environmental Conservation) has conducted a hazing program since 1998. In 1998, the hazing effort began on September 1 with 1,880 DCCOs present. By September 5, the number of birds on the lake was 145. Results for other years have been similar and the work at Oneida Lake has been considered very successful (C. Adams, Cornell University, pers. comm.). In the first year of implementation, it was roughly estimated to have reduced DCCO consumption by 30,000 walleye and 90,000 perch (USDA-APHIS 1998). The long-term impacts of this reduced DCCO fish consumption on fish populations has not been examined.

We conclude that non-lethal control efforts can, if carried out intensely enough, reduce DCCO predation in the short-term at the site-specific level. However, this approach has the disadvantage of moving birds to other areas where they are likely to continue to come into conflict with other resources and thus, overall, it is considered to be less effective than the No Action alternative.

4.3.3 Impacts to Other Birds

Risks to other birds from carrying out this management alternative would be variable depending on the level of cohabitation and the degree of disturbance (van Dam and Asbirk 1997). Harassment activities aimed at preventing DCCOs from nesting, roosting, or feeding at particular sites can clearly lead to indirect impacts on other bird species, with the greatest risk of impacts coming from those actions occurring at breeding colonies where other bird species are present. If birds nesting with DCCOs have already established their nests, nest abandonment, predation, and overexposure could occur as a result of harassment efforts (Carney and Sydeman 1999). The extent of the impacts will vary by species, time of year, and location.

Bayer (2000) noted that DCCO harassment efforts at various estuaries along the northern Oregon Coast caused disturbance to "waterfowl," "herons," and Black Brant but no biological impacts associated with this disturbance were noted. In the Final Environmental Assessment for the take of cormorants and gulls on Lake Champlain Islands, Vermont (USFWS 1999b), non-lethal management techniques were considered very likely to disrupt other nesting species. In particular, it was believed that "pyrotechnics...would frighten non-target species sharing islands with cormorants, and could result in abandonment by gulls and common terns." For this reason, the requirement that non-lethal management techniques be used before the authorized egg oiling and nest/egg destruction activities was waived.

When carried out on a limited and localized level, non-lethal activities are probably not a serious threat to populations of colonial waterbirds. However, if practiced on a much broader level (such as might be required to enhance the effectiveness of a non-lethal management regime), and if largely carried out at multi-species colonies, negative population impacts could occur as a result of repeated nest failures.

4.3.4 Impacts to Vegetation

Harassment may be effective at protecting vegetation at specific locations by preventing the establishment of DCCOs. Where vegetative damage has already occurred, recovery will be slow or non-existent, depending on the particular habitat type.

4.3.5 Impacts to Federally-Listed Threatened and Endangered Species

Bayer (2000) found that hazing of cormorants on a few northern Oregon Coast estuaries was not correlated with improved hatchery returns of salmonids. Nor have average spawning ground counts of wild coho salmon, winter steelhead, and fall chinook increased since hazing began. Bayer observed that "Returns may not have increased with hazing because it was ineffective in substantially reducing predation, because smolts saved by hazing died anyway, or because other factors such as unfavorable ocean conditions may have been much more important in affecting smolt survival than hazing." While hazing/harassment efforts may reduce the level of predation for a specific time period (until the birds return or are replaced by others), actual long-term benefits to any populations of threatened and endangered fish species from these actions alone are unlikely.

Overall, impacts to threatened and endangered species would be similar to the No Action alternative.

4.3.6 Impacts to Water Quality and Human Health

Where impacts are directly related to the presence of specific birds, harassment may help alleviate these conflicts (e.g., where birds only needed to be moved away) but, overall, this alternative would be less effective than the No Action alternative.

4.3.7 Economic Impacts

4.3.7a Aquaculture

Surveys of aquaculturists reveal that harassment patrols are commonly utilized, despite the fact that few consider them very effective. Stickley and Andrews (1989) reported that 60 percent of respondents who reported using harassment techniques used vehicle patrols combined with shooting to repel (not to kill) birds; of these, 13 percent found this combination to be very effective, 47 percent somewhat effective, and 40 percent not effective. Of these same respondents, 9 percent utilized pyrotechnics regularly; of these, 24 percent found pyrotechnics to be very effective, 57 percent somewhat effective, and 19 percent not effective. Catfish producers implementing roost dispersal activities may reduce depredation to fish stocks for a period of time, but only temporarily (Glahn et al. 2000; Glahn et al. 1996; Mott et al. 1998; Tobin et al. In Review). Damage abatement activities typically shift bird activities from one area to another, thereby reducing damage at one site while often increasing it at another (Aderman and Hill

1995; Mott et al. 1998; Reinhold and Sloan 1999; Tobin et al. In Review).

A survey of catfish producers in the southern U.S. (Wywialowski 1998, 1999) revealed that 14 percent reported using night roost harassment, most of whom were in Mississippi (32 percent of all Mississippi catfish producers). Mott et al. (1998) and Reinhold and Sloan (1999) provide the most recent summaries of the Mississippi Delta program, as described in Wires et al. (2001). Mott et al. (1998) concluded that, although harassment of roosts does not eliminate the DCCO predation problem at catfish farms, it does reduce the number of cormorants on or near catfish ponds. Overall, night roost harassment was not considered to be sufficient for eliminating the need to practice other forms of DCCO control at aquaculture facilities, though it may be effective at decreasing losses (Littauer et al. 1997; Mott et al. 1998; Reinhold and Sloan 1999).

4.3.7b Recreational Fishing Economies

The impacts of this alternative on local economies that are closely coupled with recreational fishing would probably be worse than the No Action alternative. The continued presence of "unmanaged" DCCOs would very likely discourage anglers and they would not increase their fishing participation levels.

4.3.8 Impacts to Hatcheries

Harassment activities are of limited effectiveness at fish hatcheries and, in many cases, exclusion devices are not considered to be cost effective. Thus, depredation at fish hatcheries would be dealt with less effectively under this alternative than under the No Action alternative.

4.3.9 Impacts to Property Losses

Some property losses could be dealt with effectively through non-lethal management. Others would necessitate removal of birds. Thus, property losses would be dealt with less effectively under this alternative than under the No Action alternative.

4.3.10 Impacts to Existence and Aesthetic Values

Existence value would be compromised the least under this alternative since no DCCOs would be killed. However, it is possible that not effectively managing an abundant species such as DCCOs could, ultimately, reduce existence value if a lack of management contributed to the species being viewed as a "nuisance" or "pest." As Conover (2001) noted, "[when] a wildlife population increases and the animal becomes abundant, negative values may increase faster than positive ones."

Effects on aesthetic value would depend on the individuals perspective. Those who find DCCOs aesthetically-pleasing would be slightly negatively affected because in many local situations DCCOs would be harassed out of the area and thus would not be available for immediate viewing, although it would not be difficult to find them in other locations. On the other hand, those who view DCCOs as compromising aesthetic values with their presence would appreciate the fact that DCCOs could not be viewed.

4.3.11 Direct, Indirect and Cumulative Effects

In summary, the chief direct effects (i.e., those caused by the action(s) and occurring at the same time and place) associated with this alternative would be displacement of nesting, roosting, or feeding DCCO populations and some harassment of bird species that nest, roost, or feed with DCCOs.

Indirect effects (i.e., those caused by the action(s) but occurring later in time or farther in distance) include limited positive impacts to fisheries, vegetation, threatened and endangered species, water quality and human health, aquaculture, hatcheries, and property losses associated with localized displacement of DCCOs. A negative indirect effect could be the relocation of nuisance birds to new areas where they weren't previously a problem.

We foresee no significant cumulative effects (i.e., those that result from the incremental impact of the action(s) when added to other past, present, and reasonably foreseeable future actions) associated with this alternative except that DCCO populations will continue to increase. Monitoring efforts (e.g., population surveys) would help confirm this prediction.

4.4 Increased Local Damage Control Alternative

4.4.1 Impacts to Double-crested Cormorants

In their analysis of the impacts of various management strategies for Great Cormorants in Europe, Bregnballe et al. (1997) observed that, since the outcome depends on the extent of competition in the population and the degree of density-dependence working within the population, it is difficult to predict quantitative impacts on cormorant population size. Even for species, such as mallards, for which there is a highly structured annual system of resource monitoring and data analyses, certainty in predicting the population effects of management actions has remained elusive (USFWS 2000c). Veldkamp (1997) commented that, with respect to population-level control measures, since cormorants have "remarkable reproductive skills," only massive long-term and large scale measures are likely to result in a significant population reduction.

We estimate that permit issuance under this alternative would increase by no more than 30 percent, leading to additional mortality of approximately 3,600 adult or immature DCCOs annually. Egg mortality would also increase by a limited amount. Because egg oiling is labor intensive and its effectiveness in reducing DCCO damage is much less immediate than shooting, we predict that it will not be as widely used under this alternative as taking adult and immature birds will be. The majority of breeding pairs in the Interior and Atlantic populations (73 and 59 percent, respectively) will be exempt from egg oiling under this alternative because they nest in Canada (Hatch 1995, USFWS 1998b). Thus, we estimate that increased egg oiling efforts would not significantly impact continental populations but might decrease DCCO regional production (especially in the Great Lakes, where conflicts associated with breeding DCCOs are most common) compared to the No Action alternative.

Under this alternative, the Aquaculture Depredation Order allowing take at commercial freshwater aquaculture facilities in 13 States would be expanded to include take at winter roost areas in those States (this would, in effect, involve only 12 States, however, since DCCOs are not present in Minnesota during the winter months). Glahn et al. (1999) proposed that, in order to maintain the effectiveness of shooting DCCOs at reducing depredation damage, shooting birds at winter roosts should be allowed. Shooting DCCOs at aquaculture facilities is, by itself, not considered an effective population control technique (Thompson et al. 1995; Simmonds et al. 1997), although it is believed that depredations on aquacultural stock are less than they would be without lethal control (Glahn et al. 2000a).

Glahn (2000) found that, despite deploying skilled marksmen to shoot DCCOs in winter roosts, only a relatively small number of DCCOs (<5% of the roosting population) were killed, mainly due to the dispersal effects of shooting at them. Thus the author concluded that allowing DCCOs to be shot at roosts is "unlikely to result in a large number of birds killed." Anecdotal evidence indicates that DCCOs are wary birds and are difficult to kill at aquaculture facilities (Hanebrink and Byrd 1989; Conniff 1991; Price and Nickum 1995). Some empirical evidence on the difficulty of killing cormorants at aquaculture facilities appears in Hess (1994 in Reinhold and Sloan 1999) where it was shown that, during 3000 person-hours of effort in which maximum take was not limited, only 290 DCCOs (12 percent of the 2500 authorized) were killed over a 19-week period at two aquaculture facilities in the Mississippi Delta. We estimate that take under the expanded Depredation Order would increase by 25 percent, as compared to the standing Depredation Order, leading to about 45,000 adult and immature DCCOs being killed annually to protect commercial aquaculture under the Depredation Order.

In total, we predict DCCO take under this alternative would not exceed 61,000 birds per year, or 3.1 percent of the estimated continental population. Given the current demographics and status of DCCO populations, we feel that it is very unlikely that increased control efforts to reduce localized damages would threaten regional or continental DCCO populations.

4.4.2 Impacts to Fish

This alternative would be more responsive to concerns about DCCO impacts to fish populations and would be more likely to reduce predation and benefit fish populations than the No Action alternative. Shooting birds may benefit fish for two reasons: 1) the immediate effect of removing depredating birds and 2) the secondary effect of scaring away other birds and reinforcing non-lethal harassment efforts. Additionally, killing birds, as opposed to harassing them, avoids the problem of merely moving DCCOs to another area where they could potentially cause damage. Localized egg oiling is a longer term action that has been shown to help reduce predation levels on local fish populations, as described under the No Action alternative.

Responses of DCCOs to localized control efforts will vary from site to site depending on the movements of birds to and from the particular area (e.g., it is possible that shot birds could simply be replaced by immigrating birds). Additionally, the specific effects on fish populations and/or the likelihood of recovery of the fishery are difficult to predict because of uncertainty about the role of DCCO predation relative to other factors limiting fish populations. However, in areas where DCCOs have been shown to be a significant source of mortality to a specific fishery, this alternative will prove more effective at reducing impacts than the No Action alternative.

4.4.3 Impacts to Other Birds

In addition to harassment (see section 4.3.3), this alternative authorizes shooting, egg oiling, and nest destruction, all of which could lead to increased human disturbance of mixed species breeding colonies. Increased shooting would likely lead to greater incidental take, especially for look-alike species. Simmonds et al. (1997) reported that in Oklahoma, Anhinga, Cattle Egrets, and Little Blue Herons were shot during DCCO lethal control efforts. In three Canadian provinces (Prince Edward Island, Nova Scotia, and New Brunswick), DCCO control activities have either led to, or are not allowed because of the threat of, by-kill of Great Cormorants (Milton et al. 1995; Korfanty et al. 1997). In particular, under the expanded Aquaculture Depredation Order, incidental take of Neotropic Cormorants and Anhingas would increase compared to the No Action alternative, although we don't anticipate this having significant negative effects on populations of these species. Overall, we do not consider by-kill to be a significant problem.

We predict that the net effect of the management activities associated with this alternative would be to benefit other birds over the long-term to the extent that it reduces nest competition in those instances where abundant DCCOs inhibit the nesting of other birds. It is more likely to have positive net effects on other birds than the No Action alternative.

4.4.4 Impacts to Vegetation

Impacts to vegetation would be dealt with more effectively than under the No Action alternative since the ability to control DCCOs causing such problems would be enhanced. To the extent that control activities prevent the establishment of DCCOs, vegetation at specific locations will be protected. Where vegetative damage has already occurred, recovery will be slow or non-existent, depending on the particular habitat type.

4.4.5 Impacts to Federally-Listed Threatened and Endangered Species

Impacts to threatened and endangered species would be similar to the No Action alternative.

4.4.6 Impacts to Water Quality and Human Health

Controlling DCCOs in localized situations would likely not eliminate, or necessarily even alleviate, human health risks associated with contaminants due to the effects of other piscivorous birds, the persistence of organochlorine chemicals in Great Lakes waters, and bioaccumulation of those chemicals from fish to humans. Where DCCOs are a direct source of bacterial contamination, this alternative would allow for as effective control as the No Action alternative.

4.4.7 Economic Impacts

4.4.7a Aquaculture

Some investigators have begun to question the long-term effectiveness of night roost harassment. Glahn et al. (2000a) observed that, while roost dispersal programs continue to shift DCCOs away from areas of high catfish concentration, such results are "temporary at best." The number of known night roosts within the Delta has increased recently, making monitoring and harassment more difficult. Control efforts associated with the expanded Depredation Order are predicted to enhance the effectiveness of DCCO management carried out under the No Action alternative.

4.4.7b Recreational Fishing Economies

In many cases, this alternative would be more responsive to concerns about DCCO impacts to fish populations than the No Action alternative. If this leads to increased angler participation, benefits to local economies that are closely tied to recreational fishing might occur, but we predict that this is not highly likely under this alternative.

4.4.8 Hatcheries and Environmental Justice

Depredation at hatcheries, especially National Fish Hatcheries, would be more effectively reduced than under the No Action alternative since the ability to manage DCCOs causing such problems would be enhanced. Impacts to low income Native American communities dependent on fish raised at Federal hatcheries would also be reduced.

4.4.9 Impacts to Property Losses

Property losses associated with DCCOs would be as effectively managed as under the No Action alternative.

4.4.10 Impacts to Existence and Aesthetic Values

Existence Value. More DCCOs would be killed under this alternative than under the No Action and thus, to some people, existence value would be compromised. However, overall populations of DCCOs would not be significantly reduced, so effects on existence value would be minimal.

Aesthetic Value. Effects on aesthetic value associated with this alternative would vary depending on individual perspective. For those who find DCCOs aesthetically displeasing, reduced presence associated with control actions carried out under this alternative would be viewed positively. For those who appreciate the sight of DCCOs, aesthetic value would be somewhat compromised, compared to the No Action alternative.

4.4.11 Direct, Indirect and Cumulative Effects

In summary, the chief direct effects (i.e., those caused by the action(s) and occurring at the same time and place) associated with this alternative would be displacement and limited take of nesting, roosting, or feeding DCCOs or their nests or eggs and some displacement of bird species that nest, roost, or feed with DCCOs, as well as limited incidental take. These effects would occur at a higher rate than under the No Action Alternative but are not predicted to be significant.

Indirect effects (i.e., those caused by the action(s) but occurring later in time or farther in distance) associated with this alternative could include positive impacts to fisheries, other birds, vegetation, aquaculture, and hatcheries.

Cumulative effects (i.e., those that result from the incremental impact of the action(s) when added to other past, present, and reasonably foreseeable future actions) associated with this alternative would include possible long-term benefits to vegetation and to populations of fish and other birds and reduced depredation at aquaculture facilities and hatcheries. For example, Farquhar et al. (2001) estimated that consumption of smallmouth bass declined by more than 28 percent (compared to a no management condition) after egg oiling efforts on Little Galloo Island, New York, largely due to fewer overall DCCO feeding days. The cumulative effects of reduced predation of this magnitude should be positive on the fishery relative to the No Action alternative.

Cumulative effects on DCCO populations are not anticipated to be significant. Population monitoring would help ensure this.

4.5 Alternative D: Public Resource Depredation Order (PROPOSED ACTION)

4.5.1 Impacts to Double-crested Cormorants

Relative to the No Action alternative, a Public Resource Depredation Order would likely result in a marked increase in the annual mortality of DCCOs due to the killing of adults and immatures. Over three recent years (1998-2000), the projected total annual take of DCCOs in the contiguous U.S. for depredation control purposes averaged 47,661 birds. This take represents 2.4 percent of the estimated continental population of 2 million birds.

To determine how the take of DCCOs would increase under this alternative and what impact that would have on their populations requires that we take into account several considerations. Since participation of State agencies in the Public Resource Depredation Order would be strictly voluntary, we will assume that no more than 50 percent of the States (excluding Alaska and Hawaii) would elect to authorize the take of DCCOs under it. In addition to States, any Federal (e.g., Bureau of Reclamation, Army Corps of

Engineers, U.S. Forest Service) or Tribal land management agency could carry out control activities on DCCOs roosting, feeding, or nesting on land or water managed under their authority or on private lands (with permission from the appropriate landowners). Agencies that participate will be able to shoot DCCOs with greater efficiency than aquaculture producers do under the Aquaculture Depredation Order (e.g., they will have more resources to expend and will be able to focus their activities in areas in which cormorants are concentrated in greatest abundance). Compared to the Aquaculture Depredation Order (average of 2,185 birds killed annually per participating State), we assume that twice as many DCCOs would be killed annually in each participating State under this alternative, or about 4,370 per State (this amounts to an annual take of 105,000 adult and immature DCCOs).

Additionally, we estimate that Federal and Tribal agencies would kill no more than 38,500 DCCOs annually under authority of the Public Resource Depredation Order. Of approximately 328 DCCO breeding/roosting sites for which land ownership was reported (see Appendix 6), only .6 percent (2 sites) were on Tribal lands and 22.9 percent (75 sites) were on Federal land (Wires et al. 2001). During the public scoping period, no significant concerns were expressed by Tribes or by Federal land management agencies (e.g., Army Corps of Engineers, Bureau of Reclamation, Bureau of Land Management, etc.) so we have reason to believe that take would be relatively low. If 500 birds were killed at each of 77 Federally and/or Tribally-owned DCCO breeding/wintering sites, that amounts to a take of 38,500 birds. Assuming that take under the Public Resource Depredation Order was additive to the 61,000 birds taken under depredation permits and the expanded Aquaculture Depredation Order (as described in section 4.4.1), the estimated total mortality under this alternative would be 204,500 birds, or roughly 10 percent of the continental population.

Table 14. Estimated Take Under Proposed Action

Depredation permits and expanded Aquaculture Depredation Order	61,000
Public Resource Depredation Order (States)	105,000
Public Resource Depredation Order (Tribes and Federal agencies)	38,500
TOTAL	**204,500**

In reality, we expect that the number of adults and immatures killed will be lower than 204,500 birds. First, many agencies will be reluctant to implement any kind of control action under a Public Resource Depredation Order. Second, those agencies that do implement control actions will likely be prudent and conservative in their approach. Control actions will be carefully targeted at local areas in which DCCOs have concentrated in such numbers as to be causing serious damage to public resources. Third, it will likely be difficult for agencies to kill as many DCCOs as they might want (cf. Glahn 2000). Repeated shooting and harassment will likely cause DCCOs to quickly abandon traditional concentration areas and move elsewhere. Finally, some 60 percent of breeding DCCOs occur in Canada. Although these birds could be killed in the U.S. during migration or on the wintering grounds, for at least 3 months of the year they occur outside of the scope of the proposed action.

Adoption of this alternative could result in moderate reductions in annual recruitment of young DCCOs at some colonies by means of egg oiling or destruction. In recent years (1999-2000), just two States have conducted intensive egg oiling under the authority of depredation permits. Since DCCOs are relatively long-lived birds, egg oiling would have to be conducted repeatedly over a period of many years before any effect on adult populations would be evident. Because egg oiling is labor intensive, and because its effectiveness in reducing cormorant damage to public resources is much less immediate than shooting, it may be undertaken by only a few agencies. Additionally, the majority of breeding pairs in the Interior and Atlantic DCCO populations (73 and 59 percent, respectively, which amounts to approximately 60 percent of total breeding birds) will be exempt from egg oiling under this alternative because they nest in Canada (Hatch 1995, USFWS 1998b). Thus, the overall impact of egg oiling on continental and regional DCCO populations would likely be minimal. However, because it is difficult to accurately predict the extent to which egg oiling or destruction activities will be carried out by agencies, we conducted population modeling to determine the effects of various egg oiling regimes (see Appendix 9).

4.5.2 Impacts to Fish

This alternative would be more responsive to concerns about DCCO impacts to fish populations and would be more likely to reduce predation and benefit fish populations than the No Action alternative. It would give States and other agencies increased authority to decide when it is appropriate to carry out control efforts to protect fish from DCCO depredation. As discussed previously, shooting birds may benefit fish in two ways: 1) the immediate effect of removing depredating birds and 2) the secondary effect of scaring away other birds and reinforcing non-lethal harassment efforts. Additionally, killing birds, as opposed to harassing them, avoids the problem of merely moving DCCOs to another area where they could potentially cause damage. Localized egg oiling is a longer term action that has been shown to help reduce predation levels on local fish populations, as described under the No Action alternative.

Responses of DCCOs to localized control efforts will vary from site to site depending on the movements of birds to and from the particular area (e.g., it is possible that shot birds could simply be replaced by immigrating birds). Additionally, the specific effects on fish populations and/or the likelihood of recovery of the fishery are difficult to predict because of uncertainty about the role of DCCO predation relative to other factors limiting fish populations. Reductions in local populations of DCCOs, a top predator in most aquatic ecosystems, is more likely to result in positive secondary or tertiary impacts on fish communities than under the No Action alternative and thus we anticipate that this alternative will prove more effective at reducing impacts than the No Action alternative.

4.5.3 Impacts to Other Birds

While implementation of this alternative could result in increased disturbance of bird species that feed, nest, or roost in association with DCCOs, relative to the No Action alternative the direct and indirect negative impacts of DCCOs on other birds would very likely be reduced under this alternative. Increased incidental take of look-alike species such as Anhingas, Neotropic Cormorants, Great Cormorants, Pelagic Cormorants, and Brandt's Cormorants may occur, although incidental take is anticipated to be insignificant since shooting, especially when carried out by trained wildlife damage professionals as would largely be the case under this alternative, is a highly target specific technique. Agencies carrying out DCCO control actions, especially at breeding colonies, would need to consider mitigative measures to prevent significant disturbance of other bird species.

4.5.4 Impacts to Vegetation

Impacts to vegetation would be dealt with more effectively than under the No Action alternative since the ability to control DCCOs causing such problems would be enhanced. To the extent that control activities prevent the establishment of DCCOs, vegetation at specific locations will be protected. Where vegetative damage has already occurred, recovery will be slow or non-existent, depending on the particular habitat type.

4.5.5 Impacts to Federally-Listed Threatened and Endangered Species

Negative impacts of DCCOs on threatened and endangered species would likely be reduced relative to the No Action alternative. A Biological Assessment currently being prepared by the Service will further evaluate potential effects on federally-listed species.

4.5.6 Impacts to Water Quality and Human Health

Relative to the No Action alternative, local water quality–to the extent that it is impacted by DCCOs–would be expected to improve under this alternative. Concentrations of pathogens (e.g., *E. coli*) in local water bodies might decline proportionally to reductions in the number of DCCOs and problem birds could be managed directly by public agencies when necessary. Since DCCOs are merely a means by which contaminants may be distributed within aquatic ecosystems, not a direct source of the contaminants themselves, reductions in cormorant numbers are not expected to reduce overall contaminant levels.

4.5.7 Economic Impacts

4.5.7a Aquaculture

Control efforts associated with the expanded Aquaculture Depredation Order (i.e., winter roost control) are predicted to enhance the effectiveness of DCCO management carried out under the No Action alternative. Additionally, control efforts associated with the Public Resource Depredation Order are likely to have the secondary benefit of reducing DCCO depredation at aquaculture facilities, or increasing the effectiveness of harassment efforts.

4.5.7b Recreational Fishing Economies

Assuming that the control actions associated with this alternative contributes to a reduction in DCCO predation and a subsequent increase in angler participation, recreational fishing economies could benefit from this action relative to the No Action alternative.

4.5.8 Impacts to Hatcheries and Environmental Justice

Relative to the No Action alternative, depredation of some stocks of hatchery fish would very likely be reduced. Impacts to low income Native American communities dependent on fish raised at Federal hatcheries would also be reduced.

4.5.9 Impacts to Property Losses

Relative to the No Action alternative, property losses would be dealt with more effectively under this alternative. Although property losses do not receive increased consideration under this alternative, reductions in local populations would likely have the secondary impact of reducing property damage.

4.5.10 Impacts to Existence and Aesthetic Values

Existence Value. More DCCOs would be killed under this alternative than under the No Action and thus, to some people, existence value would be compromised. However, overall populations of DCCOs would not be significantly reduced, so effects on existence value would be minimal.

Aesthetic Value. Effects on aesthetic value associated with this alternative would vary depending on individual perspective. For those who find DCCOs aesthetically displeasing, reduced presence associated with control actions carried out under this alternative would be viewed positively. For those who appreciate the sight of DCCOs, aesthetic value would be somewhat compromised, compared to the No Action alternative.

4.5.11 Direct, Indirect and Cumulative Effects

In summary, the chief direct effects (i.e., those caused by the action(s) and occurring at the same time and place) associated with this alternative would be displacement and limited take of nesting, roosting, or feeding DCCOs or their nests or eggs and some displacement of bird species that nest, roost, or feed with DCCOs, as well as limited incidental take. These effects would occur at a higher rate than under the No Action Alternative but are not predicted to be significant.

Indirect effects (i.e., those caused by the action(s) but occurring later in time or farther in distance) would include, in some but not all situations, positive impacts to fisheries, vegetation, other birds, threatened and endangered species, water quality and human health, property losses, aquaculture, and hatcheries. We do not foresee any significant negative indirect effects associated with this alternative.

Cumulative effects (i.e., those that result from the incremental impact of the action(s) when added to other past, present, and reasonably foreseeable future actions) associated with this alternative would include long-term benefits to vegetation and to populations of fish and other birds and reduced depredation at aquaculture facilities and hatcheries. These effects would occur at a greater magnitude than either the No Action or the Increased Local Damage Control alternatives.

Cumulative effects on DCCO populations are not predicted to be significant. Some local populations of DCCOs will likely be eliminated but not to the extent that continental or regional DCCO populations are threatened. The restrictions built into the Public Resource Depredation Order and Federal oversight will help ensure this. See Appendix 9 for results of population modeling.

4.5.12 Other Considerations for the Proposed Action

4.5.12a Mitigating Measures

Adaptive Management, Monitoring, and Mitigation. Adaptive management has played a central role in the management of waterfowl populations in North America, particularly in the establishment of annual harvest regulations (Williams 1989, Williams and Nichols 1990, Johnson et al. 1993, Nichols et al. 1995, Johnson and Williams 1999). Adaptive management is a method for dealing with uncertainty, and provides a protocol for modifying future management activities as new information is received about the effects of past management actions on populations. Because our proposed action does not manage DCCOs at the continental or regional population level, but rather at the local level, there are no specific population objectives to be attained or to evaluate control measures against. In general, our goal is to maintain healthy, viable populations of DCCOs (while increasing management flexibility and alleviating resource conflicts), which we define here as maintenance of continental DCCO populations at no less than 60 percent of current levels. An adaptive management scheme for DCCOs will need to serve two functions: 1) evaluate effects of control measures on DCCO populations and 2) evaluate the extent to which damages are alleviated as the proposed action is implemented. If future information provided by research and other sources (as described below) reveals that DCCO populations are threatened or that specific damages/conflicts associated with DCCOs are not being effectively reduced under the proposed action, the Service would need to re-evaluate its management plans and adjust them accordingly.

1) Population Monitoring
There is no single monitoring technique or survey that will provide reliable information on the future status of DCCO populations. Because of the difficulty of monitoring migratory bird populations, redundancy in the form of multiple monitoring techniques is a decided advantage. One survey may or may not yield trend data that reflects reality. But if data from two or more surveys yields similar trends, then you have greater confidence that the apparent trends are real. The following paragraphs describe some proven and potential monitoring programs/techniques for tracking DCCO population status and trends.

A. **Audubon Christmas Bird Count (BirdSource)** - The entire CBC database (1900-2000) is available online in a searchable format at www.birdsource.org, but detailed analyses of the CBC data are generally not provided.

Top 100 Counts - This is an annual feature provided by the online database. The data can be presented as either the total number of birds seen or as the number seen per party-hour. Depicting trends in the highest count of cormorants is a simple, but potentially misleading, way of tracking changes in the relative abundance of this species on Christmas Bird Counts. Alternatively, annual high counts of cormorants could be compared to annual high counts of some other relatively abundant species, such as the American Crow.

Analysis by States and Provinces - Data on DCCOs has been extracted from the BirdSource CBC database (1900-2000). The resultant database (U.S. Fish and Wildlife Service, unpublished) contains records of 5,807,696 individual cormorants recorded on 33,683 annual counts at the 1,437 sites (or count circles) at which cormorants were detected. The data has been summarized for each of 5 time periods (1900-1959, 1960-1969, 1970-1979, 1980-1999, 1990-1999) by State and province. The data allow a comparison of trends in relative abundance among States and provinces. This database will be updated annually. As data accumulate for the period 2000-2009, it will be compared with data for the period 1990-1999.

B. **Audubon Christmas Bird Count (Patuxent Wildlife Research Center)** - In 1996, Sauer et al. (http://www.mbr.nbs.gov/bbs/cbc.html) provided an initial analysis of CBC data for the period 1959-1988. As a result, the following information is available for DCCOs:

Table of population trends - http://www.mbr.nbs.gov/bbs/cbct/t1200.html
Graph of annual population indices - http://www.mbr.nbs.gov/bbs/cbcgr/h1200gr.html
Comparison of BBS and CBC indices - http://www.mbr.nbs.gov/bbs/cbccomp/h1200cp.html
Map of winter spatial abundance/distribution - http://www.mbr.nbs.gov/bbs/cbcra/h1200ra.html

In 1997, Sauer (http://www.mbr.nbs.gov/cbc/cbcnew.html) presented the 1959-1988 in a slightly different format, including a revised map of winter spatial abundance and distribution (http://www.mbr.nbs.gov/bbs/htm96/cbc622/ra1200.html).

The above analyses have historical importance but, because they include information only for the period 1959-1988, they will be of limited value in assessing current and future status of the double-crested cormorant. However, this data source could again assume great importance in the event that is ever updated to incorporate data from 1989 to the present.

C. **Band Recovery Analysis** - DCCOs were first banded in 1929. In the period 1955-2000 alone, 179,408 cormorants were banded and 8,974 (5.0%) of them were subsequently recovered. This sample of 8,974 banded and recovered cormorants provides an opportunity to monitor trends in survivorship over time. Survivorship is one of the demographic parameters that could be most useful in tracking the impacts of management actions on cormorant populations. Program MARK, which is available in a Windows format at http://www.cnr.colostate.edu/~gwhite/mark/mark.htm, is perhaps the most appropriate and robust software currently available for conducting such an analysis. A band recovery file for the double-crested cormorant can be obtained on request from the U.S. Geological Survey's Bird Banding Laboratory (http://www.pwrc.usgs.gov/bbl/default.htm).

D. **Breeding Bird Atlases** - Multi-year volunteer efforts to document the spatial distribution of breeding birds have been conducted (and the results published) for about 20 States. In most cases, field work was conducted from the mid-1980s to the mid-1990s. For each species, the results are shown as maps and tables. The basic survey unit in each State was a 10 mi x 10 mi (sometimes 5 mi x 5 mi) block. Breeding evidence is presented as Confirmed, Probable, Possible, or Not Observed within each block. The existing published atlases present a picture of cormorant breeding distribution for the period 1985-1995. If (as planned) these States conduct followup atlasing field work in future years, it will be possible to quantitatively document changes (expansions or contractions) in breeding range.

E. **Breeding Colony Surveys** - The standardized and coordinated inventory and monitoring of colonial waterbird colonies in the United States is still in it's infancy (see, for example, http://www.mp1-pwrc.usgs.gov/birds/othbird.html#cwb). Efforts began in a modest way in the early 1970s with development of the Cornell Laboratory of Ornithology's (now defunct) Colonial Waterbird Registry. In the mid-1970s, proposed oil and gas exploration and drilling in U.S. coastal waters prompted initiation of the Outer Continental Shelf Environmental Assessment Program. OCSEAP efforts resulted in extensive inventory of coastal colonial waterbird colonies, with the results published as a series of atlases. Since then, monitoring of waterbird colonies has been conducted with varying degrees of frequency and intensity by Federal and State agencies, nonprofit conservation and environmental organizations, universities, and private individuals. Some of this monitoring data has been published, but most has not, hence the need for an interactive online colony monitoring database. A prototype monitoring database for the West Coast has been developed by the U.S. Geological Survey's Alaska Biological Science Center in conjunction with the Pacific Seabird Group. Similarly, a national monitoring database is under development by the U.S. Geological Survey's Patuxent Wildlife Research Center. The goal of any Statewide or regional program to monitor cormorant breeding populations should be to conduct comprehensive surveys of all colonies at regular intervals of not less than 5 years, and more frequently if possible to document annual variations in colony attendance.

F. ***North American Birds* Regional Reports** - The seasonal regional reports published in *North American Birds* and its predecessors (*Field Notes, National Audubon Society Field Notes, American Birds, Audubon Field-Notes,* and *Bird-Lore*) provide a treasure trove of qualitative and semi-quantitative information on the status, trends, and movements of North American birds. As an example, the Fish and Wildlife Service has compiled (unpublished data) statements made about Double-crested Cormorants that appeared in 1,674 seasonal reports spanning a 52-year period (fall 1946 to winter 1997-1998). Reading these statements in chronological order provides a vivid picture of the changing fortunes of this species throughout its range. We will continue to extract and compile these statements in a text file that will be posted on the Division of Migratory Bird Management's web page.

G. **North American Breeding Bird Survey** - The BBS database is available online in an interactive searchable format at http://www.mbr-pwrc.usgs.gov/bbs/bbs.html, and revised analyses of population trends are provided annually. The BBS was not expressly designed to monitor flocking species such as cormorants, and provides poor coverage of the open-water and nearshore coastal habitats preferred by this species. Nevertheless, the BBS does provide some useful trend data for the Double-crested Cormorant, and BBS trends closely mirror those derived from the Christmas Bird Count and other sources.

H. **Sea Watches or Coastal Counts** - A Sea Watch or Coastal Count can be viewed as the equivalent of a Hawk Migration Count. Observations are made from a stationary point of all waterbirds moving up or down the coast. Counts are normally made daily throughout the spring or fall migration period. The primary object is to document the seasonal timing and magnitude of migratory flights of coastal waterbirds. These counts are most often conducted by local bird observatories, with some spanning several decades (e.g., Avalon, New Jersey). The number and availability of sea watch/coastal count databases, and their usefulness for monitoring regional trends in cormorants, has not been assessed.

I. **Winter Roost Counts** - Aerial counts have been conducted annually in January or February by APHIS/WS in the Mississippi Delta region of northern Mississippi. These counts provide information on the number, location, and approximate size of cormorant night roosts in the vicinity of one of the major catfish producing areas in the nation. These counts will continue to be conducted annually.

J. **Waterfowl Breeding Pairs Survey** - The annual Waterfowl Breeding Pair Survey, which consists of a series of aerial transects across the best waterfowl habitat in North America, provides an opportunity to gather information on the number of cormorants detected on these transects. This information, gathered in a consistent manner from year to year, could provide an independent index of cormorant breeding populations. Of special relevance is the fact that this survey covers the prairie lakes and potholes of Canada, an area that accounts for about 68 percent of the North American DCCO breeding population. The U.S. Fish and Wildlife Service will examine the feasibility of adding the DCCOs to the list of birds counted during this survey beginning in May 2002.

2) Damage Management

Evaluating the effects of our proposed action on DCCO-related damages and conflicts is important too, since part of the purpose of the action is to reduce these. The Service typically receives word of the existence and extent of wildlife conflicts via formal and informal communications with the public, other affected agencies (e.g., APHIS/WS and States), elected representatives (e.g., members of Congress or State legislatures), and internal agency discussions. To the extent that our proposed action alleviates damages and conflicts, we anticipate that concerns expressed by these groups will decline significantly. Additionally, more quantitative means of tracking trends in DCCO conflicts come through reporting requirements and the APHIS/WS Management Information System.

A. **Reports of DCCOs Killed under Depredation Permits and the Depredation Orders** - Individual depredation permits and the Aquaculture Depredation Order require producers to keep a log of DCCOs killed at commercial freshwater aquaculture facilities and State hatcheries, and to make that information available to Service officials when requested. Additionally, under the terms of the Public Resource Depredation Order, responsible agencies are required to report annually the number of DCCOs taken. A periodic review and assessment of this information will allow the Service to track trends in the number of birds being killed which could be an indirect measure of the degree to which they are viewed as a problem. The first such survey of aquaculture producers was conducted in mid-2001.

B. **APHIS/Wildlife Services Management Information System** - This database tracks complaints from landowners about damages to private property and agricultural crops caused by wildlife, including cormorants. Tracking complaints about DCCOs may yield information on the geographic areas in which they are of greatest concern, and may help to determine if control actions are having the desired result of reducing conflicts with human interests.

C. **Trends in Depredation Permit Issuance** - Each Regional Migratory Bird Permit Office keeps records of depredation permits issued by year, species, and resource category. This information could be tracked to follow trends in permit issuance as new management programs are implemented.

3) Mitigation

A. **A General Overview**

Under NEPA, there are five ways of dealing with significant environmental effects: avoiding the impact by not taking certain action or parts of an action; minimizing impacts by limiting the degree or magnitude of the action and its implementation; rectifying the impact by repairing, rehabilitating, or restoring the affected environment; reducing or eliminating the impact over time by preservation and maintenance during the life of the action; and compensating for the impact by replacing or providing substitute resources or environments.

The two categories of mitigation most applicable to the current situation are avoidance and minimization. These can be incorporated as conditions that responsible agencies must abide by in undertaking activities under the depredation order (e.g., requirement to use lead shot only, thus mitigating the impacts of lead poisoning on non-target birds and other wildlife). The adoption of monitoring programs (including annual reports) and adaptive monitoring techniques could also be considered mitigation techniques, as well as the provision allowing us to suspend the privilege of agencies to take action under the Public Resource Depredation Order.

B. **Specific Examples**

Carney and Sydeman (1999) noted that techniques such as limiting the number and duration of intrusions (to nesting sites), minimizing physical contact with birds, and moving slowly while in colonies can serve to minimize negative impacts on most colonial waterbird species. They reported that negative impacts to Ring-Billed Gulls were "nearly eliminated" when measures such as visiting colonies early in the day to avoid thermal stress, avoiding unnecessary chick handling, and moving slowly through colonies were carried out. On islands with mixed seabird colonies in the St. Lawrence River Estuary, Bédard et al. (1999) minimized disturbance to sensitive species such as Razor-billed Auks, Common Eiders, and Black-crowned Night-Herons by coordinating control and census efforts into a single visit. During DCCO management activities on Little Galloo Island, Lake Ontario, New York, efforts are made to limit the time spent in close proximity to the Caspian Tern (a sensitive species) colony there (NYSDEC 2000).

Laser guns have been marketed to startle DCCOs in low-light conditions (Wires et al. 2001, Hatch and Weseloh 1999). McKay (1999) reported that laser guns have been used effectively against Great Cormorants in England, Wales, France, and Italy. This technique effectively reduced numbers of birds at night roosts as well as numbers feeding in nearby ponds in England and Wales. These investigators recommended this technique be utilized especially in regions where pyrotechnics will disturb other species.

Specific mitigation measures associated with the proposed action include:

1) Lethal control techniques allowed under the Public Resource Depredation Order are limited to

shooting, egg oiling and destruction, and nest destruction, all of which are highly target specific. Additionally, non-toxic shot is required for use in shotguns, further limiting effects on non-target species.

2) Population surveys of DCCOs will be conducted at regular (~5-year) intervals to monitor impacts to local, regional, and national populations.

3) Agencies taking DCCOs under the Public Resource Depredation Order must annually report the number of birds killed. Additionally, if they choose to carry out control at breeding colonies, they must conduct a baseline (i.e., before control) colonial waterbird survey of the affected area and subsequent annual surveys for each year of control. The results of these surveys must be reported to the Service annually.

4) The Service retains the authority to suspend or revoke an agency's authority to conduct control under the Public Resource Depredation Order if they fail to adhere to its terms and conditions, if we determine that DCCOs are no longer a threat to the public resource, or if the viability of DCCO populations is threatened.

5) Individuals and agencies taking DCCOs under the Aquaculture Depredation Order must keep records of numbers of birds taken and provide this information to the Service upon request.

6) The Service will regularly assess take reports and population monitoring information to ensure the compatibility of the proposed action with the long-term conservation of DCCO populations.

4.5.12b Unavoidable Adverse Impacts

This section refers to those adverse effects that cannot be avoided as a result of management activities carried out under the proposed action. Implementation of the proposed action is intended to move toward an overall improved condition, but adverse environmental effects will occur. DCCOs will be killed (and/or their nests and eggs will be destroyed) under this alternative, with the possibility that some local populations would be reduced or eliminated; however, there are no anticipated significant negative effects on DCCO populations. Disturbance to other bird species that nest, roost, or feed in the vicinity of DCCOs is very likely, although significant adverse effects are not anticipated. Aquaculture producers will continue to experience economic losses due to DCCO depredation, although to a lesser degree than under the No Action alternative.

4.5.12c Short-term Effects and Long-term Productivity

The control activities carried out under this alternative will, in some cases, lead to short-term disturbance of breeding colonies. However, it is anticipated that these actions will lead to increases in long-term productivity due to the increased avian biodiversity resulting from reduced DCCO presence. Additionally, it is anticipated that DCCO control activities will lead to increased productivity of specific fisheries and will lessen the overall economic impact of DCCO depredation at aquaculture and hatchery facilities.

4.5.12d Irreversible or Irretrievable Commitments of Resources

Expenditure of funds to implement activities in the proposed action would be an irreversible commitment of monetary resources. An irreversible commitment of resources is one that results from an action that prevents an area or a resource type from returning to its natural condition for an extended period of time, or one that utilizes non-renewable resources. The only irreversible commitment of resources anticipated under the proposed action would be the use of fossil fuels for energy as DCCO management activities are carried out.

Irretrievable commitments of resources occur when we forego the opportunity to use or produce a specific resource for a period of time while favoring the production of another resource. The commitments are irretrievable rather than irreversible because the reversal of management decisions would allow uses of these resources to occur again. Management actions under the proposed action could result in irretrievable commitments if they caused any inadvertent damage and subsequent loss of threatened, endangered, or otherwise sensitive wildlife and plant species.

4.6 Alternative E: Regional Population Reduction

4.6.1 Impacts to Double-crested Cormorants

According to demographics information (section 3.1.1c), DCCO populations are thriving and have, for the most part, steadily increased over the past 20 years. We predict that it is unlikely that the long-term health of continental DCCO populations would be threatened significantly by reducing local and regional populations, if done in a controlled manner.

Reduction of regional DCCO populations would be carried out via extensive localized control efforts. Glahn et al. (2000b) suggested that DCCO populations be managed on a "flyway" basis, using a goal-oriented population model to guide management decisions. The objective would be to reduce localized conflicts by managing regional cormorant populations. While no consensus on the biological and/or social carrying capacities for DCCOs currently exists (and thus we cannot realistically state population objectives at this time), insights from population modeling and resource economics, in addition to dialogue among interested agencies and organizations, could contribute to the development of biologically and socially acceptable population goals (Glahn et al. 2000b). As stated in the analysis of the No Action alternative, current damage control efforts help to reduce cormorant depredations but apparently have little overall effect on regional populations (Belant et al. 2000, Glahn et al. 2000a, Mott et al. 1998). Therefore, methods of control such as shooting, egg oiling, and nest destruction would need to be implemented at a greater level with the likelihood that some local populations of DCCOs would be significantly reduced or eliminated.

4.6.2 Impacts to Fish

Reducing regional populations of DCCOs would be more likely to reduce predation rates on fisheries than the No Action alternative. As described under the No Action alternative, local population control efforts have been shown to reduce predation levels on local fish populations.

4.6.3 Impacts to Other Birds

Relative to the No Action alternative, the direct and indirect negative impacts of DCCOs on other birds would very likely be reduced under this alternative. Implementation of this alternative could result in considerably increased disturbance of bird species that feed, nest, or roost in association with DCCOs and increased incidental take of look-alike species such as Anhingas, Neotropic Cormorants, and Great Cormorants. However, incidental take is anticipated to be insignificant since shooting, especially when carried out by trained wildlife damage professionals as would largely be the case under this alternative, is a highly target specific technique.

One important concern with this alternative, however, is whether or not control actions sufficient enough to bring about reductions in DCCO populations could be carried out without major disturbances to other bird species. Preventative mitigation measures would need to be employed.

4.6.4 Impacts to Vegetation

Impacts to vegetation would be dealt with more effectively than under the No Action alternative since the ability to control DCCOs causing such problems would be enhanced. With population reductions originating at the local level and objectives focusing on reducing damage, control activities carried out under this alternative should help alleviate these conflicts. Where vegetative damage has already occurred, recovery will be slow or non-existent, depending on the particular habitat type.

4.6.5 Impacts to Federally-Listed Threatened and Endangered Species

Reducing regional populations of DCCOs would be more likely to reduce negative impacts on threatened and endangered species than the No Action alternative. With population reductions originating at the local level and objectives focusing on reducing damage, control activities under this alternative should help alleviate these conflicts where they occur, although their ability to significantly contribute to recovery of these species is probably limited due to the importance of other factors.

4.6.6 Impacts to Water Quality and Human Health

Similar to the discussion under the previous alternative, local water quality would be expected to improve relative to the No Action alternative, to the extent that it is impacted by DCCOs. Concentrations of pathogens (e.g., *E. coli*) in local water bodies might decline proportionally to reductions in the number of cormorants. Since DCCOs are merely a means by which contaminants may be distributed within aquatic ecosystems, not a direct source of the contaminants themselves, reductions in cormorant numbers are not expected to reduce overall contaminant levels although, under this alternative, they may do so at the site-specific level.

4.6.7 Economic Impacts

4.6.7a Aquaculture

Glahn et al. (1999) concluded that currently available DCCO control techniques are "of limited effectiveness and are becoming increasingly difficult to implement." They predicted that increases in DCCO population sizes will further reduce the effectiveness of these techniques and suggested that effective management of cormorants for reducing depredation to southern aquaculture will likely require more intensive control on the wintering grounds, control on the breeding grounds, or a combination of both. Reinhold and Sloan (1999) also suggested that "management implications should focus more on the long term goals of managing DCCO populations."

However, in discussion and modeling of management scenarios for European Great Cormorants, it has been suggested that reducing the size of the overall population may not result in equivalent reductions in the number of cormorants occurring at high quality foraging areas, such as aquaculture facilities (Bregnballe et al. 1997; Van Eerden and van Rijn 1997 in Wires et al. 2001). Because foraging habitats vary in quality and cormorants are efficient at detecting high quality foraging sites, overall population reductions may first cause birds to disappear from least preferred or low quality areas, and declines may be less marked in high quality areas (Hodges 1989; T. Bregnballe, pers. comm. in Wires et al. 2001). Additionally, scale of damage caused by DCCOs may not be directly related to total numbers in local areas (Bregnballe et al. 1997).

Furthermore, the relationship between control activities carried out in one location and resource conflicts occurring in another is not a predictable one. In the case of southern aquaculture, most of the depredating DCCOs occur for much of the year in northern breeding grounds (e.g., the Great Lakes) and then migrate to wintering grounds in another region (e.g., the Mississippi Delta). By analyzing band-recovery data, Dolbeer (1991) found that birds in the southern Mississippi region originated from breeding areas as far west as Alberta and as far east as New England. The data suggest that, while Lakes Michigan and Superior were the most important sources of DCCOs wintering in the lower Mississippi Valley, significant numbers of DCCOs also came from the region between Saskatchewan and eastern Lake Ontario. Hatch (1995:19), citing Dolbeer (1991), stated that "wintering birds that eat a Mississippi farmer's catfish could come from anywhere across the 3000 km [1850 mile] breeding range of the populations that winter there."

Currently, satellite telemetry is being used to further investigate the migration patterns of DCCOs wintering in Alabama, Arkansas, Louisiana and Mississippi. Preliminary results of this research also indicate that birds wintering in the Delta region originate from across the Interior population's breeding range (S. Werner, APHIS/WS, pers. comm.). Based on these data, controlling breeding DCCOs to reduce numbers of birds on the wintering grounds would likely require a tremendous effort to be successful and would require a coordinated effort among the four regions. According to J. Glahn (APHIS/WS, pers. comm.), the increase in numbers of DCCOs wintering in the Delta region of Mississippi has been proportionally larger than the increase in numbers of catfish ponds in the area. Thus, it is very possible that even broad reductions in DCCO populations would be unlikely to eliminate the need to continue local exclusion and harassment efforts.

Nonetheless, population reductions would likely make efforts to manage existing depredating birds more effective and thus we predict that reducing regional DCCO populations (in particular birds of the Interior population) would be more likely to reduce depredation of aquacultural resources than the No Action alternative.

4.6.7b Recreational Fishing Economies

Reducing regional populations of DCCOs would likely reduce predation rates on fish resources more effectively than the No Action alternative. This reduction in predation would benefit the local economies that are closely tied to recreational fishing if angler participation increases subsequently.

4.6.8 Impacts to Hatcheries and Environmental Justice

Reducing regional populations of DCCOs would likely help reduce depredation of hatchery stocks more effectively than the No Action alternative. Impacts to low income Native American communities dependent on fish raised at Federal hatcheries would also be reduced.

4.6.9 Impacts to Property Losses

Relative to the No Action alternative, property losses would be dealt with more effectively under this alternative. Although property losses do not receive increased consideration under this alternative specifically, reductions in regional populations would likely have the secondary impact of reducing property damage.

4.6.10 Impacts to Existence and Aesthetic Values

Existence Value. More DCCOs would be killed under this alternative than under the No Action and thus, to some people, existence value would be compromised. However, overall populations of DCCOs would not be significantly reduced, so effects on existence value would be minimal.

Aesthetic Value. Effects on aesthetic value associated with this alternative would vary depending on individual perspective. For those who find DCCOs aesthetically displeasing, reduced presence associated with control actions carried out under this alternative would be viewed positively. For those who appreciate the sight of DCCOs, aesthetic value would be somewhat compromised, compared to the No Action alternative.

4.6.11 Direct, Indirect and Cumulative Effects

The chief direct effects (i.e., those caused by the action(s) and occurring at the same time and place) associated with this alternative would be displacement and limited take of nesting, roosting, or feeding DCCOs or their nests or eggs and some displacement of bird species that nest, roost, or feed with DCCOs. Some incidental take of look-alike species is likely but not expected to be significant if proper mitigative measures are carried out. All of these effects would occur at a higher rate than under the No Action Alternative.

Several indirect effects (i.e., those caused by the action(s) but occurring later in time or farther in distance) are likely under this alternative. Because population objectives would be tied to specific damages, positive impacts to fisheries, vegetation, threatened and endangered species, water quality and human health, aquaculture, and hatcheries would be expected to occur as a result of lower overall numbers of DCCOs. We do not foresee any significant negative indirect effects associated with this alternative.

Cumulative effects (i.e., those that result from the incremental impact of the action(s) when added to other past, present, and reasonably foreseeable future actions) associated with this alternative would include long-term benefits to vegetation and to populations of fish and other birds and reduced depredation at aquaculture facilities and hatcheries.

The most significant potential negative cumulative effect associated with this alternative is that DCCO populations might be threatened by successive years of population control. However, this alternative would be carried out in such a way that risks to viable regional and continental DCCO populations would be minimized (e.g., through the use of population goals and monitoring). Cumulative impacts to other birds that would be disturbed or killed by DCCO population reduction efforts are an important concern as well. It is unclear whether or not the benefits of less competition with DCCOs would outweigh the costs associated with regional DCCO control actions.

4.7 Alternative F: Regulated Hunting Season

4.7.1 Impacts to Double-crested Cormorants

The number of DCCOs killed by hunters would be variable depending on hunter success and the number of States participating. Hunting of DCCOs would take place at any area open for legal hunting, including sites where DCCOs are a nuisance. DCCOs would typically be hunted in open water feeding and loafing areas and at roosting locations. Due to the aquatic nature of DCCO habitat, it is expected that, in addition to those interested in only hunting DCCOs, other participants would largely be waterfowl hunters. To maximize participation, hunting seasons would follow similar seasons as waterfowl and take place during the fall, winter, and spring migration months with juvenile and adult birds of both sexes being harvested, although males are expected to be taken at a higher level than females (Campo et al. 1993, Glahn et al. 1995, Glahn et al.1999).

The number of hunters participating in a DCCO hunting season is expected to be low when compared to other game species because of two key concerns. First, there may be a lack of desire on the part of most hunters to kill a non-traditional species such as cormorants. Bédard et al. (1999) commented that it would be “a mistake to turn into game a species that has been excluded from the hunter’s bag for 80 years.” They felt that cormorants do not inspire respect among waterfowl hunters and would likely not be used as “real game.” Finally, the inability to consume birds because of low palatability and/or because they carry high contaminant loads would probably further limit the number of hunters willing to harvest DCCOs.

Since lethal actions could be taken during a hunting season without first obtaining a depredation permit, it is expected that more DCCOs would be killed than under the No Action alternative. However, hunter avoidance behavior exhibited by DCCOs will limit the number of DCCOs harvested (Glahn et al. 2000a, Bregnballe et al. 1997). Collection of DCCOs for a food habit study in open water habitat, using firearms, resulted in a minimal number of birds being taken (average < 1%) when compared to the number of DCCOs feeding in the lake prior to shooting (Glahn et al. 1998). Decoys and blinds were not used in this study, but have been used to successfully lure DCCOs into shooting range (Bur et al. 1999, Glahn et al. 1995) and would likely increase the success of shooting DCCOs (USFWS 1998b). Glahn (2000a) found that, despite deploying skilled marksmen to shoot DCCOs in winter roosts, only a relatively small number of DCCOs (<5% of the roosting population) were killed while attempting to enter night roosting sites.

Conover (2001) wrote that hunting is one of the “few human activities that reinforces an animal’s fear of humans.” Bregnballe et al. (1997) predicted that increased shyness toward humans associated with hunting would more greatly restrict cormorants’ choices of breeding and feeding areas and their choices of loafing and roosting sites. As a result, more individuals would stay in safe (i.e., non-hunted) areas and competition would increase for available resources which would likely lead to increased density-dependent effects on populations.

The relationship between hunting pressure and population size is not linear, due to the buffering effect of density-dependence (Bregnballe et al. 1997). While there would be an anticipated compensatory response in the population, the increased mortality caused by hunting could, depending on the length of the season and hunter interest in shooting cormorants, likely be an important tool in reducing the size of the cormorant population. Model predictions by Bregnballe et al. (1997) showed that hunting cormorants in the fall would lead to a lower overall population and to a lower breeding population; these effects will be more pronounced the higher hunting mortality is and the weaker density-dependent winter mortality is.

Overall impacts to DCCO populations would include the number of DCCOs killed under the No Action alternative in addition to the number of birds harvested under a hunting season. Annual DCCO mortality (hunters + permits + Aquaculture Depredation Order) is expected to be no more than 10 percent (~200,000) of the estimated continental DCCO population of 2 million birds. A 10 percent annual reduction of the continental population of DCCOs would be more than offset by the recruitment of young birds into the population each year (USFWS 1998b). On Prince Edward Island, Canada, a hunting season on DCCOs had no significant impact on the population there (Korfanty et al. 1997). We predict that a hunting season in addition to the continuation of current management practices would have no significant negative impact on continental DCCO populations, although it might reduce certain regional populations to some extent.

4.7.2 Impacts to Fish

Hunting would reduce DCCO predation rates more effectively than the No Action alternative, but this would be variable based upon hunter participation and success. It would likely be used as a means of reducing fish depredation at many locations and could help alleviate impacts to fish population.

4.7.3 Impacts to Other Birds

Direct and indirect negative impacts to other bird species would be more likely to be reduced than under the No Action alternative, but actual effects would be variable based upon hunter participation and success. By-kill, especially of look-alike species such as Great Cormorants, Neotropic Cormorants, and Anhingas, would occur more frequently than under the No Action alternative. This would be a greater concern under this alternative than others because much of the killing is being conducted by the public rather than trained wildlife damage professionals. In the case of Great Commorants, for example, in Prince Edward Island, Canada, legal hunting of DCCOs reduced local Great Cormorant populations by 50 percent (Korfanty et al. 1997). In order to alleviate potential impacts to Great Cormorants it would possibly be necessary to restrict hunting in areas where the two species' ranges overlap. Hunting would not be allowed during the spring nesting season in any areas.

4.7.4 Impacts to Vegetation

Impacts to vegetation would be more effectively reduced than under the No Action alternative. Management practices under the No Action alternative would continue plus some hunting would likely target individuals responsible for damage to vegetation.

4.7.5 Impacts to Federally-Listed Threatened and Endangered Species

Hunting would be more likely to reduce DCCO predation on threatened and endangered species than the No Action alternative, but actual effects would be variable based upon hunter participation and success.

4.7.6 Impacts to Water Quality and Human Health

Similar to previous conclusions, local water quality–to the extent that it is impacted by DCCOs–would be expected to improve under this alternative relative to the No Action alternative. Concentrations of pathogens (e.g., *E. coli*) in local water bodies might decline proportionally to reductions in the number of cormorants and birds could be directly controlled at specific sites. Since DCCOs are merely a means by which contaminants may be distributed within aquatic ecosystems, not a direct source of the contaminants themselves, reductions in cormorant numbers are not expected to reduce overall contaminant levels.

The human consumption of DCCOs would, for health reasons, not be advisable due to high contaminant loads. Statewide advisories are commonly issued to warn the public of the potential for widespread contamination of certain species of fish or certain species of wildlife. Mercury, PCBs, chlordane, dioxins, and DDT (DDE and DDD) were at least partly responsible for 99 percent of all fish consumption advisories in effect in 1999 (EPA 1999a). One hundred percent of Great Lakes waters and their connecting waters are under advisory for restricted consumption of fish or certain wildlife coming from these waters (EPA 1999a). Seventeen States (Alabama, Connecticut, Florida, Indiana, Louisiana, Maine, Massachusetts, Michigan, Missouri, New Hampshire, New Jersey, New York, North Carolina, Ohio, Rhode Island, Texas, and Vermont) and Washington, D.C. currently have statewide advisories in effect. In any State where there is a statewide advisory against the consumption of fish, DCCOs should not be consumed.

4.7.7 Economic Impacts

4.7.7a Aquaculture

Hunting would likely reduce depredation of aquaculture stock more effectively than under the No Action alternative, but actual effects would be variable based upon hunter participation and success. In addition to killing birds, hunting would be an effective supplement to roost dispersal programs. Glahn (2000) concluded that shooting with live ammunition is at least equally effective as pyrotechnics for dispersing DCCOs from their night roosts. Conover (2001) also noted that hunting is likely to increase the effectiveness of non-lethal techniques.

4.7.7b Recreational Fishing Economies

Hunting would be more likely to benefit local economies than the No Action alternative, but actual effects would be variable based upon hunter participation and success as well as whether or not take of DCCOs associated with hunting effectively contributes to increased angler participation.

4.7.8 Impacts to Hatcheries

Hunting would likely help reduce depredation at fish hatcheries more effectively than under the No Action alternative, depending on hunter participation and success and the proximity of hunting areas to hatchery sites. Impacts to low income Native American communities dependent on fish raised at Federal hatcheries would also be reduced.

4.7.9 Impacts to Property Losses

Losses to property would be more effectively reduced than under the No Action alternative. In some cases, hunting could be used as a tool to directly control damage to property.

4.7.10 Impacts to Existence and Aesthetic Values

Existence Value. More DCCOs would be killed under this alternative than under the No Action and thus, to some people, existence value would be compromised. However, overall populations of DCCOs would not be significantly reduced, so effects on existence value would be minimal.

Aesthetic Value. Effects on aesthetic value associated with this alternative would vary depending on individual perspective. For those who find DCCOs aesthetically displeasing, reduced presence associated with control actions carried out under this alternative would be viewed positively. For those who appreciate the sight of DCCOs, aesthetic value would be somewhat compromised, compared to the No Action alternative.

4.7.11 Direct, Indirect and Cumulative Effects

In summary, the chief direct effects (i.e., those caused by the action(s) and occurring at the same time and place) associated with this alternative would be displacement and limited take of nesting, roosting, or feeding DCCOs or their nests or eggs and some displacement and incidental take of bird species that nest, roost, or feed with DCCOs. All of these effects would occur at a higher rate than under the No Action Alternative.

Indirect effects (i.e., those caused by the action(s) but occurring later in time or farther in distance) would include, in some but not all situations, positive impacts to fisheries, vegetation, threatened and endangered species, property losses, water quality and human health, aquaculture, and hatcheries. Because hunting would make DCCOs more wary of humans, we anticipate that it will significantly reinforce non-lethal management efforts and increase the effectiveness of these techniques.

Cumulative effects (i.e., those that result from the incremental impact of the action(s) when added to other past, present, and reasonably foreseeable future actions) associated with this alternative could include long-term alleviation of impacts to fisheries, other birds, vegetation, threatened and endangered species, property losses, water quality and human health, aquaculture, and hatcheries. As long as DCCO populations are adequately monitored and hunting regulations adjusted accordingly, we anticipate that risks to their populations would be minimal. Incidental take of look-alike species would occur under this alternative and would also need to be kept track of in order to minimize risks to the populations of these species.

Table 15. Impacts by Alternatives

IMPACTS	**ALTERNATIVE A: No Action**	**ALTERNATIVE B: Non-lethal Management**	**ALTERNATIVE C: Increased Local Damage Control**
Biological			
DCCO populations	No significant impact to regional or continental populations; estimated take of 47,128	No significant negative impacts; zero take	No significant impacts to regional or continental populations; estimated take of 61,000
Other bird populations	Some local disturbance, but no significant impact to regional or continental populations; appears to not be effectively alleviating conflicts	Some local disturbance, but no significant impact to regional or continental populations; would be less effective than No Action	Some local disturbance, but no significant impact to regional or continental populations; would be more effective than No Action
Fish	Potential for site-specific impacts; depredation permits have not been issued for this reason	Less effective than the No Action	Would be more likely than the No Action to alleviate predation impacts
Vegetation/ habitat	Localized destruction occurs; few depredation permits have been issued for this reason	Less effective than the No Action	More effective than No Action
T&E species	Concern about impacts to salmonids but DCCOs not considered primary cause of declines; depredation permits	As effective as the No Action	As effective as the No Action

	have not been issued for this reason		
Socioeconomic			
Water quality and human health	Limited effectiveness	Limited effectiveness	Limited effectiveness
Aquaculture	Somewhat effective at reducing depredation	Less effective than the No Action	More effective than No Action
Recreational fishing economics	Depredation permits have not been issued for this reason	Less effective than the No Action	More effective than No Action
Fish hatcheries and environmental justice	Somewhat effective at reducing depredation	Less effective than the No Action	More effective than No Action
Property losses	Somewhat effective	Less effective than the No Action	As effective as the No Action
Existence and aesthetic value	Numerous DCCOs exist; effects on aesthetic value vary with perspective	Same as No Action	Same as No Action

IMPACTS	**ALTERNATIVE D: Public Resource Depredation Order PROPOSED ACTION**	**ALTERNATIVE E: Regional Population Reduction**	**ALTERNATIVE F: Regulated Hunting**
Biological			
DCCO populations	Some local populations may be reduced or eliminated but no significant impacts to regional or continental populations; estimated take of 204,500	Very substantial, but currently unknown, increase in take; goal would be to significantly reduce regional populations	No significant impacts to regional or continental populations; estimated take of 200,000
Other bird populations	Some local disturbance, but no significant impacts to regional or continental populations; more effective than No Action	Some local disturbance, but significant impacts to regional or continental populations not anticipated; more effective than No Action	Some local disturbance, and high potential for moderate increase in take of look-alike species, but no significant impact to regional or continental populations; likely to be more effective than No Action
Fish	Would be much more likely than the No Action to alleviate predation impacts	Would be much more likely than the No Action to alleviate predation impacts	Impacts uncertain because of spatial and temporal disjunction between depredation problems and hunting areas/seasons;

			likely to be more effective than the No Action
Vegetation/ habitat	More effective than No Action	More effective than No Action	Impacts uncertain, but likely to be more effective than No Action
T&E species	More effective than No Action	More effective than No Action	Impacts uncertain, but likely to be more effective than No Action
Socioeconomic			
Water quality and human health	Limited effectiveness	Limited effectiveness	Limited effectiveness
Aquaculture	More effective than No Action	More effective than No Action	Impacts uncertain, but likely to be more effective than No Action
Recreational fishing economics	More effective than No Action	More effective than No Action	Impacts uncertain, but may be positive in localized areas
Fish hatcheries and environmental justice	More effective than No Action	More effective than No Action	Impacts uncertain, but likely to be more effective than No Action
Property losses	More effective than No Action	More effective than No Action	More effective than No Action
Existence and aesthetic value	Same as No Action	Significantly fewer DCCOs would exist regionally and continentally; effects on aesthetic value would vary with perspective	Same as No Action