Appendix 5: Discussion of Fishery Impacts

Derby and Lovvorn (1997) stated that to evaluate the effects of bird predation on fish populations, "it is best to compare estimated amounts of fish consumed with total populations or production of fish." Furthermore, Cairns (1992b) noted that "the impact of bird predation depends crucially on avian prey size selection and the growth and mortality schedules of the fish populations." Thus, information needs include a thorough knowledge of: the diet of DCCOs, either through diet studies and/or bioenergetics models that indicate food requirements, and the demographics of the fish population, including mortality factors and survival estimates for all segments of the life cycle. However, most research on DCCO-fisheries interactions has examined diet alone, often without any estimates of fish population data. Such food habit studies, while descriptive of the proportion of a fish species in DCCO diet (e.g., by weight or by number), cannot quantify the impacts of DCCO predation on fish populations. As Hatch and Weseloh (1999) stated, "cormorant predation and its impacts are not revealed by mere lists of prey or simple percentages." The following sections discuss DCCO-fishery interactions at specific locations where DCCOs have been suspected of impacting fish populations.

Oneida Lake, New York

Oneida Lake is the largest lake located entirely in New York State and is well-known for its recreational fishing. Seventy-four fish species have been identified in Oneida Lake, which is managed intensively to optimize recreational fishing opportunities for walleye (Mills et al. 1998). In fact, it has been referred to as the "Walleye Lake of New York State" and provides anglers more fish per acre than any other lake in the Northeast (Cornell Cooperative Extension of Onondaga County 2000).

However, the lake's adult walleye population has decreased during the 1990s from a long term average of 675,000 (1958-1990) to 215,000 in 1999 (VanDeValk et al. 1999). Walleye recruitment and projected stock abundance in Oneida Lake has been estimated by a stock-recruitment relationship model since 1978. Since 1999, the model has overestimated the actual abundance of adult fish, indicating increased mortality of walleye age-1 to 4. For example, this model predicted that 112,000 walleye from the class of 1995 would reach adult size, but only 32,000 actually did (VanDeValk et al. 1999). In addition to increased mortality from age-1 to age 3, walleye mortality has increased during their first year of life (from larvae to first fall). This increase in early mortality is likely due to predation by juvenile and adult fish in the lake. Predation on young walleye has likely increased because the number of larval perch has declined (VanDeValk et al. 1999, Mills et al. 1998). Small yellow perch buffer predation on walleye when they are abundant (Forney 1980). Both increased mortality during the first year and increased mortality between age-1 and 4 have contributed to the declining walleye population in the lake.

Yellow perch are a very important panfish in Oneida Lake. They are sought by anglers throughout the year, and are the main prey of walleye. The dynamics of perch and walleye populations in Oneida Lake are coupled tightly. In the absence of any other dominant forage fish, walleye productivity requires the availability of young perch as prey. For example, walleye consumed 58 percent of the estimated population of age-0 yellow perch and 47 percent of the age-1 yellow perch in the Lake in 1996 (VanDeValk et al. 1999). Similar to walleye, the contribution of yellow perch year classes to the adult stock at age-3 has been predicted by a stock-recruitment relationship model. However, as with walleye, recent forecasts of recruitment have over-estimated year class contributions. These differences between predicted and observed estimates of age-3 and older yellow perch are probably a result of increased predation between age-1 and 3 (VanDeValk et al. 1999).

DCCO Status and Diet. Oneida Lake's cormorant population increased from one nesting pair in 1984, to

305 nesting pairs in 1998. Census data of DCCOs frequenting the lake during April-May of 1998-99 indicates the population can range between 400 and 800 birds (J. Coleman and M. Richmond, Cornell University, unpubl. data). However, there has historically been a large influx of seasonal migrant birds that stop to feed and roost on the lake. For example, there may be as many as 3,000 cormorants on the lake in October (Adams 1999).

The diet of Oneida Lake's DCCOs varies from year to year, and seasonally, reflecting the absolute abundance of prey species (Adams 1999). Cormorants are known to feed on at least 25 of the 74 fish species known to occur in Oneida Lake, and one amphibian (mudpuppy); they typically feed on up to eight different fish species daily. As cormorant populations have increased during the last ten years, walleye and yellow perch have been the most abundant fish species consumed, with the heaviest feeding on adult walleye taking place in the fall during the influx of birds. In fact, the estimated number of yellow perch and walleye consumed by DCCOs is comparable to the number of fish "missing" from model predictions (i.e., the difference between the number predicted from the abundance of age-1 fish and the number of age-3 or 4 fish observed later in the lake) (VanDeValk et al. 1999). Cormorants are the main predator on these fish sizes. Adams (Cornell Univ., unpubl. data) found that in the spring of 1996, DCCOs were estimated to have consumed 1,123,800 yellow perch (12.7 percent of the population estimate) and 100,600 walleye (14.4 percent of the population estimate).

In 1997, DCCOs were estimated to have consumed about 15 percent of age-3 and older yellow perch and 7 percent of age-4 and older walleye in 1997. These exploitation rates of adult fish are comparable to the angler exploitation rate. It has been calculated that exploitation rates of cormorants were between 12 and 20 percent of age-1, 2, and 3 walleye (VanDeValk et al. 1999).

Other Factors. Oneida Lake is undergoing biological changes in response to several factors, including reduced nutrient loading and exotic species. Zebra mussels have clarified the water to record depths, stimulating the growth and distribution of submerged aquatic plants (Mayer et al. 2000). In response, walleye populations have redistributed away from shallow reefs, toward the darker water of weed beds and deeper locations in the lake. Increased water clarity may be contributing to increased mortality of age-0 walleye (a trend revealed since 1992 by index trawl data) by making them more susceptible to predation or cannibalism (Mills et al. 1998). Despite zebra mussel infestation, the lake's zooplankton population has not declined, and remains capable of supporting historic populations of yellow perch and walleye (Mills et al. 1998).

Eastern Lake Ontario, New York

Lake Ontario supports a productive sport fishery, albeit one that is changing rapidly (USFWS 1995). Although salmonids are the most popular sport fish in Lake Ontario as a whole, in the eastern basin some 48 percent of anglers surveyed were fishing specifically for smallmouth bass (McCullough and Einhouse 1999). In fact, smallmouth bass remain the most abundant and widespread sport fish in the eastern basin, attracting over 35,000 directed angler trips in 1998 (NYSDEC 2000). Numerous citizens and the New York State Department of Environmental Conservation (NYSDEC) have expressed concern about the impact of growing DCCO populations in the eastern basin on the smallmouth bass fishery there.

The smallmouth bass is a native of the Great Lakes-St. Lawrence River drainage and a key predator within the eastern basin of Lake Ontario's fish community. Their populations in Lake Ontario have remained relatively stable over the years (USFWS 1995), but dramatic declines have been documented (e.g., through creel surveys) in the eastern basin since the early 1990s. For example, the mean catch per unit effort (CPUE) from 1995-1997 was over 50 percent lower than that for 1984-1986 (Chrisman and Eckert 1999).

DCCO Status and Diet. DCCOs, first observed nesting on Lake Ontario in 1938, are an important piscivore in the Lake Ontario ecosystem. Through the 1960s and early 1970s, DCCOs were absent from Lake Ontario but in 1974 they established a colony of 22 pairs on Little Galloo Island. In 1999, the number of cormorant nests on Little Galloo Island was 5,681 (NYSDEC 2000). The Little Galloo Island colony and two other colonies, on Pigeon and Snake Islands, represent the three largest DCCO colonies in eastern Lake Ontario (Johnson et al. 2000b).

Diet studies indicate that recreationally important species such as salmonids and smallmouth bass typically do not make up a large proportion of DCCO diet in eastern Lake Ontario. A study of cormorant food habits in 1992 revealed that only about 3 out of every 1,000 fish eaten by cormorants in the eastern basin was a trout or salmonid. The failure to find coded wire tags (which were used to mark released lake trout) in any of the cormorant food samples suggested that cormorants had little if any impact on the lake trout stocking program in Lake Ontario. Alewife was found to be the most abundant prey species taken, followed by yellow perch and centrarchids (Karwowski 1992). Ross and Johnson (1994) found 32 coded wire tags in 176 pellets collected the day after a stocking event in 1993 at Stony Point, New York. Ross and Johnson (1995) estimated that 7.6 percent of a 1993 lake trout stocking and 8.8 percent of a 1994 stocking were consumed by cormorants.

Ross and Johnson (1997) found that smallmouth bass represented 0.7 to 2.1 percent (by number) of eastern basin DCCO diet items, with an average estimated annual consumption of 650,000 fish. Johnson et al. (1999) used modeling to estimate that 1.3 million smallmouth bass were consumed by DCCOs in the eastern basin in 1998. In 1993, 1994, and 1998, it was estimated that smallmouth bass contributed an average of 7.2 percent by weight to the diet of Little Galloo Island cormorants. In 1999, Johnson et al. (2000a) estimated that smallmouth bass comprised 3.6 percent of the diet of Little Galloo Island cormorants, amounting to a consumption of approximately 126,000 lbs (~57,000 kg) of smallmouth bass (R. McCullough, NYSDEC, pers. comm.). Yellow perch (28 percent), alewife (27 percent), and cyprinids (18 percent) were the major prey items, by number, of cormorants from the Little Galloo Island colony (Johnson et al. 2000a).

Johnson et al. (2000b) determined that yellow perch was the major prey of DCCOs from the Pigeon (38.4 percent) and Snake (47.7 percent) Island colonies in eastern Lake Ontario, by number. Forage fish, including alewife, cyprinids, threespine stickleback, slimy sculpin, etc. made up 50 percent and 39 percent, respectively, of Pigeon and Snake Island DCCO diets (by number) while smallmouth bass were estimated to have contributed, by weight, 5.1 percent (Pigeon) and 1.7 percent (Snake) of DCCO diet.

Other Factors. Smallmouth bass populations in the eastern basin of Lake Ontario are dependent on a number of factors, including water temperature (cf. Hoyle et al. 1998), year class strength, time of spawning, food availability, competition, predation pressure, and fishing mortality. Many changes have occurred in the eastern basin of Lake Ontario in recent years that could affect these factors, including reduced lake productivity, the introduction of zebra mussels, increased water clarity, and increased abundance of two piscivorous species, DCCOs and walleye. Food web alterations and subsequent shifts in nutrient cycling are important changes that may be caused by zebra mussels. However, little is known about the actual impacts of these changes on the population dynamics of smallmouth bass (Chrisman and Eckert 1999). While factors such as reduced productivity, dreissenid (zebra and quagga) mussel abundance and increased water clarity have impacted all of Lake Ontario, smallmouth bass populations are thriving outside of the eastern basin (Schneider et al. 1999).

Les Cheneaux Islands, Lake Huron, Michigan

Since the late 1970s, the yellow perch fishery in the Les Cheneaux Islands of northern Lake Huron, which had for decades been economically important to the area (Diana et al. 1987), has experienced a marked decline (Lucchesi 1988). In the mid-1980s, concern from anglers and local citizens helped generate a Michigan Department of Natural Resources (MDNR) study which revealed that growth overfishing (overharvest to the point that size at harvest declines dramatically) may have been at least partially responsible for the decline of the fishery (Lucchesi 1988). A 175 mm minimum size limit was instituted in 1987 in an effort to reduce mortality for smaller fish, but it did not help the fishery as predicted (Schneeberger and Scott 1997).

Yellow perch populations have been declining in many areas of the Great Lakes for several decades, most likely as a result of repeated recruitment failures (Lucchesi 1988, Haas and Schaeffer 1992). Fisheries managers and sport anglers are both concerned that predation pressure from the abundant and growing populations of DCCOs will either contribute to the further decline of yellow perch fisheries or prevent recovery (Diana and Maruca 1997).

DCCO Status and Diet. In 1980, DCCOs naturally reestablished at St. Martins Shoal, just west of the Les Cheneaux Islands, after many years of absence. Population surveys in 2001 estimated 4,039 DCCO pairs in the Les Cheneaux Islands area (D. Trexel, University of Minnesota, unpubl. data). Since 1980, diet studies in the Great Lakes have shown that alewife is the most prominent prey item for DCCOs in nearly every location where alewife and cormorants are found together (Belonger 1983, Craven and Lev 1987, Karwowski et al. 1992, Ludwig et al. 1989, Ross and Johnson 1994, Weseloh and Ewins 1994).

A study conducted in 1995 (Belyea et al. 1999) by the Michigan Department of Natural Resources and the University of Michigan evaluated cormorant-perch interactions in the Les Cheneaux Islands area and, in particular, evaluated population trends in cormorants and yellow perch and determined the effect of cormorant foraging on the yellow perch fishery. The study found that yellow perch comprised about 10 percent of overall DCCO diet with alewives and sticklebacks being the most common prey items, although yellow perch represented 48 percent of DCCO diet for a short period in April (Belyea et al. 1999).

Other Factors. The waters of the Les Cheneaux Islands comprise a dynamic area of physical and biological complexity. Part of the biological complexity results from proximity to open waters of Lake Huron and the St. Mary's River. The Les Cheneaux sport fisheries were consistently dominated by yellow perch, but catches of perch varied nearly six fold in the period between 1979 and 1995. Yellow perch populations vary throughout their range, due in part to differences in year class strength. Sport catches of other species (such as northern pike, smallmouth bass, chinook salmon, pink salmon, and lake trout) in the Les Cheneauxs vary dramatically and could have considerable influence on the fish community of the Les Cheneauxs, whether or not they directly influence yellow perch. Also, white perch were documented for the first time in the 1995 creel survey, and if numbers continue to increase, white perch may affect yellow perch populations through competition as they have in other waters (Parish and Margraf 1990, Prout et al. 1990).

Lake of the Woods, Minnesota

Lake of the Woods, located in southeastern Manitoba, southwestern Ontario, and northwestern Minnesota, is one of the larger inland lake systems outside of the Great Lakes. The lake is biologically diverse with respect to the fish found in the system, containing everything from lake trout in the deep Canadian waters, to sturgeon and percids. Lake of the Woods is one of the premier walleye lakes on the continent. While there is some commercial fishing, and native subsistence fishing (on the Canadian side), the primary harvest of game fish species is by recreational anglers. Currently, the lake is managed to optimize recreational opportunities, as well as native fish populations.

The most relevant statistical data has been gathered by the Minnesota Department of Natural Resources, Division of Fisheries, through the large lake sampling program. The primary species of interest are the percids. This group of fish is sampled at a variety of life stages through-fall gill net sampling, seining, and trawling. Several calculations reveal information about relative abundance of fish, although there is no lake-wide population estimate for any species (Heinrich 1999). The historical "catch per unit effort" (CPUE) as measured by gill net sampling reflects recent trends for each of six fish species. These data show that, overall, there has been no general decline in the abundance of any of these species.

DCCO Status and Diet. Cormorants were historically present at Lake of the Woods, but declined to a negligible number in the 1950s and 1960s. The population then started to rebound, beginning in the 1970s. The nesting population on the American side of Lake of the Woods has fluctuated from 1164 pairs in 1980, to over 7000 pairs observed in 1990. The population declined following an outbreak of Newcastle disease in the early1990s, and then increased to just over 4500 nesting pairs in 1999.

There is little quantitative information available on diet of cormorants at Lake of the Woods. Sampling of bolus regurgitations by chicks of cormorants at Lake of the Woods (K. Haws, Minnesota DNR, pers. comm.) has indicated that, of 41 samples taken in 1985, by far the greatest representation by number in the samples was yellow perch (72 percent), followed by small amounts of burbot, walleye, and sauger (8 percent), and white sucker. Other inland studies (e.g., at Lake Winnipegosis, Manitoba) have shown that cormorants eat perch, sucker, and cisco (Hobson et al. 1989). Full assessments which include adult food habits, and food habits over the entire ice-free season, have not been made.

Southeastern lakes, ponds, and reservoirs

Many of the inland lakes in the southeastern U.S. (e.g., Millwood Lake, Arkansas; Lake Livingston, Texas, etc.) are reservoirs that were created for purposes such as flood control, water conservation, irrigation, and other beneficial uses such as recreational fishing. Concernsamong anglers regarding DCCO predation on reservoir fishes in the southern Great Plains and in southeastern States have increased in recent years (Simmonds et al. 2000).

During scoping, for example, the Army Corps of Engineers and the Arkansas Game and Fish Commission expressed concerned that cormorants are having a negative impact on fish populations at Millwood Lake, Arkansas. Additionally, the Georgia Department of Natural Resources shared the results of surveys conducted by their Fisheries Management Section (in 1992 and 1994) which documented "significant fish losses" to cormorants at fishing lakes in the southern part of Georgia (while DCCOs in the northern half of the State were generally not a problem).

DCCO Status and Diet. In recent years, both wintering and breeding numbers of DCCOs have increased significantly in the southeastern U.S. (Jackson and Jackson 1995, Tyson et al. 1999, Reinhold and Sloan 1999, Wires et al. 2001). Campo et al. (1993) examined the diets of 420 DCCOs from eight public reservoirs in Texas (1986-1987) and found that DCCOs ate fishes that were most abundant in the reservoirs. Shad and sunfishes accounted for 90 percent of the total food items by number. Sport fish (largemouth and white bass, catfishes, and crappies) made up a significant portion of DCCO food by weight, but not by number on some reservoirs. The sport fish taken by DCCOs were much smaller than those taken by sport anglers. The authors concluded that, at that time, "consumption of desired sport fish in reservoirs was an insignificant portion of cormorant diets in Texas."

Glahn et al. (1998) compared percentages of prey species in the diet of DCCOs at Lake Beulah, Mississippi and Lake Eufala, Alabama to the percent availability of these prey species in the lakes. They found that the only sport fish that occurred in the diet in significant numbers were sunfish species, particularly bluegill. They concluded that, with the possible exception of predation on harvestable size bluegill, DCCOs do not appear to have a negative impact on fisheries in the two lakes studied.

Simmonds et al. (2000) stated that "Because cormorants prey on a variety of fish species and sizes and because their residency in Oklahoma is seasonal, their ultimate effect on sport fishery characteristics may be different from that inferred from simple calculations of consumption." They modeled effects of different levels of DCCO predation on standing crops and yields of reservoir sport and forage fish and found that: predation by DCCOs had a moderate or low effect on fish abundances and yields when DCCO abundances approximated those found on most reservoirs in Oklahoma (i.e., 2.5 cormorant days/ha), but effects on fish abundance and yield were severe when high DCCO abundances were inputted (i.e., 23.4 cormorant days/ha, a level actually observed on two reservoirs in one year). At this level of predation, simulated channel catfish and largemouth bass fisheries collapsed and yields of white crappies were greatly reduced.

On Lake Chicot, an oxbow lake on the Mississippi River in Arkansas, mortality rates of age-0 to age-1 crappie have been estimated at 90 percent in recent years. While increasing numbers of DCCOs are suspected by anglers to be the cause of these high mortality rates, the Arkansas Game and Fish Commission reports that an increase in the density of largemouth bass may be having an affect on crappie survival. The University of Arkansas is planning to carry out a study examining the diet and potential impact of both DCCOs and largemouth bass (Fenech et al. unpubl. data).