CHAPTER 3: AFFECTED ENVIRONMENT

The "affected environment" section of an EIS should "succinctly describe the environment of the area(s) to be affected by the alternatives under consideration" (40 CFR 1502.15). Thus, this chapter contains a discussion of the biological and socioeconomic conditions raised during scoping and considered by the Service and APHIS/WS to be significant.

3.1 Biological Environment

3.1.1 Double-crested Cormorants

The Service's goals in migratory bird management are to conserve DCCO populations at sufficient levels to prevent them from becoming threatened or endangered and to ensure that American citizens have continued opportunities to enjoy DCCOs.

3.1.1a Species Range

DCCOs are native to North America and range widely there. There are essentially five different breeding populations, variously described by different authors as: Alaska, Pacific Coast, Interior, Atlantic, and Southern. See Appendix 3 for a DCCO range map. Recent population expansion, however, has blurred the boundaries for the Interior, Atlantic, and Southern populations (Hatch and Weseloh 1999, Wires et al. 2001). There is high variation in the migratory tendencies of these different breeding populations. Birds that breed in Florida and elsewhere in the Southeastern U.S. are essentially sedentary, those along the Pacific coast are only slightly migratory, with the Atlantic and Interior birds showing the most significant seasonal movements (Johnsgard 1993). The two primary migration routes appear to be down the Atlantic coast and through the Mississippi-Missouri River valleys to the Gulf coast (Palmer 1962) with increasing numbers of birds remaining in the Mississippi Delta (Jackson and Jackson 1995).

3.1.1b Habitat Requirements

In the breeding season, two factors are critical to DCCOs: suitable nesting sites and nearby feeding grounds (van Eerden and Gregersen 1995, Hatch and Weseloh 1999, Wires et al. 2001). Ponds, lakes, slow-moving rivers, lagoons, estuaries and open coastlines are utilized. Small rocky or sandy islands are utilized when available. Nests are built in trees, on structures, or on the ground. Nesting trees and structures are usually standing in or near water, on islands, in swamps, or at tree-lined lakes.

Nonbreeding habitats are diverse and include lakes, ponds, rivers, lagoons, estuaries, coastal bays, marine islands, and open coastlines (Johnsgard 1993). Wintering DCCOs require similar characteristics in feeding, loafing, and roosting sites as when breeding. Where DCCOs winter on the coast, sandbars, shoals, coastal cliffs, offshore rocks, channel markers, and pilings are used for roosting. Birds wintering along the lower Mississippi River roost on perching sites such as trees, utility poles, or fishing piers and in isolated cypress swamps (Reinhold and Sloan 1999, Wires et al. 2001). In all seasons DCCOs require suitable places for nighttime roosts and daytime resting or loafing. Roosts and resting places are often on exposed sites such as rocks or sandbars, pilings, wrecks, high-tension wires, or trees near favored fishing locations (Wires et al. 2001).

Post-breeding, pre-migratory roosts. From the time DCCOs return to their breeding colonies in the spring until the adults are brooding young, the colony site is their main "center of activity," (i.e., they roost at the colony overnight and their daily foraging activities emanate from there). While most adults are attending young, however, auxiliary overnight roosts begin to develop. These may be on nearby unoccupied islands or they may be several miles away. The origin of the birds forming these roosts is not known for certain but they are most likely adults who have failed in their breeding attempts and/or non-breeding birds. The net result is that a new or additional “center of activity” is created in an area where the birds themselves do not otherwise breed. These late season roosts often remain active until the birds have left on migration in September or October. For example, DCCOs do not breed in the Bay of Quinte, a 60 mile-long, Z-shaped bay in northeastern Lake Ontario. However, in June, well before the migratory season, DCCOs begin to roost, at night, on islands in the bay and their numbers increase there through September. Birds come from these islands on daily foraging trips and have, in essence, established new centers of activity that are not related to the breeding colony, nor are they (yet) comprised of migrant birds (D.V. Weseloh, CWS, pers. comm.).

3.1.1c Double-crested Cormorant Demographics

Demographics. The DCCO is the most abundant of five species of cormorants occurring in the contiguous United States. A conservative estimate of the total population of DCCOs in the U.S. and Canada is greater than 1 million birds, including breeding and non-breeding individuals, but is probably closer to 2 million (Tyson et al. 1999). We estimate that the current continental population of DCCOs is approximately 2 million birds (J. Trapp, USFWS; L. Wires, Univ. of Minnesota; D.V. Weseloh, CWS; pers. comm.). While the total number of DCCOs in North America increased rapidly from the 1970s into the 1990s (Hatch 1995), estimates of Tyson et al. (1999) indicated that the overall rate of growth in the U.S. and Canada slowed during the early 1990s. This is consistent with observations of declines in the growth rate of expanding Great Cormorant populations in northwestern Europe (van Eerden and Gregersen 1995).

For the U.S. as a whole, according to Breeding Bird Survey (BBS) data (which are only indices of *relative* abundance), the breeding population of DCCOs increased at a statistically significant rate of approximately 7.9 percent per year from 1975-2000 (Sauer et al. 2001). Within this period, growth rates of regional populations varied substantially and thus it is important to look at DCCO population growth rates from a regional perspective as well. Here we use the breeding populations defined in Wires et al. 2001 (Northeast Atlantic, Interior, Southern, and Pacific Coast). These correspond largely to Tyson et al.’s (1999) four regions: Atlantic, Interior, Southeast, and West Coast-Alaska, summarized below in Table 8.

Table 8. DCCO Breeding Populations (from Tyson et al. 1999)

	Estimated # of nesting pairs	Percent of continental population	Estimated population growth rate *
Atlantic	85,510	23%	-6.5% (15.8%)
Interior	256,212	68%	6.0% (20.8%)
Southeast	13,604	4%	2.6% (76.9%)
West Coast-Alaska	17,084	5%	-7.9% (-0.6%)
TOTAL	> or = 372,410		2.6% (16.2%)

* number in parentheses indicates “category A” estimates (i.e., results of surveys in which nests were systematically counted)

Atlantic. Twenty-three percent of North America's DCCOs are found in the Atlantic population (Tyson et al. 1999). In this region, DCCOs are strongly migratory and occur with smaller numbers of Great Cormorants. From the early 1970s to the early 1990s, the Atlantic population increased from about 25,000 pairs to 96,000 pairs (Hatch 1995). While the number of DCCOs in this region declined by 6.5 percent overall in the early to mid-1990s, some populations were still increasing during this period (Tyson et al. 1999). Very large numbers breed in Quebec and the surrounding area (including the St. Lawrence River and its estuary) and in Nova Scotia and Prince Edward Island. Very large breeding concentrations also occur in New England along the coasts of Maine and Massachusetts. With the exception of Maine (where numbers began declining between the mid-1980s and early 1990s), rapid increases have occurred since the 1970s (Wires et al. 2001). From 1977 to the 1990s, the number of DCCOs in the northeastern U.S. increased from 17,100 nesting pairs to 34,200 pairs (Krohn et al. 1995). In parts of southern New England (Connecticut, Rhode Island, coastal New York) the DCCO has recently been documented as a breeding species and numbers are growing fairly rapidly. First breeding records were obtained in New Jersey and Pennsylvania between the late 1970s and 1990s (Wires et al. 2001). The estimated number of nesting pairs in this population is ≥85,510 (Tyson et al. 1999).

Small numbers of DCCOs winter in some New England States but most Atlantic birds winter along the coast from Virginia (where numbers of wintering birds are increasing) southward, along the Gulf of Mexico, and in the lower Mississippi valley (Dolbeer 1991, Hatch 1995, Wires et al. 2001).

Interior. Nearly 70 percent of North American DCCOs are found in the Interior region (Tyson et al. 1999). DCCOs in this region are highly migratory and are concentrated in the northern prairies, particularly on the large, shallow lakes of the Canadian province of Manitoba, which has the largest number of breeding DCCOs in North America (Hatch 1995, Wires et al. 2001). Additionally, a large number of the Interior region DCCOs nest on or around the Great Lakes. Since the early 1970s, their numbers have increased rapidly. Weseloh et al. (1977) observed that DCCO populations throughout the province had "increased considerably." Some ten years after cormorants had reached an all-time low in the Great Lakes, Ludwig (1984) and Weseloh et al. (1983) observed rapid population increases there.

From 1990 to 1997, the overall growth rate in the Interior region was estimated at 6 percent (Tyson et al. 1999) with the most dramatic increases occurring on Ontario, Michigan, and Wisconsin waters (Wires et al. 2001). From 1970 to 1991, the Great Lakes breeding population (which represents a portion of the greater Interior population) increased from 89 nests to over 38,000 nests, an average annual increase of 29 percent (Weseloh et al. 1995). From 1991 to 1997, the number of nests in the Great Lakes further increased to approximately 93,000, an average annual increase of 22 percent. Nest counts in 2000 estimated 115,000 nests in the Great Lakes (D.V. Weseloh, CWS, unpubl. data). The total estimated number of nesting pairs in the Interior population (including Canada) is ≥256,212 (Tyson et al. 1999).

Southern. Most DCCOs in this region are wintering migrants from the Interior and Atlantic regions (Dolbeer 1991, Jackson and Jackson 1995). However, breeding DCCOs in this region are on the rise as Jackson and Jackson (1995) predicted. Historically, sedentary breeding populations of DCCOs occurred in Florida and other southern states north to North Carolina (Hatch 1995), while in recent years DCCOs have started breeding again in States such as Arkansas, Georgia, Mississippi, and Tennessee (Wires et al. 2001). Today, four percent of the North American breeding population of DCCOs occurs in the Southeast region (Tyson et al. 1999). Currently, breeding colonies exist in Arkansas, Delaware, Florida, Georgia, Louisiana, Maryland, Mississippi, North Carolina, South Carolina, Tennesee, Texas, and Virginia (Wires et al. 2001). The total estimated number of nesting pairs in this population is >13,604 (Tyson et al. 1999).

Over the last few decades, numbers of wintering DCCOs have dramatically increased in several southern States. Since the late 1970s, wintering DCCOs have increased in the Mississippi Delta (Jackson and Jackson 1995) from an average of 30,000 in the winters of 1989-93 (Glahn et al. 1996) to greater than 55,000 in the winter of 1996-1997 (Reinhold and Sloan 1999). Data from Christmas Bird Counts conducted between 1959-1988 show increases ranging from 3.5-18.7 percent in several States within this region, with the largest increases occurring in Louisiana, Mississippi, and Texas (Wires et al. 2001).

Pacific Coast-Alaska. Five percent of North America's DCCOs are found in this population, which has an estimated ≥17,084 nesting pairs (Tyson et al. 1999). Alaska DCCOs represent approximately 12 percent of the entire Pacific coast marine population (Carter et al. 1995b) and occur with Red-faced Cormorants. At the southern end of their breeding range (Mexico), Pacific Coast DCCOs occur with Neotropic Cormorants and throughout their coastal range they exist with larger numbers of Pelagic and Brandt's Cormorants (Hatch 1995). Carter et al. (1995b) observed that, overall, DCCOs will likely continue to expand on the Pacific Coast and speculated that population trends are probably affected by movements of nesting birds during El Niño oceanographic conditions and due to habitat loss at interior colonies, as well as increased use of artificial nesting habitats.

The DCCO has been documented as a nesting species in Washington since 1907 (Wires et al. 2001). Carter et al. (1995b) estimated 1,618 breeding pairs at 22 colonies along the coast in 1992, which comprised 7 percent of the total Pacific coast population. While there is considerable fluctuation in number of breeding birds between years, the overall population trend was increasing (Henny et al. 1989, Wilson 1991, Carter et al. 1995a) until recent years (from about 1992 to present) when the observed trend was negative, with an approximately 80 percent decline estimated for the outer coast (U. Wilson, USFWS, unpubl. data).

DCCOs have been a documented nesting species in Oregon since the late 1800s (Wires et al. 2001). In the last 20 years, the largest increases on the west coast have taken place in the Columbia River Estuary: East Sand Island is the largest active colony (6,390 pairs in 2000) on the Pacific coast (Carter et al. 1995b, Collis et al. 2000, Wires et al. 2001). The Oregon coastal population increased by 532 percent from 1979 to 1992, while the Columbia River Estuary population alone roughly doubled between 1992 and 1998 (Carter et al. 1995b, Collis et al. 2000).

The DCCO has been a longtime resident and breeding species in California (Wires et al. 2001). Carter et al. (1995b) reported that California's DCCOs make up about 21 percent of the Pacific Coast marine population. In northern California, a new population of DCCOs emerged in the 1960s and, by 1989, had approximately 3,252 breeding individuals, or 1,626 pairs. On the central coast, the South Farallon Islands colony has been slowly declining over the last decade (Wires et al. 2001). On the southern California coast, the overall number of breeding DCCOs has increased (Carter et al. 1992, Carter et al. 1995b) until recently (1991-2000), when numbers were observed to be somewhat declining (Wires et al. 2001). Complete surveys of interior California populations were conducted between 1997-1999 and estimated a population of 6,900 pairs at 32 active colonies (Wires et al. 2001). A major increase in nesting in interior (i.e., non-coastal) California occurred in the 1990s. By 1999, 80 percent of all interior pairs occurred at the Salton Sea, with the population at Mullet Island there estimated at 5,546 pairs (Wires et al. 2001).

Table 9. Changes in DCCO Populations

DCCO Population	Year(s)	Estimated Nesting Pairs	Source
Atlantic	1940	~10,000	Krohn et al. 1995
	1972	~25,000	Hatch 1995
	early-mid 1990s	~86,000	Tyson et al. 1999
Interior	1925-35	~7,600	Mendall 1936
	1970s	~6,500	Hatch 1995
	early-mid 1990s	~256,000	Tyson et al. 1999
Southern	late 1970s	~15,000	Hatch 1995
	early-mid 1990s	~14,000	Tyson et al. 1999
West Coast-Alaska	1968-1992	~18,000	Carter et al. 1995b
	late 1980s-early 1990s	~17,000	Tyson et al. 1999

3.1.1d Factors associated with population increases

Factors contributing to the resurgence of DCCO populations include reduced levels of environmental contaminants, particularly DDT; increased food availability in breeding and wintering areas; and reduced human persecution (Ludwig 1984, Vermeer and Rankin 1984, Price and Weseloh 1986, Fox and Weseloh 1987, Hobson et al. 1989, Weseloh et al. 1995, Wires et al. 2001). A brief case study of DCCOs in the Great Lakes provides an example of factors associated with changes in DCCO population numbers:

Organochlorine Chemicals. In the early 1940s, DCCO populations in the American and Canadian Great Lakes were increasing rapidly (Postupalsky 1978, Weseloh et al. 1995). After 1945, however, organochlorine pesticides came to be widely used in the Great Lakes basin. The residues of such chemicals, particularly DDT, are ecologically persistent and rapidly bioaccumulate in the aquatic food web, and this led to severe eggshell thinning in DCCOs and other waterbirds. Cormorant eggs with thinned shells broke easily during incubation and led to a period, in the 1950s and 1960s, of almost zero productivity due to low hatching success (Postupalsky 1978, Weseloh et al. 1983, Weseloh et al. 1995). Similar eggshell thinning and reproductive failure were also found in DCCOs in southern California in the late 1960s (Gress et al. 1973). Following restrictions on the use of DDT in 1972, levels of organocholorine contaminants found in DCCO eggs declined in much of the Great Lakes (Ryckman et al. 1998) and DCCO productivity increased accordingly during the late 1970s (Scharf and Shugart 1981, Ludwig 1984, Noble and Elliot 1986, Price and Weseloh 1986, Bishop et al. 1992a and b). Organochlorine contaminant-related eggshell thinning no longer appears to be a major limiting factor for DCCO reproduction on the Great Lakes (Ryckman et al. 1998), even though there are still lingering effects of these chemicals in parts of this ecosystem three decades after they were banned (Custer et al. 1999).

Food Supply. Changes in the food supply available to Great Lakes cormorants, on both the breeding and wintering grounds, have also played a role in their population increase. Great Lakes fish populations underwent major changes in the 20th century. Populations of forage fish species increased significantly during the late 1950s through the 1980s, likely as a result of dramatic declines in large, native predatory fish, such as lake trout and burbot, that occurred during the 1940s and 1950s. These declines in larger predatory fish were brought about by a combination of such factors as overfishing, sea lamprey predation, and loss of spawning habitat (Weseloh et al. 1995) and led to population explosions of smaller forage fish species. In particular, rainbow smelt and alewife, neither of which are native to the upper Great Lakes, became very abundant in Lakes Michigan, Huron, Ontario, and Erie through the 1970s and 1980s (Environment Canada 1995). Various studies suggest that annual productivity and post-fledging survival of DCCO young are high in years of alewife abundance (Palmer 1962; van der Veen 1973, Weseloh and Ewins 1994). In fact, changes in prey abundance have been associated with increases in populations of several fish-eating bird species worldwide (Environment Canada 1995).

The growth of the aquaculture industry has provided DCCOs with an abundant food supply on their southern wintering grounds as well. The aquaculture industry (consisting largely of channel catfish production) has experienced significant growth in the southern U.S. over the last 20 years. While Great Lakes DCCOs historically migrated down to the coastal areas of the Gulf of Mexico to winter, since the early 1970s wintering populations of DCCOs in the lower Mississippi valley have been increasing (Reinhold and Sloan 1999, Glahn et al. 1996). The DCCO is the primary avian predator utilizing channel catfish stocks (Wywialowski 1998, Reinhold and Sloan 1999). Glahn et al. (1999b) analyzed monthly changes in body mass of wintering DCCOs in the delta region of Mississippi and in areas without extensive aquaculture production and found that DCCO utilization of catfish has likely increased winter survival and contributed to the cormorant's recent population resurgence.

Human Persecution. Weseloh et al. (1995) suggested that the cormorant's initial rate of colonization into the Great Lakes was suppressed by human persecution until the 1950s. Indeed, destruction of DCCO nests, eggs, young, and adults, by fishermen and government agencies, was a common occurrence in the Great Lakes basin from the 1940s into the 1960s (Baillie 1947, Omand 1947, Postupalsky 1978, Ludwig 1984, Craven and Lev 1987, Ludwig et al. 1989, Weseloh and Ewins 1994, Weseloh et al. 1995, Matteson et al. 1999) and in the Pacific Northwest (Gabrielson and Jewett 1940, Ferris 1940, Mathewson 1986, Bayer and Ferris 1987, Carter et al. 1995a). Similar control efforts, involving large-scale spraying of eggs, occurred in Maine in the 1940s and 1950s (Gross 1951, Krohn et al. 1995, Hatch 1995) and in Manitoba on Lake Winnipegosis during the same period (McLeod and Bondar 1953, Hatch 1995). In 1972, DCCOs were added to the list of birds protected by the Migratory Bird Treaty Act, which made it illegal to kill them in the U.S. without a Federal permit.

3.1.1e Double-crested Cormorant Population Parameters

Compared to other common colonial waterbirds, the population dynamics of DCCOs have not been well-studied (Wires et al. 2001, Hatch and Weseloh 1999). The similar life histories of DCCOs and Great Cormorants (i.e., their being ecological counterparts), however, allow North American managers to gain insight from management efforts in Europe (Glahn et al. 2000b, Wires et al. In Press). Due to their rather large clutch size and persistent renesting efforts, DCCO breeding success is fairly high compared to other North American cormorants and colonial waterbirds in general (Johnsgard 1993).

Age at First Breeding. Van der Veen (1973) found that most birds bred for the first time at age 3 (i.e., entering their fourth year). Johnsgard (1993, citing van Tets *in* Palmer 1962) also stated that "the usual age of initial breeding in this species is probably three years, although successful breeding has occurred among two-year-olds." In the early 1990s, Weseloh and Ewins (1994) observed first-breeding by many 2-year-olds on Little Galloo Island in Lake Ontario.

Clutch Size. Average clutch sizes observed over the years include: 3.8 eggs in Utah (Mitchell 1977); 3.5 eggs in Maine (Mendall 1936); 3.11 eggs in Ontario (Peck and James 1983); 3.2 eggs in Alberta (Vermeer 1969); 3.6 and 3.2 on the Madeleine Islands in Quebec (Pilon et al. 1983); 2.7-4.1 eggs, with a mode of 4, in British Columbia (van der Veen 1973); an average of 3.12 eggs over four years on Little Galloo Island, Lake Ontario (Weseloh and Ewins 1994); and 4.1-4.2 eggs at Columbia River Estuary colonies in Oregon (Roby et al. 1998, Collis et al. 2000).

Hatching Success. Van der Veen (1973) found that hatching success varied from 50-75 percent in DCCOs in British Columbia. Drent et al. (1964) reported an average hatching success of 60.4 percent on Mandarte Island in British Columbia, while Mitchell (1977) observed a hatching success of 54.2 percent in Utah. During two years of study on the Madeleine Islands, Quebec, hatching success rates of 74.5 and 71.8 percent were observed by Pilon et al. (1983). Roby et al. (1998) estimated hatching success in the Columbia River Estuary to be 56 percent. Wires et al. (2001) reported that DCCO hatching success is usually 50-75 percent.

Fledging Success. Van der Veen (1973) estimated fledging success at 74-95 percent (1.2-2.4 young per nest). Drent et al. (1964) observed a 95 percent fledging success rate on Mandarte Island, British Columbia, or an average of 2.4 young fledged per nest. In Utah, Mitchell (1977) reported a 72 percent fledging success rate. Pilon et al. (1983) reported fledging success rates of 2.1 and 2.4 young per year in Quebec. Slightly lower average rates of 1.8 young fledged per nest (Hobson et al. 1989) and 1.9 young fledged per nest (Vermeer 1969) were observed in Manitoba and Alberta, respectively. Average productivity for the Great Lakes, between 1979 and 1991, ranged from 1.5 to 2.4 young per nest (Weseloh et al. 1995). Roby et al. (1998) and Collis et al. (2000) estimated that cormorants in the Columbia River Estuary fledged an average of 1.6 and 1.2 chicks on East Sand Island and 2.1 and 1.6 chicks on channel markers in the estuary during 1997 and 1998, respectively. Fowle et al. (1999) estimated productivity to be 2.5 young fledged per nest on Young Island in Lake Champlain, Vermont. Wires et al. (2001) reported that fledging success for DCCOs is typically 1.2-2.4 young per nest.

Survivorship. Average lifetime production has been estimated at 3.28 young per female (van der Veen 1973). Mean adult life expectancy was approximated at 6.1 years, with an estimated first-year survival rate of 48 percent, second-year survival rate of 74 percent, and 3+ years survival rate of 85 percent (van der Veen 1973). Madenjian and Gabrey (1995) estimated DCCO survival rates at: 58 percent from age 0 to age1; 75 percent from age 1 to 2 and age 2 to 3; and 80 percent for ages 3 to 4 and beyond. This is similar to survival rates estimated in European great cormorants: 35-54 percent in the first year, 75 percent in the second year, and 85 percent for year three and beyond (Veldkamp 1997, Bregnballe et al. 1997).

A major mortality factor throughout the species' range is predation. Johnsgard (1993) cited several studies indicating the following species as predators of DCCO chicks and/or eggs: California Gulls, Ring-billed Gulls, Herring Gulls, Great black-backed Gulls, American Crows, Fish Crows, Northwestern Crows, Common Ravens, and Bald Eagles. The British Columbia Wildlife Branch has associated DCCO colony failures with predation by Bald Eagles, Northwestern Crows, and Glaucous-winged Gulls (1999 unpubl. data).

Other causes of mortality include disease (e.g., Newcastle disease which killed over 20,000 DCCOs in colonies in the Great Lakes, Minnesota, and North and South Dakota in 1992 [Glaser et al. 1999]), illegal human persecution, and entanglement in fishing gear (Hatch and Weseloh 1999). Cormorant populations are influenced by both density-dependent and density-independent factors (Cairns 1992a), with age of first breeding, occurrence of non-breeding, and clutch abandonment the demographic parameters most likely to respond to density (Hatch and Weseloh 1999). In a population model developed for great cormorants in Europe, Bregnballe et al. (1997) assumed three types of density dependent mechanisms: increased exclusion of potential breeders, reduced fledgling production, and increased food competition on wintering grounds.

Contaminants. Cormorants, like other fish-eating birds, accumulate contaminants from the fish they eat. DCCO populations declined dramatically in association with high levels of contaminants during the 1960s and early 1970s. In fact, eggs of Herring Gulls, DCCOs, and Common Terns were found to contain some of the highest levels of organochlorine compounds in the world (Struger et al. 1985). Effects of chlorinated hydrocarbons on DCCOs have been most studied in the Great Lakes, where breeding populations had accumulated high contaminant burdens and showed severe impacts (Ryckman et al. 1998, Hatch and Weseloh 1999). Avian eggs and carcasses in Wisconsin were examined and contained detectable levels of several organochlorine contaminants (Dale and Stromborg 1993). The effects of these contaminants on DCCOs includes eggshell thinning (Anderson and Hickey 1972, Postupalsky 1978), elevated embryonic mortality (Gilbertson et al. 1991), reproductive failure and population declines (Weseloh et al. 1983, 1995), increased adult mortality (Greichus and Hannon 1973), increased embryonic abnormalities and crossed bills (Fox et al. 1991, Yamashita et al. 1993, Ludwig et al.

1996), egg mortality (Tillitt et al. 1992), and brain asymmetry (Henschel et al. 1997).

Over the years, the Service and the Canadian Wildlife Service have used fish-eating birds such as cormorants to study the impacts of long-term exposure to persistent lipophilic environmental contaminants within the Great Lakes ecosystem (Fox et al. 1991). Contaminant levels started decreasing in the 1970s and have continued to do so up to the present, with most associated biological parameters improving accordingly (Hatch and Weseloh 1999) . For example, by 1995, most contaminant residues in DCCO eggs had declined by 83-94 percent (Ryckman et al. 1998). However, contaminant levels in Great Lakes DCCOs continue to be significantly higher than in most other parts of North America (Somers et al. 1993, Sanderson et al. 1994), partly because of the long hydrologic retention times and depth of the Great Lakes, which renders them particularly sensitive to chemical inputs (De Vault et al. 1996).

Little work has been done on the effects or occurrence of metals in cormorants. Mercury is most often reported, but no effects have been identified in the wild (Hatch and Weseloh 1999). Methyl mercury is highly toxic; animal studies have indicated that chronic exposure to high mercury levels is associated with kidney damage, reproductive problems, nervous system effects, and other health problems (Johnson et al. 1998). In New Brunswick, total mercury concentrations in tissues of DCCOs were highest of nine seabird species examined (Braune 1987). A study in the Carson River, Nevada, found that DCCOs had the highest mercury concentrations of three species examined (Henny et al. unpubl. data). However, overall, contaminants do not appear to be a significant limiting factor of DCCO populations at the continental scale.

3.1.1f Double-crested Cormorant Foraging Ecology

DCCOs are rarely seen out of sight of land and are opportunistic, generalist feeders, preying mainly upon abundant fish species that are easy to catch (usually slow-moving or schooling fish, ranging in size from 3-40 cm [1.2-16 in]), although most commonly less than 15 cm (6 in). Glahn et al. (1998) reported that availability (i.e., abundance), rather than size, is probably the most important factor in prey selection, but given equal availability DCCOs prefer prey fish that are greater than 7.5 cm (3 in) in length. They also suggested that prey fish accessibility is important in DCCO prey selection. Neuman et al. (1997) attributed variation in DCCO diet in Lakes Huron, Erie, and Ontario to movements of fish into shallow spawning areas and to spatial heterogeneity of fish habitat. For specifics of foraging behavior at aquaculture facilities, see Appendix 4.

The prey of Atlantic birds suggests that they feed at the bottom of the water column, while that of Pacific and inland birds suggests that they feed in mid-water. DCCOs usually forage in shallow, open water (less than 8m, or 27 ft) within 5 km (3.1 mi) ofshore (Hatch and Weseloh 1999), although they will go farther. In freshwater lakes, DCCOs forage at fairly shallow depths and likely take prey from all levels fairly uniformly (Johnsgard 1993).

The DCCO appears to be almost completely diurnal in its feeding habits. When pursuing prey, it dives from the surface and chases fish underwater. While bottom-feeding is usually solitary, DCCOs may form loose foraging flocks when feeding on schooling prey. In this way, birds create a line that moves forward as individuals at the rear fly short distances to “leapfrog” diving birds in the front. DCCOs engaged in this behavior have been documented in Georgian Bay, Ontario; Massachusetts; and Green Bay, Wisconsin, as have Great Cormorants in The Netherlands (Glanville 1992, Custer and Bunck 1992, van Eerden and Voslamber 1995, Hatch and Weseloh 1999). Observations of such behavior were also mentioned frequently during the public scoping period.

Neuman et al. (1997) determined that cormorant foraging distances at Little Galloo Island (Lake Ontario) ranged from 3.7 to 20 km (with an average distance of 13 km, or 8 mi). Custer and Bunk (1992) reported that birds from two colonies in the Wisconsin waters of Lake Michigan foraged an average of 2-2.4 km (1.2-1.5 mi) from the colonies, with over 90 percent of flights being within 9 km (5.6 mi) of the colonies. In Texas, Campo et al. (1993) found that the average estimated distance from the foraging area to the nearest shore ranged from 20 to 975 meters (67-3,250 ft). DCCOs respond rapidly to high concentrations of fish and will congregate where fish are easily caught, such as "put and take" lakes, stocking release sites, and aquaculture ponds (Hatch and Weseloh 1999, Wires et al. 2001).

3.1.2 Fish

Since DCCOs are abundant, fish-eating (or "piscivorous") predators, public and agency concern over negative impacts to fish populations (and associated recreational and/or commercial catch) has been a significant issue in cormorant management. The diet of DCCOs consists largely of fish (generally slow-moving or schooling species), with some occurrence of aquatic animals such as insects, crustaceans, reptiles, and amphibians (Johnsgard 1993, Hatch and Weseloh 1999). Trapp et al. (1999) conducted a review of diet studies carried out between 1923 and 1994 and found that of 75 fish species detected as DCCO prey items, only 29 species comprised more than 10 percent of the diet at a specific site and, of those 29, five species consistently comprised greater than 10 percent of the diet: alewife, brook stickleback, ninespine stickleback, yellow perch, and slimy sculpin. These results confirm the popular notion that the DCCO is an opportunistic feeder, utilizing a wide diversity of prey. A review of the diet literature by Wires et al. (2001) indicated that, in general, sport and commercial fish species do not contribute substantially to DCCO diet, although they and Trapp et al. (1999) both cited exceptions to this rule.

In general, DCCO diet varies highly among locations and tends to reflect the fish species composition for each location, making it necessary to examine diet on a site-specific basis (Belyea et al. 1999, Wires et al. 2001). But some regional generalizations can be made about fish consumed by DCCOs. On the Pacific coast, no single species emerged as the most important prey item, although some species were very important in certain regions. In the Columbia River Estuary, diet composition differed at the two main colonies. At Rice Island, salmonids were the most important prey item with stickleback and peamouth also being important; at East Sand Island, shad, herring, and sardine were the most important prey items, with salmonids and starry flounder also important (Collis et al. 2000). In other areas, fish such as shiner perch, sculpin, gunnel, snake prickleback, sucker, and sand lance proved important components of DCCO diet (Wires et al. 2001). Aside from Pacific salmonids, several of which are Federally-listed as threatened or endangered, the populations of none of the populations of these fish species are a regional or national concern.

In the Great Lakes, fish species such as alewife and gizzard shad, appeared to be the most important prey items. Stickleback, sculpin, cyprinids, and yellow perch and, at some localities, burbot, freshwater drum, and lake/northern chub were also important prey fish species (Wires et al. 2001). None of the populations of these fish species are a regional or national concern, although yellow perch are an important sport fish and both yellow perch and alewife are fished commercially to some extent. Concerns about impacts to these fisheries, as well as smallmouth bass and walleye, are local in nature.

In the southeastern U.S., most of the diet consists of shad, catfish, and sunfish species (Wires et al. 2001). While none of these fish species' populations are a regional or national concern, DCCO consumption of commercially-raised catfish is an important economic issue and local concerns about impacts of DCCO predation on sport fish in lakes, ponds, and reservoirs are common.

In the Atlantic region, diet varies regionally to a great extent, with no single species emerging as most important. In coastal habitats, cod, sculpin, cunner, and gunnel are important as well as sand lance and capelin. Where DCCOs are found inland or at estuaries, alewife, rainbow smelt, stickleback, smallmouth bass, yellow perch, pumpkinseed, cyprinids, and salmonids (mainly Atlantic salmon) are important prey items (Wires et al. 2001). Of these species, Atlantic salmon are Federally-listed as threatened, smallmouth bass and yellow perch are important sport fish, and cod, alewife, and rainbow smelt are commercially fished. Concern about impacts of DCCO predation on these fish has been expressed.

Table 10. Geographic Range of Common DCCO Prey Species

Largemouth Bass: originally ranged in the Atlantic slope watersheds south of Maryland, the St. Lawrence River basin, Great Lakes, and Mississippi River basin to northeastern Mexico. They have been stocked throughout the United States.
Smallmouth Bass: originally ranged from Minnesota to Quebec, including the Great Lakes, southward to northern Alabama, and west to eastern Kansas and Oklahoma. Because of its sporting qualities, it has been introduced to many other states, Canadian provinces, and 41 other countries.
Channel Catfish: naturally occurred in the central and eastern United States and southern Canada. They ranged throughout the Mississippi River drainage to northeast Mexico; to the east from the St. Lawrence River, along the western slope of the Appalachian Mountains to central Florida. They were conspicuously absent along the watersheds of the Atlantic seaboard. The species has been widely introduced for sport fishing throughout the United States.
Walleye: native range is throughout most of eastern North America, including Great Lakes, but has been introduced to Western North American streams where habitat is suitable.
Northern Pike: range is extensive, greater than any other freshwater game fish. Pike can be found throughout the northern half of North America, including the Great Lakes.

Yellow Perch: on the Atlantic coast, range from South Carolina north to Nova Scotia. They can also be found west through the southern Hudson Bay region to Saskatchewan, including the Great Lakes, and south to the northern half of the Mississippi drainage.
Bluegill: original range includes most of central and eastern United States, north into southern Canada.
Alewife: native to the Atlantic Coast and entered the Great Lakes through the Welland Canal. Alewife populations have become established in Great Lakes and many landlocked lakes in New York, Maine, Connecticut, and other New England states.
Gizzard Shad: Mississippi and Atlantic drainages, including the Great Lakes.
Rainbow Smelt: essentially a marine species with chief distribution along Canadian coastal waters. Intruded into fresh waters of northeastern U.S. and the Great Lakes.

3.1.3 Other Birds

Over the course of their life cycle, individual DCCOs may interact with other species of birds in a variety of ways. These interactions may involve competition for nest sites, competition for food, and disease transmission. In a survey conducted by Wires et al. (2001), impacts to other bird species were reported by respondents from the States of Arkansas, Illinois, Iowa, Maine, Massachusetts, Michigan, Mississippi, New York, Ohio, Vermont, and Wisconsin. Impacts to other colonial waterbirds, particularly herons and egrets, were reported most often and these impacts were associated mainly with DCCO-related habitat degradation and competition for nest sites.

Table 11. Avian Associates of DCCOs (Source: Kaufman 1996 and Ehrlich et al. 1988)

American White Pelican: Habitat includes lakes, marshes, salt bays. Total population probably declined through first half of 20th century, but has increased substantially since 1970s.
Anhinga: Habitat includes cypress swamps, rivers, and wooded ponds in the southern U.S.
Black-crowned Night-Heron: Habitat includes marshes and shores; roosts in trees. Populations probably declined in 20th century due mostly to habitat loss; in recent years, overall population stable or increasing.
Brandt's Cormorant: Habitat includes rocky areas along Pacific coast. Local populations fluctuate, but overall numbers probably stable.
Caspian Tern: Habitat includes large lakes, coastal waters, beaches, bays. Overall population probably stable, perhaps increasing.

Common Tern: Habitat includes lakes, ocean, bays, beaches. Northeastern populations probably lower than they were historically. Some inland populations declining, including Great Lakes.
Great Black-backed Gull: Habitat mostly includes coastal waters and estuaries along the Atlantic coast. Populations increasing and breeding range steadily expanding.
Great Blue Heron: Habitat includes marshes, swamps, shores, tideflats; very adaptable. Common and widespread, numbers stable or increasing.
Great Cormorant: Habitat includes ocean cliffs with some found on large inland rivers in winter. North American population (also found throughout Europe) has increased dramatically in recent decades, and breeding range has expanded southward along Atlantic coast.
Great Egret: Habitat includes marshes, ponds, shores, mudflats. Nearly decimated by plume hunters in 19th century, recovered in 20th century. In recent decades, breeding range has gradually expanded northward, with some evidence that southern populations have declined.
Herring Gull: Habitat includes ocean coasts, bays, beaches, lakes, piers, farmlands, dumps. Populations increased greatly in 20th century and breeding range expanded.
Neotropic Cormorant: Habitat includes tidal waters and lakes in the southern U.S. After declines in Texas numbers in the 1950s and 1960s, is increasing again and may be spreading north inland.
Pelagic Cormorant: Habitat includes cliffs and other rocky areas along Pacific coast. Population probably stable, with close to 75% occurring in Alaska.
Ring-billed Gull: Habitat includes lakes, bays, coasts, piers, dumps, plowed fields. Populations high and probably still increasing.
Snowy Egret: Habitat includes marshes, swamps, ponds, shores. Nearly decimated by plume hunters in 19th century, recovered in 20th century. Has expanded breeding range northward in recent decades; populations increasing.
Western Gull: Habitat includes coastal waters, estuaries, beaches, city waterfronts. Common and overall numbers stable.

3.1.4 Vegetation

Concern about negative impacts of nesting and roosting DCCOs to vegetation has been expressed by the public as well as natural resource professionals. In a survey conducted by Wires et al. (2001) respondents from Alabama, Arkansas, Connecticut, Florida, Iowa, Maine, Maryland, Michigan, New Hampshire, New York, North Carolina, Ohio, Oklahoma, Rhode Island, Vermont, and Wisconsin reported impacts to trees, while the States of Iowa, Maine, Maryland, Michigan, New Hampshire, Ohio, Oklahoma, Vermont, Virginia, and Wisconsin reported impacts to herbaceous layers.

DCCOs seem to prefer nesting in trees to nesting on the ground, and trees are probably used by older, more experienced, earlier-breeding individuals (Weseloh and Ewins 1994). Along the Pacific coast, however, DCCOs nest primarily on the ground, either in low vegetation or on the barren ground of offshore islands and coastal cliffs. Typically, islands with avian breeding colonies have less vegetative cover than adjacent islands with none and, in general, plant species diversity tends to be low in colonial waterbird nesting colonies (Chapdelaine and Bédard 1995). However, the increased rate of habitat destruction associated with increasing numbers of DCCOs is viewed by many as a problem. The chief concerns associated with DCCO-induced vegetation damage are displacement of other colonial waterbird species (caused by habitat changes) and harm to plant species/communities of special management significance.

3.1.5 Federally-Listed Threatened and Endangered Species

A common concern among members of the public and wildlife professionals, including Service and Wildlife Services personnel, is the impact of damage management assistance methods and activities on non-target species, particularly threatened and endangered species. Section 7 of the Endangered Species Act (ESA), as amended (16 U.S.C. 1531-1543; 87 Stat. 884), provides that, "The Secretary shall review other programs administered by him and utilize such programs in furtherance of the purposes of this Act" (and) shall "ensure that any action authorized, funded or carried out ... is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of (critical) habitat ..." Consequently, we have initiated Section 7 consultation under the ESA for this management assessment.

Due to the large geographical context of DCCO management, a variety of special status species may occur in areas frequented by DCCOs. Although the geographic distribution of many of these species may overlap with that of DCCOs, the management techniques that are being evaluated to control this species are very selective. Also the behavior, flight pattern, size, or other characteristics distinguish these species of special status from DCCOs. A regional preliminary listing of endangered, threatened, proposed, and candidate species that may be affected by management of DCCO populations is presented in Appendix 10.

It is possible to manage certain habitats in order to make the area less attractive to DCCOs (e.g., draining a pond, wetland or lake or placing mesh covering over hatchery facilities). In these situations, the effects on DCCOs would be similar to the effects on avian species of special status, in that the birds would merely forage and/or loaf in other nearby locations more attractive to the birds.

Habitat modification and other management activities associated with DCCO population control have been reviewed in a variety of contexts. First, APHIS/WS program activities have been reviewed and assessed through consultation under Section 7 of the Endangered Species Act. The Biological Opinion issued from the Service describes methodologies to reduce or minimize disturbance of any threatened or endangered species in relation to program control activities. Although control of DCCOs was not directly addressed in this consultation, all of the methodologies employed by APHIS/WS to manage these populations were evaluated in relation to the effect on over 138 species of special status. Included within the Biological Opinion is the finding that the project would have potential negative impacts on seven mammals, eight birds, five reptiles, and one amphibian. The alternatives presented within will evaluate efforts to minimize effects on these species and other species that may be affected by management techniques used to control DCCOs. All activities associated with DCCO damage control will be conducted in compliance with specific Service authorization through the ESA.

Aside from potential negative impacts, some threatened and endangered species may benefit from DCCO control measures. These include Pacific salmonids and Atlantic salmon.

Pacific salmonids. The Oregon Department of Fish and Wildlife, the National Marine Fisheries Service, and various members of the public expressed concern about possible negative impacts of DCCO predation on populations of federally-listed Pacific salmonids. Historically, 10 to 16 million adult salmonids returned to the Columbia Basin each year. Today, about 1 million adult salmonids return and 80 percent of these are of hatchery origin. Extensive hydropower development, habitat loss, excessive harvest, and over-reliance on hatchery production have contributed to this decline. For Snake River stocks, dramatic declines followed construction of the Snake River/Hells Canyon Dam complex in the 1960s and completion of the Lower Columbia River Dams in the early 1970s. As of August 2001, NMFS had listed 12 Evolutionarily Significant Units of anadromous salmonids native to the Columbia River Basin as threatened or endangered under the Endangered Species Act.

Atlantic salmon. During the public scoping period, the Maine Department of Inland Fisheries and Wildlife listed DCCO predation on stocked and native Atlantic salmon as an issue of concern. Atlantic salmon were once native to between 28 and 34 Maine rivers. By the early 1800s, Atlantic salmon runs in New England had been severely depleted because of fishing, declining water quality, and barriers to migration (USFWS/NMFS 2000). By the mid-1900s, the total adult run of Atlantic salmon to U.S. rivers had declined from hundreds of thousands in the early 1800s to a likely range of 500-2000 fish, mostly in rivers in eastern Maine. The spawning stocks of Atlantic salmon throughout much of the North Atlantic, including Maine, continue to be very low and are not expected to improve rapidly. Maine Atlantic salmon (i.e., those of the Gulf of Maine Distinct Population Segment) exhibit critically low spawner abundance, poor marine survival, and increased threats from artificially reduced water levels, diseases and parasites, recreational and commercial fisheries, sedimentation, and genetic corruption by commercially-raised Atlantic salmon (USFWS/NMFS 2000). In November 2000, the Atlantic salmon was federally-listed as endangered under the Endangered Species Act. This listing covers the wild population of Atlantic salmon found in rivers and streams in Maine from the lower Kennebec River north to the U.S.-Canada border.

3.2 Socioeconomic Environment

Concerns about increasing DCCO populations extend beyond the biological to include social (those having to do with humans) and economic (those having to do with monetary value) impacts as well. While wildlife species are widely regarded as providing economic benefits to humans (Decker and Goff 1987), they can cause significant adverse economic impacts as well.

3.2.1 Water Quality and Human Health

The major human health concern expressed during public scoping was contamination of water supplies by DCCO excrement. Eight States expressed concern over possible DCCO-related impacts to water quality in a survey conducted by Wires et al. (2001). Those States were Alabama, Arkansas, Connecticut, Maine, Massachusetts, Michigan, Rhode Island, and South Carolina. Additionally, residents of Henderson, New York, near Little Galloo Island in eastern Lake Ontario (home to a very large DCCO colony), expressed concern about DCCOs presenting a threat to their groundwater.

Waterbird excrement can contain coliform bacteria, streptococcus bacteria, Salmonella, toxic chemicals, and nutrients, and it is known to compromise water quality, depending on the number of birds, the amount of excrement, and the size of the water body. Although the 1992 Section 305(b) State Water Quality Reports indicate that, overall, the Nation's groundwater quality is good to excellent, many local areas have experienced significant groundwater contamination. The sources and types of groundwater contamination vary depending upon the region of the country, but those most frequently reported by States include: leaking underground storage tanks, septic tanks, municipal landfills, agricultural activities, and abandoned hazardous waste sites (EPA 1992). Concerns about water quality and DCCOs exist on two levels: contaminants and pathogens.

Contaminants. Elevated contaminant levels associated with breeding and/or roosting concentrations of DCCOs and their potential effects on groundwater supplies are the major concerns regarding DCCO impacts to human health. Metals and toxic organic chemicals typically originate in industrial discharges, runoff from city streets, mining activities, leachate from landfills, and a variety of other sources. These toxic chemicals, which are generally persistent in the environment, can cause death or reproductive failure in fish, shellfish, and wildlife. In addition, they can accumulate in animal tissue, be absorbed in sediments, or find their way into drinking water supplies, posing long-term health risks to humans (EPA 1992).

The most toxic and persistent environmental contaminants include chlorinated hydrocarbons (also known as organochlorine chemicals; e.g., PCBs, dioxin-like compounds, and certain pesticides such as DDT). These compounds enter the food chain and are retained there at a rate higher than they can be eliminated, a process known as bioaccumulation. DCCOs bioaccumulate these substances through eating contaminated fish.

Pathogens. Escherichia coli (*E. coli*) are fecal coliform bacteria associated with fecal material of warm blooded animals. There are over 200 specific serological types of E. coli and the majority are harmless (Sterritt and Lester 1988). Aquatic birds can be a source of fecal contamination of water resources. For example, Simmons et al. (1995) used genetic fingerprinting to link fecal contamination of small ponds on Fisherman Island, Virginia to waterfowl. Klett et al. (1998) were able to implicate waterfowl and gulls as the source of fecal coliform bacteria at the Kensico Watershed, a water supply for New York City. Also, fecal coliform bacteria counts correlated with the number of Canada Geese and gulls roosting at the reservoir (Klett et al. 1998). Additionally, excessive numbers of resident Canada Geese can affect water quality around beaches and in wetlands (Draft EIS for Resident Canada Geese, USFWS unpubl.).

3.2.2 Economic Impacts

3.2.2a Commercial Aquaculture Production

Aquaculture, the cultivation of finfish and invertebrates in captivity, has grown exponentially in the past several decades (Price and Nickum 1995). The principal species propagated in the United States are catfish, trout, salmon, tilapia, hybrid striped bass, mollusks, shrimp, crayfish, baitfish and ornamental tropical fish (Price and Nickum 1995; USDA 2000a). A 1998 census revealed that the U.S. domestic aquaculture industry represents slightly over 4,000 farms, with total sales reaching $978 million (USDA 2000a). Freshwater and saltwater farms accounted for over 320,700 and 92,600 acres of production, respectively in 1998 (USDA 2000a). The 13 State southern region represented over two-thirds of the reported farms and total sales, followed by the western region, eastern region, north-central region, and the tropical and subtropical region, respectively (USDA 2000a). USDA (2000a) reported the top five States in U.S. aquaculture sales in 1998 were Mississippi, with sales of $290 million of catfish; Arkansas, with $84 million of catfish and baitfish; Florida, with $77 million of ornamental fish, mollusks and other products; Maine, with $67 million of Atlantic salmon; and Alabama, with $59 million of catfish. While each of these industries has its own unique set of bird depredation problems, they all share a basic concern for developing and implementing the best methods for protecting aquaculture stocks from predation.

Catfish Industry. Channel catfish production is the largest segment of the aquaculture industry, and the one which is probably most susceptible to predation by DCCOs. See Appendix 4 for details of DCCO foraging behavior at aquaculture facilities. Catfish production accounts for approximately 50 percent of the aquaculture industry in the U.S. (Mott and Brunson 1997). Catfish growers in 13 states reported sales of $488 million during 1999, with the top four production states of Mississippi, Alabama, Arkansas, and Louisiana accounting for 96 percent of the U.S. total sales. Mississippi farms represented over half of the catfish sales in 1999, with slightly over $294 million dollars in sales. (USDA-NASS 2000a). There were more than 76,612 hectares (189,230 acres) of catfish ponds in the United States as of January 1, 2000 (USDA-NASS 2000a) which represented a 2.7-fold increase from about 28,300 hectares (69,900 acres) in production in the 1970s (USFWS 1998b). The four principal catfish-producing States accounted for 95 percent of the total area, with Mississippi alone accounting for about 58 percent (USDA-NASS 2000a).

Baitfish Industry. Louisiana and Arkansas together represent 90 percent of the baitfish production in the U.S. (Price and Nickum 1995). A National Agricultural Statistics Service 1998 Census of Aquaculture (USDA 2000a) reported that Arkansas baitfish growers accounted for $23 million in sales in 1998, which represented over 60% of U.S. baitfish sales.

Trout/Salmon Industry. Trout producers in 20 states reported sales of $76.9 million in 1999, with Idaho, North Carolina, California, and Pennsylvania representing the top 4 states in production. Idaho accounted for almost half of the trout sold in the U.S. in 1999 (USDA-NASS 2000a). In 1993, the Atlantic salmon industry was valued at $55-60 million (Price and Nickum 1995). A National Agricultural Statistics Service 1998 Census of Aquaculture (USDA-NASS 2000b) reported that 47 salmon producers in the U.S. reported sales of over $103 million, with Maine accounting for over $64 million in sales.

Ornamental Tropical Fish Industry. USDA (2000) reported in 1998 there were 345 ornamental fish growers in the U.S. with $69 million in sales. Florida was reported dominating the industry, accounting for 171 of the ornamental fish growers and 81 percent of total U.S. sales (USDA 2000a).

Crayfish Industry. USDA-NASS (2000b) reported over $10 million in reported crayfish sales in 1998. The crayfish aquaculture industry is centered primarily in Louisiana, accounting for approximately 92 percent of U.S. production. Freshwater crayfishes have been most commonly used as food and fish bait but are also commercially used in the pet trade as pets and food for predaceous pet fishes, and in the academic community for teaching and research purposes (Huner 1997). Between 1960 and 1996, commercial crayfish acreage in Louisiana increased from 800 ha to 45,000 ha (Glahn et al. In Press).

3.2.2b Recreational Fishing Economies

Recreational fishing benefits local and regional economies in many areas of the U.S. As participation in a recreational fishery increases, so does the total amount of money entering local and regional economies as angler expenditures. In this way, growth of recreational fishing can stimulate economic activity (Royce 1987 in Ross 1997). During public scoping, concern was expressed that increased DCCO predation has impacted recreational fisheries which has, in turn, impacted the economies of communities that rely heavily on income associated with recreational fishing.

The many public benefits provided by recreational fishing are supported by an extensive body of Federal legislation and international treaty conventions. These include the Anadromous Fish Conservation Act of 1985, the Fish and Wildlife Coordination Act, the Fish and Wildlife Act of 1956, the Great Lakes Fishery Act of 1956, the Great Lakes Fish and Wildlife Restoration Act of 1990, and the Boundary Waters Treaty of 1909 between the United States and Great Britain (USFWS 1995). Moreover, Executive Order 12962, signed by President Clinton in 1995, recognizes the social, cultural, and economic importance of recreational fisheries and directs Federal agencies, to the extent practicable and where permitted by law, "to improve the quantity, function, sustainable productivity, and distribution of U.S. aquatic resources for increased recreational fishing opportunities..." (USFWS 1997).

The Service's responsibilities related to recreational fisheries management include administering the Fisheries Across America grant program, in which the Service pursues cost-sharing opportunities with non-Federal entities to enhance recreational fishing opportunities by restoring aquatic ecosystems and native fish populations. Under the Land and Water Conservation Fund, the Service also acquires lands and waters that address the needs of recreationally important species. On National Wildlife Refuges, the Service manages recreational fisheries such as rainbow trout, char, grayling, and sheefish in Alaska, and largemouth bass and sunfish in the lower 48 States. Outside of Federal lands, the Service assists States and Tribes with management of migratory interjurisdictional recreational fish species of national concern, such as Atlantic and Pacific salmon and lake trout. Finally, the Service, through its National Fish Hatchery System, propagates fish that are important to the survival, maintenance, and restoration of recreationally valuable stocks of freshwater, anadromous, and coastal fisheries (USFWS 1997).

In 1996, 35.2 million adult anglers in the United States spent $37.8 billion and fished the equivalent of 626 million days. These anglers spent an average of $1072 on fishing-related expenses (USDI/USDC

1997). When that figure was adjusted to account for economic-multiplier effects, anglers' annual spending was shown to have a nationwide economic impact of about $108.4 billion, support 1.2 million jobs, and add $5.5 billion to federal and state tax revenues (ASA 1996). Additionally, through the Federal Aid in Sport Fish Restoration Program, a portion of the money that is spent by anglers on equipment and supplies is used to support sport fish restoration, management, or enhancement programs, including research activities, boating access development and maintenance, aquatic resource outreach and education projects, land acquisition, hatchery construction, and habitat enhancement.

In addition to measuring expenditure levels, "net economic value" is an indicator of the economic benefit to individual participants; it is measured as participants' willingness to pay beyond what they spend to participate. Adding the net economic values of all individuals who participate in an activity derives the value to society (Boyle et al. 1998). For example, the mean net economic value per year for trout fishing in California, Idaho, Nevada, Oregon, and Washington is $126 per angler. The net economic value per *day* for the same angler would be $12. For bass and trout fishing in New York, the mean net economic value per year is estimated at $150, or $10 per day.

While economic impacts associated with recreational fishing may be locally important in many regions of the country, the five States with the highest levels of annual fishing expenditures in 1996 were: California ($3.3 million), Florida ($3.3 million), Texas ($2.9 million), Minnesota ($1.9 million), and New York ($1.8 million). The total annual fishing expenditures for all eight Great Lakes States combined amounted to $10.1 million in 1996 (USDI/USDC 1997). Of these five States, residents of Texas, Minnesota, and New York expressed major concerns during public scoping about impacts of DCCOs on recreational fishing, while such complaints in California and Florida were minor in comparison.

Texas. In Texas, 2.6 million anglers spent $2.9 billion on fishing expenses in 1996 (including food and lodging, transportation, and other expenses such as equipment rental or boat fuel). Each angler spent an average of $457 on trip-related costs during 1996 (USDI/USDC 1998b).

New York. In New York, 1.5 million anglers spent $1.3 billion in 1996 (USDI/USDC 1998a). The Lake Ontario fishery alone has been estimated to generate over $100 million in annual angler expenditures (Connelly et al. 1990) and, in 1996, an estimated 188,000 anglers spent a daily average of about $34 en route and at location fishing in Lake Ontario and its bays (Connelly et al. 1997).

Specifically, the eastern basin of Lake Ontario is an important tourist destination, but one that faces major economic challenges. Jefferson and St. Lawrence counties, for example, have some of the highest unemployment rates in the State of New York. The area is rich in natural and scenic resources and the success of many local businesses is closely related to the fish and wildlife resources of the region. Thus, many communities look to recreation (such as fishing) and tourism for "economic salvation" (Schusler and Decker 2000). Indeed, the Henderson Harbor, New York area has been described as a "waterfront community [relying] heavily on the economic contribution of warm season recreational fishing" (Schusler and Decker 2000).

Recreational fishing is also economically important to the Oneida Lake area. In 1996, fishing trips to Oneida Lake generated an estimated $10.6 million (Cornell Cooperative Extension of Onondaga County 2000). In that same year, an estimated 50,850 anglers spent a daily average of $18 en route and at location fishing in Oneida Lake (Connelly 1997). A report of the socioeconomic impacts associated with declining fisheries on New York's Oneida Lake came to the following conclusions based on surveys of local marinas and sporting good shops: hundreds of anglers had moved their boats from the lake's marinas, fewer out-of-state anglers were coming to the area, daily boat rentals had declined, bait and tackle business had declined, and fewer anglers were participating in local fishing derbies (Schriever and Henke 2000).

The Great Lakes. In the Great Lakes, outdoor recreation makes a substantial contribution to the region's economy and quality of life (Allardice and Thorp1995). The 1996 National Survey of Fishing, Hunting and Wildlife-Associated Recreation indicated that two million U.S. anglers fished the Great Lakes that year. In 1996, Great Lakes anglers participated in 20.1 million days of fishing (down from 25.3 million in 1991), or an average of 10 days per angler. Two types of fish, walleye and perch, dominated fishing activity, together comprising 67 percent of the time spent fishing. Salmon and “black bass” (largemouth and smallmouth bass, etc.) fishing made up 29 and 24 percent, respectively, of fishing activity in the Great Lakes (USDI/USDC 1997).

Great Lakes sport fishing results in a substantial economic impact, particularly for coastal communities that are near popular fishing spots. Various studies (Brown et al. 1991, Connelly and Brown 1988) have provided evidence for the positive relationship between Great Lakes fisheries and tourism-related economic benefits to local communities. In 1996, total U.S. Great Lakes fishing expenditures were projected at $1.4 billion. Trip-related expenditures, including food, lodging, transportation and guide/package fees amounted to $719 million with equipment-related costs ($686 million) comprising the remainder. Expenditures per angler were figured at about $353 for the year, or $21 per day. It is estimated that about half of Great Lakes sport fishing is done from boats, some of which make up a growing charter fishing industry. Since the mid-1970s, roughly paralleling the growth in sport fishing, the number of charter boats increased from 500 to more than 3000 (USDI/USDC 1997; Dawson et al. 1988). However, the number of charter boats has reportedly dwindled in recent years.

The dynamics between the availability of sport fish and the willingness of sport anglers to spend money in pursuit of their prey is poorly known. A 1976 survey of licensed New York State anglers suggested that days of angler participation in bass fishing were found to be significantly influenced by angler preferences, travel costs to angling sites, proximity of neighboring sites, and the quantity of shoreline distance available for angling (Menz 1981). In a survey conducted in 1996, 65 percent of 35 million adult anglers nationwide reported that "they did not fish as often in 1996 as they would have liked" for two key reasons: (1) family or work commitments (43 percent) and not enough time (21 percent). "Not enough fish" was listed as a main reason by only 1 percent of respondents (USDI/USDC 1997). This suggests that factors other than lack of fish may be contributing to declines in angler participation and subsequent economic losses.

3.2.3 Fish Hatcheries and Environmental Justice

The Service has a responsibility to conserve, restore, enhance, and manage the Nation's fishery resources and aquatic ecosystems for the benefit of future generations. Federal stewardship of the Nation's fishery resources has been a core responsibility of the Service for over 120 years. The National Fish Hatchery System was established in 1871 by Congress through the creation of a U.S. Commissioner of Fish and Fisheries. The original purpose of the National Fish Hatchery System was to provide additional domestic food fish to replace declining native fish populations. Cultured fish were used to replace fish that were lost from natural (drought, flood, habitat destruction) or human (over-harvest, pollution, habitat loss due to development and dam construction) influences, to establish fish populations to meet specific management needs, and to provide for the creation of new and expanded recreational fisheries opportunities. The National Fish Hatchery System also has a unique responsibility in helping to recover species listed under the Endangered Species Act, restoring native aquatic populations, mitigating for fisheries lost as a result of federal water projects, and providing fish to benefit Tribes and National Wildlife Refuges.

The Service’s responsibility to provide fish stock to Tribes raises an Environmental Justice concern. Executive Order 12898 ("Federal Actions to Address Environmental Justice in Minority Populations and

Low-Income Populations") requires Federal agencies to make environmental justice part of their mission, and to identify and address disproportionately high and adverse human health and environmental effects of Federal programs, policies and activities on minority and low-income persons or populations.

Additionally, States and Tribes manage numerous public fish hatcheries across the country. For example, in Oregon, approximately 80 percent of all trout harvested come from Oregon fish hatcheries. In Wisconsin, fourteen State hatcheries raise fish such as walleye, steelhead, lake trout, and suckers. Texas fish hatcheries, such as the Texas Freshwater Fisheries Center, not only raise fish to stock lakes and rivers, but also offer opportunities for entertainment and education. Additionally, nine of eleven Great Lakes Indian Fish and Wildlife Commission member Tribes operate tribal fish hatcheries, annually stocking millions of fry and fingerlings into reservation and off-reservation waters. The costs associated with raising hatchery stock can be significant. For example, in 2001, the Oneida Lake Hatchery in New York spent approximately $265,000 producing fry, pond fingerlings, and advanced fingerlings for stocking Oneida Lake (Richard Colesante, Hatchery Manager, pers. comm.).

3.2.4 Property Losses

Private property losses associated with DCCOs include impacts to privately-owned lakes that are stocked with fish, damage to boats and marinas or other properties found near DCCO breeding or roosting sites, and damage to vegetation on privately-owned land.

3.2.5 Existence and Aesthetic Values

Wildlife populations provide a variety of social and economic benefits (Decker and Goff 1987). These include direct recreational benefits such as bird watching but also may include indirect (or intangible) benefits. Existence value is the value a person associates with the knowledge that a resource exists, even if that person has no plans to directly use that resource. Individuals may hold this value for a number of reasons: 1) they wish to preserve the resource for future generations (bequest value); 2) they wish to hold open the option to use the resource in some way in the future although they have no immediate plans to do so (option value); or 3) they may simply feel that preservation of a resource is the right thing to do, and therefore attach a value to it (existence value) (USFWS 2000a).

One of the qualities commonly attributed to wildlife is that it provides humans with aesthetic benefits (Decker and Goff 1987). Aesthetic value refers to our sense of beauty and is, by nature, subjective and difficult to quantify. Aesthetic and existence values are more difficult to quantify than are economic impacts. No studies have been carried out to estimate the dollar value that Americans assign to DCCOs and, if there were, this value would certainly vary considerably from person to person. While we were not able to quantify the existence or aesthetic value of DCCOs to various stakeholders, we still feel that these are valuable concepts because they remind decision makers that, although the direct economic benefits of DCCOs may be limited when compared to economic impacts, they are not devoid of value.