Appendix 7: Management Techniques

Wildlife damage control activities generally fall into one of three broad categories: 1) resource management, 2) physical exclusion, and 3) wildlife management (USDA-APHIS 1997b).

1. Resource Management

Cultural methods may include facility location, facility design, and fish management (Gorenzel et al. 1994) and are carried out by land owners/managers. The physical location, design, and construction of an aquaculture facility influence the susceptibility of fish to bird predation, while facility design influences success in protecting fish stocks from predation. Fish management may include locating the most susceptible fish species and size close to the center of human activity and near buildings that might be incorporated in a bird exclusion system, and altering fish stocking dates so that vulnerable fish are not stocked when substantial bird numbers are present (Mott and Boyd 1995).

Environmental/habitat modification can be an integral part of wildlife damage management. Since the presence of wildlife is directly related to the type, quality, and quantity of suitable habitat, habitat itself can be managed to reduce or eliminate the production or attraction of certain bird species. In most cases, the land owner/manager is responsible for implementing habitat modifications. Habitat management is most often a primary component of wildlife damage management strategies at or near airports (i.e., to reduce bird aircraft strike problems by eliminating bird nesting, roosting, loafing, or feeding sites). Generally, many bird problems on airport properties can be minimized through management of vegetation and water from areas adjacent to aircraft runways (Godin 1994).

Nest/tree removal is the removal of nesting materials during the construction phase of the nesting cycle or the removal of trees used for nesting/roosting. Nests can be removed or destroyed manually or by use of high pressure water to dislodge nests from trees (Chipman et al. In press). Nest/tree removal has been used to manage DCCOs locally (to eradicate colonies) and regionally (to reduce populations). The technique has been used on both ground and tree nests. Nest destruction on the ground simply involves the physical breakup of nest structures. Tree nests present a greater challenge. Entire trees have been removed, both in private (Anderson and Hamerstrom 1967) and official control efforts (USFWS 1999a, b).

Nest removal, even when successful at preventing colonization attempts, cannot be considered permanent; control must be repeated each time cormorants attempt to nest in areas of concern. It may also eliminate nest substrates for other species. Where DCCOs have already made trees unsuitable for nesting by other species, this may not be an issue; however, removing nest trees may shift DCCO nesting and move them into conflict with other species (Wires et al. 2001). Additionally, because DCCOs frequently nest on the ground, tree removal may only be effective where the substrate is inappropriate for nesting or the threat of mammalian predation is high (Wires et al. 2001).

2. Physical Exclusion

Birdproof barriers can be effective but are often cost-prohibitive, particularly because of the aerial mobility of birds which requires overhead barriers as well as peripheral fencing or netting. Exclusion adequate to stop bird movements can also restrict movements of people, including fish maintenance and harvesting operations, and are susceptible to ice and wind damage (Littauer et al. 1997). Barrier systems using wire, line, and string in parallel and grid patterns and polyethylene rope with foam floats have been used for deterring DCCOs (Mott et al.1995; Littauer et al. 1997). The concept is meant to take advantage of the relatively long take-off distance (approximately 30 feet) that DCCOs generally require. Parallel wires should be positioned perpendicular to the prevailing wind as cormorants generally take off and land into the wind. Colored streamers have been used to increase visibility of the wires and strings. However, cormorants have been known to adapt readily to parallel wires so grid patterns are inherently more effective (Littauer et al. 1997).

3. Wildlife Management

A. Non-lethal techniques

Harassment or animal behavior modification. This refers to tactics that alter the behavior of wildlife to reduce damage. Animal behavior modification may involve use of scare tactics to deter or repel animals that cause loss or damage (Gorenzel et al.1994; Littauer 1990; Reinhold and Sloan 1999). Numerous techniques and devices can be used to frighten DCCOs. Wires et al. 2001 reviewed these non-lethal techniques by dividing them into three categories: 1) direct human harassment, in which humans attempt to frighten, but not kill, cormorants, 2) simulated human harassment, in which static or animated devices frighten cormorants by simulating human threats, and 3) other harassment, in which the negative stimulus is not necessarily connected to human activity. Some but not all methods that are included in this category are:

- Electronic guards
- Propane exploders
- Pyrotechnics
- Distress calls and sound producing devices
- Repellents
- Scare crows
- Mylar tape
- Eye spot balloons
- Vehicle horn and chase
- Live ammunition

These techniques are generally only practical for small areas. Scaring devices such as distress calls, helium-filled eye spot balloons, scare crows, effigies and silhouettes, mirrors, and moving disks can be effective but usually for only a short time before birds become accustomed and learn to ignore them (Mason and Clark 1997; Mastrangelo et al. 1997, Stickley, et al. 1995; Stickley and King 1995; Mott et al. 1995; Reinhold and Sloan 1999). Littauer et al. (1997) noted that a scaring program must be consistent and aggressive to be successful. Timing is also critical (Mott and Boyd 1995) and therefore harassment must begin as soon as it can be economically justified and continued until all undesirable birds vacate the area (Reinhold and Sloan 1999).

Human harassment. As discussed in Wires et al. (2001), the most common form of direct human harassment is ground patrol with pyrotechnics. Patrols may occur on foot or in vehicles and may utilize a variety of pyrotechnics to frighten DCCOs (and, of course, other birds). Pyrotechnics include various shellcrackers, screamers, whistling projectiles, exploding projectiles, bird bangers, flash/detonation cartridges and live ammunition (Lagler 1939; Moerbeek et al. 1987; Hanebrink and Byrd 1989; Stickley and Andrews 1989; Littauer 1990; Brugger 1995; Mott and Boyd 1995; Pitt and Conover 1996; Spencer 1996; Littauer et al. 1997; Reinhold and Sloan 1999). Live ammunition is often used because it is cheaper and more readily available than pyrotechnics (Littauer 1990; Mott and Boyd 1995; Littauer et al. 1997). Cormorants are often frightened from aquaculture ponds simply because of the presence of humans (Hanebrink and Byrd 1989; Spencer 1996; and Reinhold and Sloan 1999). Hodges (1989) concluded, for example, that the presence of humans at aquaculture facilities during critical periods may be the most effective means of keeping DCCOs off ponds.

Simulated Human Harassment. To reduce labor costs for harassment patrols, various devices, both static and animated, have been developed to simulate the threat of human activity near areas of concern, usually aquaculture ponds. These devices range from simple wood cutout scarecrows to elaborate contraptions that create startling movements, emit numerous noises, and flash lights (Wires et al. 2001).

Human effigies/scarecrows have long been used against avian predators at many different types of agriculture fields, despite their general lack of success at preventing depredations (Lagler 1939; Inglis 1980). Increasing both realism and level of animation in scarecrows may improve their ability to scare birds, and combining scarecrows with automated sound devices may enhance the frightening effect (Littauer 1990; Littauer et al. 1997). Stickley et al. (1995) and Stickley and King (1995) tested an inflatable effigy called Scarey Man® on catfish farms in Mississippi, as described in Wires et al. (2001). For relatively short lengths of time (10-19 days), the device significantly reduced the number of DCCOs on the ponds (71-99 percent reduction in number of DCCOs flushed from ponds during ground patrols). Compared to replacement cost of catfish consumed (based on mean DCCO consumption rate in Stickley et al. 1992), Scarey Man® devices were considered to be economically efficient (Stickley et al. 1995). However, evidence of habituation was reported, especially when day roosts were in view of the Scarey Man® devices. Stickley and King (1995) suggested that the device be used where DCCO depredations are "serious."

Another animated scarecrow was described by Conniff (1991). This device was described as a jack-in-the-box scarecrow with inflatable plastic arms, revolving strobe lights, and amplified sounds (130 dB) of horns honking, people shouting, shotguns firing, and birds screaming. The device was declared "ineffectual," indicating that "a cormorant can get used to almost anything."

Other harassment. As described in Wires et al. (2001), other means to startle birds into flight have been developed, and many have been used against DCCOs. These include amplified DCCO distress calls; sirens and other electronically generated noises; tin plates, mylar balloons, reflecting tape and other reflectors; and eyespot balloons and raptor silhouettes (Lagler 1939; Barlow and Bock 1984; Moerbeek et al. 1987; Parkhurst et al. 1987; Stickley and Andrews 1989; Littauer 1990; Brugger 1995; Mott and Boyd 1995; Price and Nickum 1995; Spencer 1996; Littauer et al. 1997; Reinhold and Sloan 1999.)

Auditory scaring devices such as propane exploders, pyrotechnics, electronic guards, and audio distress/predator vocalizations are effective in many situations for dispersing damage-causing bird species. However, birds often habituate to such devices, rendering them ineffective. Using a combination of harassment devices prolongs habituation and provides the greatest amount of protection. Frequently changing and moving devices further enhances protection (Gorenzel et al. 1994; Reinhold and Sloan 1999).

Visual scaring techniques such as use of mylar tape (highly reflective surface produces flashes of light that startles birds), eye-spot balloons (the large eyes supposedly give birds a visual cue that a large predator is present), and flags, sometimes are effective in reducing bird damage (Gorenzel et al. 1994; Littauer et al. 1997; Stickley et al. 1995; Stickley and King 1995).

Reviewers have generally found distress calls ineffective against DCCOs for long periods of time (Wires et al. 2001). Hanebrink and Byrd (1989) mention that, while APHIS-WS recommended using amplified distress calls, the calls merely moved birds to different ponds. Littauer (1990a) listed distress calls among other electronically generated noises whose effectiveness was "uncertain," but did note observations of DCCOs apparently being *attracted* to distress calls. Effectiveness of audio and visual scare tactics (specifically distress calls, electronically generated noises, tin plates, mylar ribbon, flash tape, flagging, helium balloons, inflatable eyespot balloons and hawk silhouette kites) have generally been found to be low when deployed by themselves or over long periods of time (Littauer 1990; Spencer 1996; Reinhold and Sloan 1999).

Various noisemakers to scare DCCOs have been developed, including the rope firecracker, which sets off explosions as the rope burns (Littauer 1990) and propane/butane/acetylene cannons, some of which can be programmed to go off at varying intervals and variable numbers of times. The effectiveness of cannons is itself variable (Wires et al. 2001). Stickley and Andrews (1989) reported that 40 percent of respondents used propane cannons. Of these, 60 percent found them to be either somewhat or very effective against DCCOs. Brugger (1995) reported initial success with cannons, but with relatively quick habituation. Conniff (1991) reported that butane cannons eventually became perches for DCCOs. Individuals using propane cannons in Oklahoma and Georgia reported them to be ineffective (Spencer 1996; Simmonds et al. 1995a) and Moerbeek et al. (1987) found gas cannons generally ineffective against Great Cormorants in the Netherlands.

Given the general lack of success with harassment techniques used separately (largely due to habituation), many investigators have concluded that, to be effective, 1) a variety of techniques must be used, 2) techniques should be applied vigorously, 3) location of static and automatic devices should be changed frequently, and 4) the combination of techniques should be altered frequently (Moerbeek et al. 1987; Littauer 1990; Mott and Boyd 1995; Mott and Brunson 1997; Reinhold and Sloan 1999). The recommendation by Littauer (1990a) that use of gas cannons be stopped once habituation begins to occur (to prevent a decrease in their utility at a later date) could probably be applied to all forms of non-lethal harassment (Wires et al. 2001).

Non-lethal Dispersal at Night Roosts. Night roost dispersal is used to harass DCCOs from their roosting sites in an effort to re-locate birds away from a particular area or region (Mott et al. 1998; Reinhold and Sloan 1999). The goal of this approach is to keep DCCOs from roosting in the area at night and subsequently to decrease the number of depredating birds within the harassment area during the day. Most discussion of this technique has focused on the Mississippi Delta region where it has been practiced since 1992 (Mott et al. 1998). This type of dispersal program is labor intensive and requires a great deal of organization and coordination to be effective (Reinhold and Sloan 1999; Tobin 1998). Electronic noise generators, amplified recordings, propane exploders, pyrotechnics, and firecrackers can be used to disperse birds.

Discussions of the effectiveness of the Mississippi Delta program are limited, but tend to suggest that the program may be numerically and economically effective (Wires et al. 2001). Surveys within harassment areas during the winter of 1993-94 counted 70 percent fewer birds than the previous winter (1992-93) when there was no harassment; surveys from 1994-95 showed a 71 percent decrease from number of birds detected in 1992-93 (Mott et al. 1998). Survey data from aquaculturists in 1994 revealed that 62 percent within the harassment zone reported fewer problems with DCCOs than in previous years, whereas 38 percent outside the zone had the same sentiments; data from 1995 revealed little change, with 74 percent of aquaculturists within the harassment zone reporting fewer problems and 38 percent outside reporting the same (Mott et al. 1998). These perceptions are reflected in the amount of money spent on harassment at individual aquaculture facilities: within the harassment zone, aquaculturists reported an average $1,406 decrease in expenses for harassment at their facilities in 1994, and $3,217 in 1995. Cost of the program was $16,757 in 1994 and $32,302 in 1995. If these costs were divided equally among participating aquaculturists, each would have paid $419 in 1994 and $557 in 1995. Based on a comparison between cost of the night roost harassment program and reductions in harassment expenditures at individual aquaculture facilities, the control program was considered economically effective. However, Reinhold and Sloan (1999) point out that "ever-increasing numbers" of night roosts can limit the success of dispersal programs.

Prevention of colony establishment. Another important means of limiting the damages caused by DCCOs is to prevent birds from establishing colonies in areas of concern. Bregnballe et al. (1997) predicted that potential breeders prevented from founding a new colony could be expected to either delay breeding to a later year or to join existing colonies. This would likely have two effects: (1) the population would stabilize sooner and (2) the population would stabilize at a lower absolute population size because the resources available at breeding would be reduced. Without persistent, frequent attempts to harass birds away from potential breeding sites, however, or if individuals attempt to nest at sites that have been previously used for roosting, it is likely that they would be less willing to abandon nesting attempts. Bregnballe et al. (1997) suggested that it might therefore be necessary to shoot some of these individuals to prevent colonization.

B. Lethal techniques

Egg and nestling destruction. DCCO eggs and nestlings have been destroyed in attempts to reduce recruitment into populations and to eliminate colonies at specific locations (in conjunction with other forms of harassment). Bregnballe et al. (1997) predicted that the effect of increased egg mortality on autumn population size would be buffered by increased density-dependent chick survival. However, if repeated egg oiling efforts led to near total clutch failure at ground-nesting colonies, the population would be expected to stabilize at lower sizes and the proportion of the foraging area being exploited during breeding would decline. Van Dam and Asbirk (1997) predicted no risk to cormorant populations from reducing reproductive output if it was carried out "under control."

In general, egg and nestling destruction may not be effective at completely eliminating reproduction for individual DCCOs during a nesting season because of their tendency to renest after disturbance. As reported in Wires et al. (2001), in some instances (Lake Winnipegosis, Manitoba; Lake of the Woods, Minnesota and Ontario; St. Lawrence River Estuary, Quebec) local DCCO populations continued to rise despite egg and nestling destruction efforts (Hobson et al. 1989; Baillie 1939, 1947; DesGranges and Reed 1981). In contrast, some investigators have suggested that egg and nestling destruction on a large scale (often in conjunction with killing adults) may have slowed the growth of populations (Weseloh and Collier 1995), stabilized populations, or contributed to declines (Ewins and Weseloh 1994; Sheppard 1994/5; USFWS 1999b). McLeod and Bondar (1954) concluded that consistent destruction of eggs and young appeared to reduce the breeding population fairly effectively on Lake Winnipegosis in the 1940s and 1950s. The key factor is most likely whether density-dependent mechanisms are sufficiently overcome by the specific management actions.

Effectiveness at causing colony abandonment appears to vary; newly established colonies appear to be more easily eliminated than well established ones (Wires et al. 2001). Most recently, egg and nestling destruction, in conjunction with nest destruction and sometimes harassment, has been found to be effective at preventing renesting for a year or more at newly established colonies (USFWS 1999a, b).

Egg oiling has essentially the same result as that of killing eggs and nestlings, but with the added benefit that DCCOs are less likely to abandon nests and lay replacement clutches, making the technique more effective as an annual treatment (Wires et al. 2001). Bédard et al. (1995) report, "None of the eggs in 427 experimentally treated nests hatched in 1987 and nearly half were still tended by adults 49 to 59 days after laying (the remainder having been abandoned and scavenged)." Shonk (1998) reports, "Of the eggs treated with oil, 49 percent were incubated past the expected hatching date. The remainder of the eggs were lost during the incubation." Human disturbance during oiling increases predation by gulls (Shonk

1998), which may cause some DCCOs to renest.

Egg oiling is a method of suppressing reproduction of nuisance birds by spraying a small quantity of food grade vegetable oil or mineral oil on eggs in nests. The oil prevents exchange of gases and causes asphyxiation of developing embryos. The method has an advantage over nest or egg destruction in that the incubating birds generally continue incubation and do not renest. The EPA has ruled that use of corn oil for this purpose is exempt from registration requirements under the Federal Insecticide, Fungicide, and Rodenticide Act. To be most effective, the oil should be applied anytime between the fifth day after the laying of the last egg in a nest and at least five days before anticipated hatching. This method is extremely target specific and is less labor intensive than egg addling.

Effectiveness at killing embryos is high, with mortality rates approaching 100 percent when the oil/solution is applied correctly (Gross 1951; DesGranges and Reed 1981; Blokpoel and Hamilton 1989; Christens and Blokpoel 1991; Shonk 1998; Bédard et al. 1999). Although laboratory tests found oiling ineffective when applied only to part of an egg (Blokpoel and Hamilton 1989), field tests in which only the tops of eggs were sprayed were highly successful, indicating that careful application to the entire egg surface may not be necessary (Christens and Blokpoel 1991; Bédard et al. 1999). Egg-rolling activities by parents may assist in covering the entire surface (Christens and Blokpoel 1991).

The effectiveness of egg oiling as a population control method can be quite variable. Because DCCO egg laying is not synchronous, only one spraying per summer may not treat enough of the eggs laid that nesting season to have a significant impact on the population, and multiple oiling efforts to overcome this problem may increase the cost of control beyond acceptable levels. Both problems were cited as reasons for the failure of egg oiling efforts in Maine by Dow (1953). If carried out with appropriate intensity, egg oiling can be a very effective means of reducing local populations, although the results are more slowly seen than with culling or a combination of the two techniques. Modeling of the St. Lawrence River Estuary, Québec, DCCO population suggested that egg oiling alone would not be sufficient to bring DCCO numbers to target levels within the desired time frame, leading to the selection of a combined strategy of egg oiling and shooting adults (Bédard et al. 1995).

Killing adults. Shooting adults has been a commonly used technique for controlling DCCOs (Matteson 1983; Hobson et al. 1989; Ewins and Weseloh 1994; Sheppard 1994/5; Carter et al. 1995b; Jackson and Jackson 1995; Ludwig and Summer 1995; Weseloh and Collier 1995; USFWS 1999b). Shooting DCCOs is believed to reinforce non-lethal harassment (EIFAC 1988, Hess 1994, Littauer 1990, Mastrangelo et al. 1997, Rodgers 1988 and 1994, Tucker and Robinson 1990, USDA 1994 cited in Glahn et al. 2000b) and is highly selective for target species. Shooting is typically conducted with shotguns or rifles and can be relatively expensive because of the staff hours sometimes required (USDA 1994).

The effectiveness of shooting to kill adults may be limited since DCCOs can be wary and difficult to shoot (Wires et al. 2001). In cases where large numbers of birds are present, it may be more effective as a dispersal technique than as a way to reduce bird densities. A study by Glahn (2000) indicated that shooting DCCOs in roosts was as effective as frightening them with pyrotechnics for dispersing them, and may not result in habituation.

Wires et al. (2001) discussed that the killing of adult DCCOs may be a successful technique for controlling regional populations, but would likely require that large numbers be killed and that the geographic range of the program be sufficiently wide. Killing nesting DCCOs is most likely to be successful at reducing population levels when two conditions are met: (1) scale of control is large enough to overcome the effects of immigration and (2) the control effort is well coordinated, long-term, and sufficiently rigorous to overcome density-dependent compensation mechanisms. The success of a culling program is not only limited to the number of birds removed but also the age and sex of the individuals being removed (Bédard et al. 1999, Ludwig and Summer 1995, Wires et al. 2001). As a means of reducing population levels, it is believed that it is more effective to kill breeding birds than to destroy eggs, nestlings, or fledglings because first-year birds frequently have low survival rates and many would not have survived to breed anyway (Wires et al. 2001).

Shooting adults at colonies may have impacts beyond killing individual breeders because of harassment effects on survivors. Cairns et al. (1998) observed that the abandonment of a large DCCO colony in waters of Prince Edward Island, Canada, seemed to have been caused by shooting and harassment at the colony that had taken place when cormorants first returned to the area in the spring. The birds from the abandoned Ram Island colony apparently shifted to nearby Little Courtin Island. However, since DCCOs usually exhibit strong philopatry and site-fidelity, the displacement was judged to be highly "anomalous." Ewins and Weseloh (1994) reported that the shooting of > 50 adults on Pigeon Island, Lake Ontario, in 1993 (when the colony had 818 pairs) reduced reproductive output for that year: fledging rates were 0.3 vs. 1.6 young/nest on a nearby island that was not subject to shooting. Long-term impacts on the colony were not reported (Wires et al. 2001).

Limited data are available on the effectiveness of killing adults on controlling local populations/colonies (Wires et al. 2001). Matteson (1983) noted that shooting DCCOs at pound nets by fishermen did not prevent the nearby Mink Island, Lake Ontario population from increasing from 40 nests in 1945 to 50 nests in 1956. Ludwig and Summer (1995) analyzed leg band recovery data for DCCO colonies in the Les Cheneaux region of Lake Huron and concluded that, based on the level of immigration into this region, lethal control of adults would have to be Great Lakes-wide to be effective at controlling local populations (see also Korfanty et al. 1999).

The St. Lawrence River Estuary, Québec, control program provides an example of a control effort intensive and expansive enough to reverse DCCO population growth. The goal of a 5-year control program on the St. Lawrence River Estuary, Québec, was to reduce the cormorant population to 10,000 pairs. Culling was halted after only four years, however, due to quicker than anticipated results believed to be caused by the fact that adult male DCCOs were more vulnerable to shooting than adult females (at a ratio of 2:1 males to females). Another goal of this program was to discourage tree nesting. In 1989, the year the culling program began, 43 percent of all nests were in trees; five years later, in 1993, only 27 percent of nests were arboreal (Bédard et al. 1999).

Effectiveness of killing adults relative to other forms of population control are unknown, although it is believed that, individual for individual, killing adults that have survived to breed is more effective at reducing populations than destroying eggs, nestlings or fledglings. Ludwig and Summer (1995:40) estimated that, "From the whole population perspective, killing a young adult just before first nesting will have a 3 to 6 fold greater effect on population control than killing fledglings, chicks or eggs."

Without adequate knowledge of intercolony migration rates it is difficult to predict the minimum scale of control necessary to overcome effects of immigration (Wires et al. 2001). For lethal control to effectively reduce predation levels, the mortality rate must be higher than the immigration rate. This level of lethal control may be difficult to achieve without extensive control efforts. In Bavaria, Germany, the number of Great Cormorants reported shot during the winters of 1995-96 to 1998-99 was approximated at 50 to 100 percent of the average Bavarian winter cormorant population. Despite this high level of mortality, mean winter numbers of cormorants did not substantially decrease. Shooting did not remove birds from water bodies that were supposed to be protected, but simply killed migrant birds which were rapidly replaced by newly arriving individuals. Because mean winter cormorant numbers did not decrease substantially, shooting was considered an inappropriate management tool for reducing overall fish depredation in Bavaria (Keller et al. 1998; Keller 1999).